STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

CONSTRUCTION MANUAL

APRIL 2016

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
1263 S. Stewart Street
Carson City, Nevada 89712

JIM GIBBONS
Governor

SUSAN MARTINOVICH, P.E., *Director*

In Reply Refer to:

Welcome to the Nevada Department of Transportation Construction Manual. Although this manual is based on previous editions, this 2009 edition is the result of extensive research into construction materials and techniques, and collaboration with Department administrators, engineers, and technicians. For the first time, the Manual is not only available in printed form, but also in electronic form.

This Construction Manual meets the requirements of Transportation Policy 1-8-1 by establishing uniform policies and procedures for administration of the Department's construction contracts and provides guidance and direction to the personnel administering them. This Manual was written for four principal audiences:

- Employees who are new to the roadway construction industry
- Experienced employees who are new to the procedures of the Nevada Department of Transportation
- Experienced employees who have responsibilities in technical areas to which they are new
- Engineering consultants retained by the Department

Our goal was to provide a manual that leads to the construction of quality transportation projects by improving decision making in the field, serving as a training tool, and providing statewide consistency. The extent to which you use this manual to improve your inspections and contract administration skills will reflect on how successful we have been in empowering you to provide the people of Nevada quality construction projects.

To supplement this Construction Manual, the Construction Division holds classes and workshops to educate employees on more detailed aspects of construction materials, techniques, and administrative procedures. This Construction Manual is not intended to educate construction personnel fully, but to provide initial exposure to the relevant issues of roadway construction. This manual should not be considered a substitute for administrative or engineering knowledge nor should it be considered as all encompassing. It does not replace or supersede the Standard Specifications, Standard Plans, project plans, special provisions, or other contract documents. The Construction Manual is not a contract document.

The Department's construction program is ever changing. New materials, new construction techniques, new procedures, and new laws and regulations place a burden on administrators and field crews to stay current on changes. To stay current and to be responsive to these changes, the Construction Manual will be updated frequently by the Construction Division. During these updates, the manual will incorporate additions, deletions, and revisions to keep the subject matter current.

This Construction Manual was prepared in close coordination and collaboration with Resident Engineers, field crews, District Engineers, headquarters personnel, FHWA, and several consultant firms. The names of those individuals are too numerous to list here, but I would like to express my appreciation to them all for the assistance and expertise they have provided. As questions arise and opportunities for improvement become evident, communicate this information to the Construction Division. We look forward to improving this manual for all users.

Sincerely,

Gary Selmi

Gary Selmi, P.E.
Chief Construction Engineer

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GENERAL

1-100 HISTORY

In 1917, the Nevada legislature enacted the "State Highway Law." The law created the Nevada State Highway Department with a board of three directors appointed by the governor. To administer the highway program, the governor appointed a State Highway Engineer.

The Department of Highways became the Nevada Department of Transportation in 1979. The title of the administrator of the new department changed from State Highway Engineer to Director, and under the director was a Deputy Director and four Assistant Directors for the divisions of Administration, Operations, Engineering, and Planning and Program Development. Soon thereafter, the Department's six districts were reduced to three. In 2003, the legislature approved a second Deputy Director position, located in southern Nevada. The Deputy Director in the Department's headquarters office also maintains the title of Chief Engineer.

1-200 FEDERAL HIGHWAY ADMINISTRATION

The Federal Highway Administration (FHWA) plays an important role in Nevada's highway system. As an agency of the Federal Department of Transportation, the FHWA provides transportation funding to the Nevada Department of Transportation (NDOT). These funds are subject to federal law, executive orders, regulations, and agreements.

The FHWA Nevada Division, located in Carson City, provides federal-funding oversight throughout Nevada. On many projects with federal funding, the FHWA oversees NDOT work to ensure regulatory compliance. On other projects, the FHWA delegates oversight responsibility to NDOT. This delegation occurs through the FHWA Stewardship Program. Refer to Section 3-500 of this *Construction Manual* for a brief description of the Stewardship Program.

The FHWA Division Administrator assigns engineers as NDOT's contacts for various support services. The Chief Construction Engineer is the NDOT contact with the FHWA for construction administration matters. In preparing and approving standard specifications, general special provisions, and this *Construction Manual*, the Construction Division seeks the review and approval of the FHWA. Using the approved provisions and meeting the required outcomes described in this *Construction Manual* become the basis of federal reimbursement.

1-300 FUNDING

In Nevada, transportation project funding can come from several sources.

- State and federal governments (the principal funding sources for NDOT projects)
- City and county governments
- Regional Transportation Commissions, such as in Clark County, Washoe County, and Carson City
- Private developers (not common)

If a single project has multiple funding sources, a specific funding source may pay for only a portion of the work to be completed. For example, a roadway project may start in the City of Las Vegas, and then cross the City boundary into the City of North Las Vegas. If NDOT and the FHWA participate in funding the project, each city would provide funds for work only within their city. NDOT monitors and documents the cost of work completed in specific portions of the project to ensure that each entity funds only its respective part of the project cost.

1-400 ORGANIZATION

The seven-member State Transportation Board, chaired by the governor, establishes Nevada's transportation program. Elected officials and public appointees comprise the Board. The elected officials are the governor, lieutenant governor, attorney general, and state controller. The governor appoints three public members, one from each of NDOT's three transportation districts.

Nevada law establishes the general structure of NDOT (Nevada Revised Statutes, NRS, Chapter 408). The Transportation Board appoints a Director to administer the state's transportation program. The Director appoints two Deputy Directors and four Assistant Directors. Figure 1-400.1 shows how NDOT

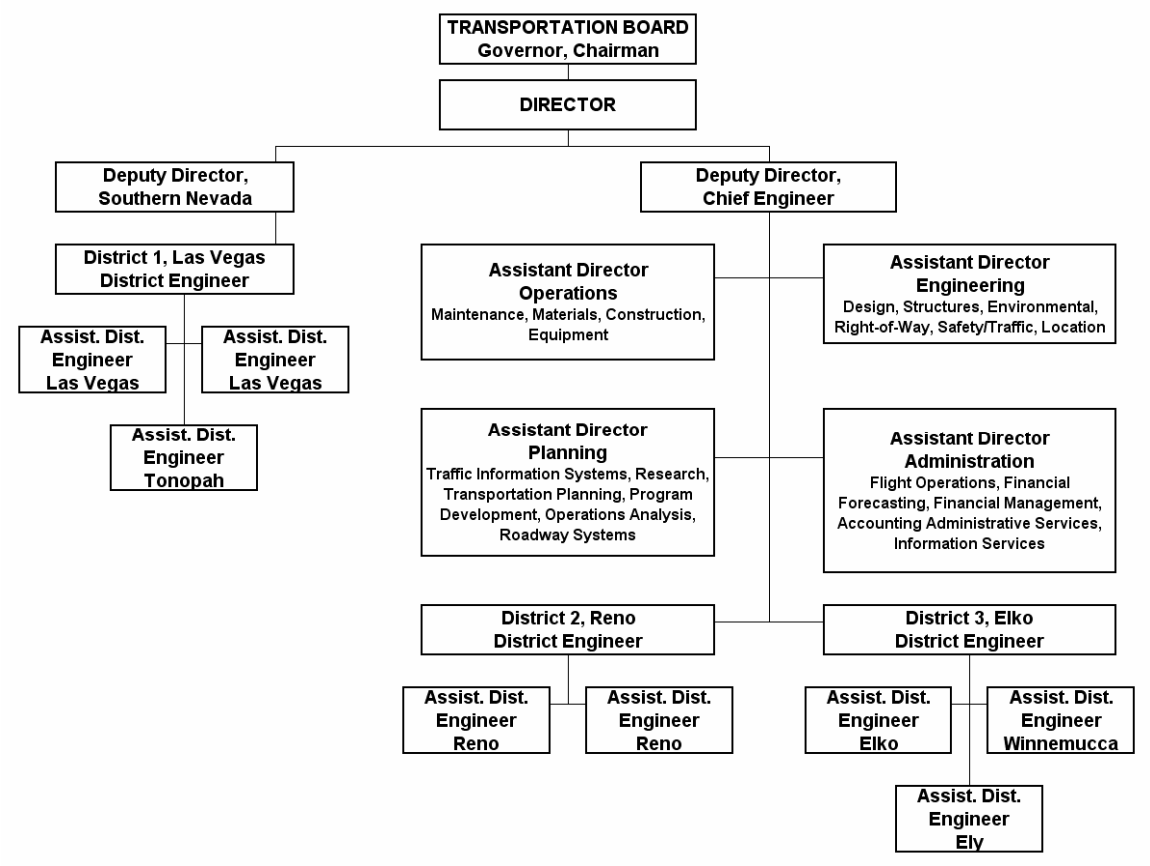


Figure 1-400.1. Nevada Department of Transportation Organization Chart.

As a project moves from a concept to completion of construction, several NDOT divisions play significant roles in the process: is organized.

- Planning – Identifies the general scope and cost of a project
- Location – Performs preliminary surveying
- Right-of-Way – Establishes project boundaries and acquires needed property
- Design – Designs the project
- Structures – Designs bridges and other major structures
- Materials – Provides input and guidance on construction materials
- Project Management – Manages the project during planning and design, and serves as a resource during construction
- Traffic & Safety – Provides traffic engineering
- Environmental – Provides guidance on conformance with environmental regulations
- Construction – Provides input and guidance on construction matters

While these divisions carry out responsibilities during project development, they also provide support during construction. When the construction plans and specifications are complete, the Construction Division confirms that the plans and specifications for the project are consistent with requirements.

1-401 CONSTRUCTION DIVISION

The NDOT Director delegates various responsibilities for administering construction contracts to the Assistant Director of Operations. In turn, the Assistant Director of Operations delegates many of these responsibilities to the Chief Construction Engineer. To carry out NDOT's construction program, the Construction Division is organized as shown in Figure 1-401.1.

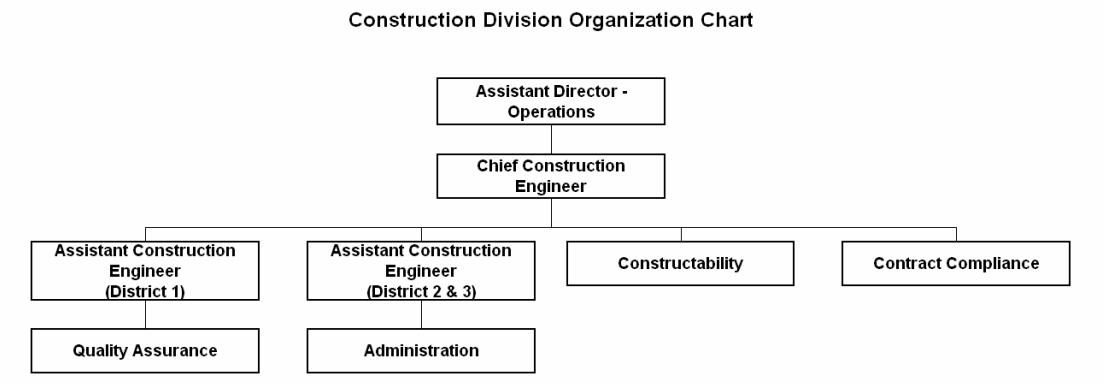


Figure 1-401.1. Construction Division Organization Chart.

1-402 DISTRICTS

Three districts implement NDOT's transportation program. Figure 1-402.1 depicts the boundaries of each district and sub-district, and Figure 1-402.2 shows the typical construction organization of each district. A District Engineer directs the operations within each district. At least two Assistant District Engineers support the District Engineer. Principal activities within the districts include construction and maintenance of transportation facilities.

The Construction Division, with input from the District Engineer, assigns projects to Resident Engineers, who administer the construction project. The District Engineer assigns available staff within the District to the Resident Engineer. If sufficient staff is not available within the District, the District Engineer notifies the Chief Construction Engineer. The Chief Construction Engineer may reassign staff from other districts or retain consultants.

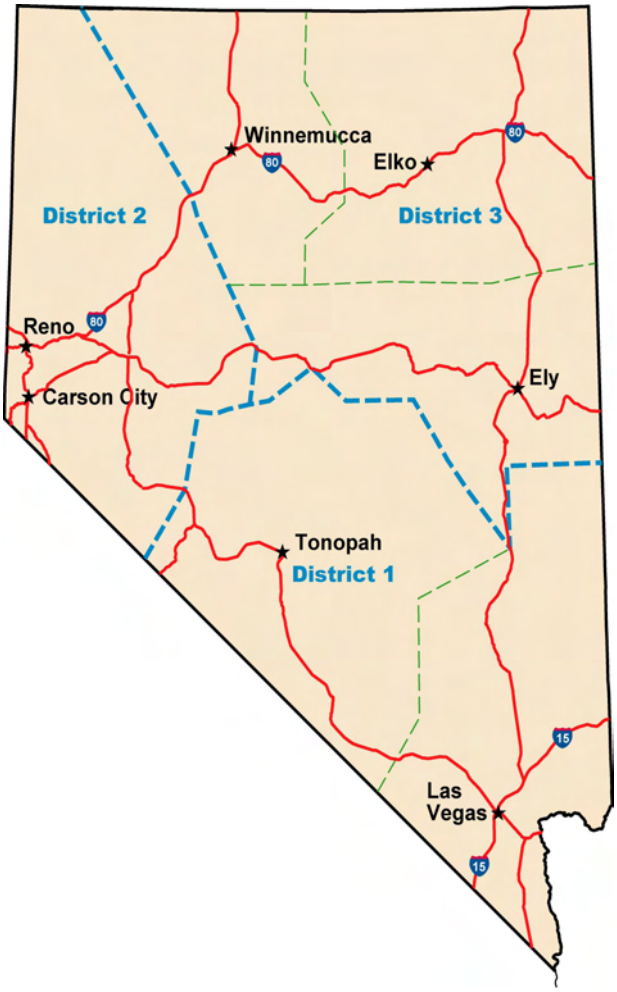


Figure 1-402.1. District and Sub-District Boundaries.

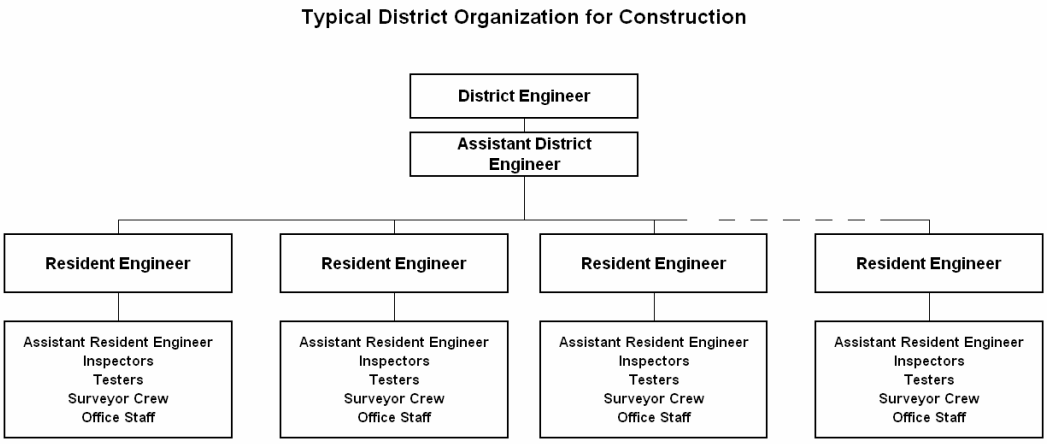


Figure 1-402.2. Typical District Organization for Construction.

A project crew typically consists of a Resident Engineer, assistant Resident Engineer, inspectors, materials testers, and a survey crew chief. The Resident Engineer is NDOT's field representative on construction projects. The Resident Engineer administers the construction of transportation projects, which includes monitoring and documenting the contractor's operations.

RESPONSIBILITIES

2

2-100 INTRODUCTION

Several divisions carry out NDOT's transportation construction program. The success of a construction project requires a clear understanding of each individual's role and responsibilities. The Chief Construction Engineer, District Engineer, and Resident Engineer have specific responsibilities in assuring that construction projects are completed successfully. This section provides detailed information about each of these areas of responsibility, so each division can accomplish its individual duties efficiently and effectively.

2-200 CHIEF CONSTRUCTION ENGINEER RESPONSIBILITIES

The Chief Construction Engineer manages the statewide construction program. Managing the program includes assigning personnel and resources, providing technical support and training, establishing policies and procedures for statewide uniformity, and making budget decisions. Additional responsibilities include:

- Establishing construction-related policies and directives
- Developing and maintaining various guidance manuals, such as the *Construction Manual*, *Documentation Manual*, and *Surveying and Stakeout Manual*
- Developing construction specifications
- Providing technical expertise to legislative and regulatory agencies
- Resolving construction claims and disputes
- Serving as NDOT liaison with the construction industry

Two Assistant Construction Engineers and technical staff support the Chief Construction Engineer. One Assistant Construction Engineer oversees the construction program in the southern portion of the state, and the other Assistant Construction Engineer oversees the construction program in the northern portion of the state. The technical staff provides support in four areas: Administration, Quality Assurance, Constructability, and Contract Compliance.

RESPONSIBILITIES

2-201 ADMINISTRATION

The Administration Section ensures statewide uniformity in construction project documentation. Responsibilities include the following:

- Reviewing project documentation for completeness and accuracy
- Serving as a resource to the project crew on administrative matters
- Auditing field office project records
- Reviewing and processing contractor pay estimates
- Reviewing and processing contract change orders, letters of authorization, and force account documentation
- Reviewing and processing requests for stockpile payment
- Providing assistance and guidance regarding funding eligibility and allocation
- Performing project final "close-out" procedures
- Administering and managing construction consultant services
- Developing and maintaining the NDOT *Construction Manual* and *Documentation Manual*

2-202 QUALITY ASSURANCE

The Quality Assurance Section establishes statewide uniformity in construction project materials testing and inspection. Responsibilities include the following:

- Reviewing project documentation for completeness and accuracy
- Managing the statewide Independent Assurance testing program
- Providing technical support regarding construction methods and techniques
- Training field personnel (informal on-the-job and formal)
- Researching construction practices and technologies
- Collaborating with the construction industry and other stakeholders to improve the quality of construction
- Developing construction specifications
- Participating in construction-related research

- Oversight of the field tester qualification program
- Develop field test methods and revise, as necessary
- Manage the nuclear testing program
- Provide independent on-site quality assurance reviews

2-203 CONSTRUCTABILITY

The Constructability Section provides advice and recommendations on constructability matters. Responsibilities include the following:

- Reviewing plans and specifications for constructability issues during the design phase
- Developing project schedules and limitations on construction operations
- Reviewing and providing recommendations on contractor schedules
- Providing guidance on proposed traffic control
- Reviewing claims and providing claims support and research
- Participating in NDOT bid review process
- Conducting post-construction reviews

2-204 CONTRACT COMPLIANCE

The Contract Compliance Section provides support relating to employment laws and regulations, such as labor, wages, and equal employment opportunities. Responsibilities include the following:

- Monitoring federal and state requirements to confirm NDOT contractor compliance
- Auditing contractor records to verify compliance with labor and wage regulations
- Administering Nevada's Disadvantaged Business Enterprise program
- Administering the requirements of Title VI of the Civil Rights Act, which prohibits discrimination on the basis of race, color, or national origin in programs or activities receiving federal financial assistance

2-300 DISTRICT ENGINEER RESPONSIBILITIES

The District Engineer directs the operations within the boundaries of a district. Assistant District Engineers support the District Engineer in accomplishing the NDOT transportation program. Typically, one Assistant District Engineer manages construction and another manages maintenance and related operations. In districts that cover large geographical areas, the District Engineer may assign additional Assistant District Engineers to outlying locations that manage construction and maintenance activities for that area. Each Assistant District Engineer reports directly to the District Engineer.

The District Engineer manages the overall administration of construction projects assigned to the district, from providing input regarding the scope of a project through completion of construction. The District Engineer also maintains a staff capable of carrying out the Department's policies and procedures efficiently and effectively.

District Engineers delegate authority to Resident Engineers to supervise personnel and maintain a field office and equipment needed for administration of construction projects. The District Engineers evaluate, process, and recommend approval of change orders, and resolve disputes and claims within the limits of their authority. In cases that exceed allowable authority—through cost, scope, or complexity—the District Engineer will recommend decisions, based on a Resident Engineer's recommendation, on project issues before forwarding them to the Chief Construction Engineer.

The District Engineer is responsible for apprising the Chief Construction Engineer on the status of work. Common status issues include problems or issues encountered on projects, decisions that have been made, and recommendations for improvements in construction practices. The District Engineer is also responsible for conforming to NDOT and Construction Division policies and directives, and coordinating construction activities with other district operations. The District Engineer also manages the project's final inspection and recommends final acceptance.

Because each district is unique in topography, climate, population, and industry, districts must be involved in the scoping, design, and construction phases of a project. The District Engineer's input is crucial in describing the impacts—such as traffic delay and business disruption—that the project may have on the local communities within the district.

2-400 RESIDENT ENGINEER RESPONSIBILITIES

The Resident Engineer is responsible for the management, administration, and successful completion of an NDOT construction project. The Resident Engineer is a direct representative of the Director and reports directly to the District Engineer.

The Director delegates authority to the Resident Engineer to administer construction projects. A project's successful completion depends on the Resident Engineer's positive leadership of the project crew and a professional relationship with the contractor.

By building and maintaining trust and teamwork on the project, the Resident Engineer creates a collaborative environment with the contractor, NDOT field crew, and other NDOT divisions. Additionally, being knowledgeable of project-related issues allows the Resident Engineer to respond quickly. To maintain a high level of involvement, the Resident Engineer must frequently visit the project site and review the work. Constant and accurate communication enhances the collaborative environment among team members.

In addition to establishing and maintaining a positive relationship with the contractor, the Resident Engineer provides leadership to the staff assigned by the District Engineer. The Resident Engineer builds an effective staff by emphasizing communication and learning. When the staff communicates well among themselves—sharing knowledge and experience—they can quickly and confidently address situations that arise on a project.

In addition to working with the contractor and supervising the field crew, the Resident Engineer has specific project-related responsibilities that include the following:

- Providing input on development of project plans and specifications
- Assessing the compatibility of the design with site conditions
- Administering the project in accordance with established policies and procedures
- Monitoring projects to confirm compliance with the plans and specifications
- Overseeing documentation, surveying, inspection, and testing
- Ensuring proper documentation
- Preparing contractor pay estimates
- Resolving issues and disputes with the contractor within the Resident Engineer's authority
- Negotiating and preparing contract change orders
- Minimizing construction impacts to the public
- Protecting the state from harm or damage during construction of the project

- Providing guidance and training to the field crew
- Communicating with the District Engineer and Chief Construction Engineer on major issues that have immediate and significant public impact
- Oversee implementation of NDOT's Work Zone Safety and Mobility Policy 07-02 plan, which addresses the flow of traffic and the safety of workers and the public in the construction project

When conflicts occur, a quick resolution is critical to maintaining project progress. The Resident Engineer is the first level of authority in resolving issues or conflicts. The Resident Engineer typically resolves issues, such as non-conforming materials, disputes, and plan errors. If the Resident Engineer desires guidance on resolving issues or conflicts, the Resident Engineer consults with the District Engineer or Construction Division. If guidance on resolving an issue or conflict is unavailable, the Resident Engineer should make a decision instead of allowing the project to be adversely affected.

NDOT may retain engineering consultants to administer construction projects. When a consultant performs the duties of a Resident Engineer, the responsibilities are identical, except a consultant cannot do the following:

- Obligate funds
- Authorize payment on behalf of NDOT

As NDOT's most visible representative on a project, the Resident Engineer frequently communicates with the public, government representatives, and motorists. The Resident Engineer's professionalism often establishes the public's image of NDOT. The Resident Engineer's conduct should be a credit to both the individual, to NDOT, and to all state employees.

2-401 OFFICE PERSONNEL RESPONSIBILITIES

Office personnel manage the administrative activities under the supervision of the Resident Engineer. Administrative responsibilities span project matters, as well as NDOT-related administrative matters. Principal responsibilities include the following:

- Maintaining project files, field books, general files, personnel files, and documents
- Preparing field books, measurement and payment books, calculation sheets, and forms
- Maintaining inventory of survey field books prepared by the survey crew chief
- Checking test reports and calculations
- Preparing contractor pay estimates
- Performing preliminary calculations for liquidated damages
- Reviewing prior approvals, change orders, and letters of authorization for completeness
- Reviewing force account computations for completeness and accuracy
- Ensuring conformance with Construction Division administrative policies and procedures

Office personnel are the primary resource in the Resident Engineer's office for implementing the requirements of the *Documentation Manual*.

2-402 SURVEY CREW CHIEF RESPONSIBILITIES

The survey crew chief, under the supervision of the Resident Engineer, is responsible for the accurate and prompt completion of all construction survey activities. The survey crew chief's primary responsibility is to confirm that project personnel complete the survey in conformance with the plans and specifications. To perform these responsibilities, all survey equipment and instruments must be in proper condition and accurately calibrated. The survey crew chief must be knowledgeable and understand current survey practices and technologies. Additionally, the survey crew chief maintains complete and accurate survey documentation.

After construction activities are complete, notations are added to the project plans, describing all revisions that were made to the original plans. These drawings are called record drawings, or as-built drawings. The survey crew chief is responsible for adding survey information to two sets of as-built drawings. If the contractor performed the survey, then the survey crew chief collects and reviews the contractor's survey data. The Resident Engineer reviews the survey data prior to archiving the data with the project records.

Section 4, Surveying, of this *Construction Manual* describes general surveying activities, procedures, and responsibilities.

2-403 INSPECTOR RESPONSIBILITIES

Under the supervision of the Resident Engineer, inspectors are authorized to inspect all work performed and materials furnished. Inspections may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the work materials. Inspectors are not authorized to alter or waive provisions of the plans and specifications, issue instructions contrary to the plans and specifications, or direct contractor operations. However, an inspector communicates with the contractor and other project personnel to reduce misunderstandings relating to the interpretation of the plans and specifications.

Inspectors have two important responsibilities. The first and primary responsibility is to confirm that the contractor's work and site activities conform to the plans and specifications. The second responsibility is to document the contractor's work.

Inspection duties include:

- Observing and documenting the contractor's workmanship, materials, and methods for conformance with the plans and specifications
- Communicating the project requirements to the contractor's field staff for work under construction or about to be constructed
- Interpreting the plans and specifications
- Documenting inspection operations in the daily construction report
- Measuring work and materials for payment in accordance with the *Documentation Manual*
- Observing construction operations for compliance with safety regulations, traffic control requirements, and construction-related government regulations

2-404 TESTER RESPONSIBILITIES

Under the supervision of the Resident Engineer, testers are authorized to inspect or test materials incorporated or to be incorporated into the work. Additionally, testers may test materials fabricated at commercial material sites or fabrication facilities.

Because test results are the deciding factor in accepting or rejecting work or material, accurate test results are important. Therefore, the tester must maintain testing equipment in good condition. When testing equipment requires repair, replacement, or calibration, the tester must inform the Resident Engineer. Additionally, testing procedures must conform to NDOT test methods, and documentation must be complete and accurate.

Section 5, Sampling and Testing, of this *Construction Manual* describes tester qualifications, testing requirements, procedures, activities, frequencies, and responsibilities.

ADMINISTRATION

3

3-100 GENERAL

This section describes the processes necessary to administer a construction project.

At its most basic level, executing the state's transportation construction program means implementing—or constructing—a transportation project that addresses a need identified by the Department. NDOT designs these needed projects, either internally or through an engineering consultant. When a project is ready to be constructed, NDOT typically solicits construction bids from qualified contractors. The lowest responsible and responsive bidder is selected and the project is then constructed. Although NDOT has historically selected the lowest responsible and responsive bidder to construct projects, they may also use other procurement methods, such as design-build. Other project delivery methods, such as public-private partnerships, may be utilized.

During the design phase, the Construction Division provides support by bringing its knowledge and understanding of construction practices and the construction industry to the design. The Construction Division offers input and suggestions regarding:

- Means and methods
- Scheduling or sequencing of construction activities
- Limitations of construction operations
- Amount of working days needed to construct the project
- Establishing monetary liquidated damages, incentives, and disincentives
- Constructability
- Traffic control

The Design Division incorporates input from other divisions, including the Construction Division, and finalizes the design. The Department then advertises for bids and awards the project. At the time of award, the project is transferred to the District. The District oversees and administers the construction in accordance with NDOT policies and procedures.

3-200 HEADQUARTERS

As a project proceeds from concept to construction, the Construction Division plays a significant role. During the initial planning and preliminary design phases, the Construction Division assigns an engineer to serve on the project development team. This engineer uses knowledge of construction practices to provide input to improve the design.

The Construction Division collaborates with the District to develop a staffing plan for the construction phase of the project. The scope and complexity of the project strongly influence the staffing plan. Available NDOT personnel and project complexity are key considerations in assembling the project staff. Whether the staffing is with NDOT personnel or with consultants, the Construction Division ensures that the District Engineer has sufficient personnel to administer the project.

3-200.1 HUMAN RESOURCES

In addition to providing technical support and direction on construction-related policies, the Construction Division must ensure that it operates consistent with state and NDOT human resources policies and procedures. NDOT's Human Resources Division policies and procedures provide the framework for managing personnel. Refer to the state *Administrative Manual* and the NDOT *Transportation Policies and Procedures Manual* for human resources policies and procedures.

These policies and procedures guide how the Construction Division performs various functions, such as filling positions or transferring personnel. The Chief Construction Engineer has direct human resources responsibility for personnel assigned to the Construction Division. The District Engineer has direct human resources responsibility for construction field personnel assigned to the District. The Chief Construction Engineer is also responsible for ensuring statewide uniformity in human resource administration of construction field personnel. The Chief Construction Engineer coordinates the following administrative human resources functions for construction field personnel:

- Filling vacancies (initiates formal processing)
- New position requests
- Position upgrades/reclassifications
- Personnel transfers between Districts
- Relocation costs
- Training

The Construction Division follows human resources policies and procedures in the administration of personnel – in headquarters and in the field. When consultants are used, other state and NDOT administrative policies and procedures apply.

A Resident Engineer's crew typically consists of engineering technicians that perform the duties of inspecting, testing, surveying, and field office administration. Titles for these positions range from Engineering Technician I, the entry-level position, to Engineering Technician IV. Advancement from an Engineering Technician I to an Engineering Technician III requires satisfactory work performance evaluations and a request for promotion from the Resident Engineer. Advancement from an Engineering Technician III to an Engineering Technician IV requires 24 months of satisfactory NDOT work performance; successfully passing a written examination, ranking in the top five; and, a vacant Engineering Technician IV position to be filled. ..

To progress from an Engineering Technician I to an Engineering Technician II requires 18 months of satisfactory NDOT work performance. And, to progress from an Engineering Technician II to an Engineering Technician III requires an additional 12 months of satisfactory NDOT work performance. Therefore, to progress from an Engineering Technician I to an Engineering Technician III requires a total of 30 months of NDOT experience. The Chief Construction Engineer may grant an accelerated advancement, or an accelerated promotion, based on experience and education of the applicant. Regarding education, math and engineering classes are considered as credit for experience. 0.4 of each class credit is equal to one month of experience. Additionally, after converting credits to experience, the fraction of the month is discarded. For example, 32 class credits are converted to 12.8 months (32 x 0.4 = 12.8), which rounds to 12 months of credited experience. ..

To process a request for consideration of an accelerated promotion, the Resident Engineer must approve an employee's written request. If the Resident Engineer approves the request, the Resident Engineer forwards the request to the District Engineer for approval. After the District Engineer grants approval, the request, including supporting documentation such as transcripts, is then forwarded to the Chief Construction Engineer for approval. After the Chief Construction Engineer approves the request, processing of the promotion follows regular processing procedures. In submitting the request, the Resident Engineer should allow sufficient time to process the request. The Construction Division requires one week to review and process an approved accelerated promotion request.

3-200.2 CONSULTANTS

When the Construction Division confers with the District Engineer and Resident Engineer regarding the staffing of a construction project, they first assess the availability of NDOT personnel within the District. As part of the staffing evaluation, they determine any special knowledge or expertise that may be required for the specific project. The Construction Division uses the staffing analysis to determine if sufficient NDOT staff is available. If the staffing analysis concludes that sufficient NDOT staff or expertise is not available, the Construction Division may retain engineering consultants to fulfill particular needs. .

NDOT may retain a consultant to support, or augment, a Resident Engineer's crew. The Resident Engineer may utilize one or more individuals, such as inspectors or testers. The Resident Engineer directs the activities of the consultants that augment the crew. Consultants are independent contractors of NDOT and are responsible for their own internal supervision and personnel requirements.

When an NDOT Resident Engineer and crew are unavailable for a project, NDOT retains a consultant to administer the construction project. The consultant staff includes an engineer licensed to practice in Nevada and all necessary support staff to oversee and monitor the project in conformance with NDOT policies and procedures. The consultant Resident Engineer works under the direction of the District Engineer or Assistant District Engineer.

The Construction Division may also retain consultants for work unrelated to field activities, such as special projects or an unusually high workload. The Construction Division typically retains consultants for specific assignments, such as support in evaluating claims from contractors, in analyzing project schedules, in resolving disputes, and in determining the constructability of a project.

The Construction Division retains consultants in accordance with procedures established by the NDOT Administrative Services Division. The Construction Division selects the consultant to fulfill the specific needs and requirements of the assignment based on the consultant's qualifications. Once they make a selection, the appropriate Construction Division staff and the consultant discuss the scope of work required of the consultant and the level of resources needed to accomplish the work. This discussion of the scope of work and level of resources is commonly referred to as negotiations. During the negotiations process, the Construction Division and the consultant discuss other issues such as the number and qualifications of staff, the amount and types of equipment, and payment method. NDOT and the consultant successfully complete negotiations when they agree on the major issues. Both parties then sign a contract or agreement.

When NDOT is ready for the consultant to begin work, the Construction Division authorizes the consultant to proceed. The Construction Division Administrative Engineer administers and manages the consultant agreement. If the consultant's assignment is to provide full administrative services, the District Engineer directs the consultant's work. If the assignment is to augment an NDOT Resident Engineer, the Resident Engineer directs the consultant's work. Regardless of the specific assignment or the party directing the work, the Construction Division approves all consultant invoices for payment.

3-201 PLANNING AND DESIGN PHASE

During the planning and design phases of a project, the Construction Division principally serves as a technical advisor on construction-related matters. Involvement of the Construction Division representative is in response to the NDOT project manager. The level of involvement depends on the complexity, size, cost, and scope of the project. .

Because of the influence that construction means and methods may have on a project, the design project manager solicits input from the Construction Division. Construction methods can affect the design and the manner in which the project is constructed. Construction methods can influence material selection, staging and phasing, scheduling, and cost. Because of this influence, designers must consider constructability from the beginning of the design phase.

Most projects undergo a constructability evaluation. Consultants may perform constructability evaluations on major projects, with oversight from the Construction Division Constructability Section. The findings or recommendations of the constructability evaluation are incorporated into the plans and specifications. The constructability evaluation also provides the foundation for the Construction Division to determine the working days for the project. When the design is substantially complete, the design project manager coordinates with the Construction Division to finalize the plans and specifications.

The working days establish the length of time that a contractor has to complete construction of a project. The Construction Division also specifies the amount of liquidated damages, incentives, and disincentives to be included in the specifications. Liquidated damages are assessed when a contractor's operations delay a project's completion. Liquidated damages are a financial estimate of the administrative costs incurred by the Department because of the delay. Liquidated damages are not a penalty. Incentives and disincentives are financial estimates of costs to the traveling public.

During the design and planning phases of a project, the Construction Division and District Engineer support the development of the traffic control plan. The Construction Division, in consultation with the District Engineer, assists with developing the traffic control plan based on the anticipated sequence of construction operations that a contractor would likely use. In addition to controlling traffic, NDOT may limit or control the contractor's operations. The Construction Division limits the contractor's operations because of concerns for public health, safety, and convenience. The specifications describe the limitations placed on a contractor's construction operations. .

The Chief Construction Engineer collaborates with the District Engineer to prepare a staffing plan when enough project information is available. Depending on available NDOT staff, the project may be assigned to an NDOT Resident Engineer, an engineering consultant, or a combination of both.

When the design is complete, NDOT advertises the project to solicit bids. On complex projects, NDOT holds Pre-Bid Conferences with prospective bidders. During the Pre-Bid Conference, NDOT representatives describe project details, and prospective bidders may ask questions to clarify understanding of the project. Bidder attendance at Pre-Bid Conferences may be mandatory to ensure that all bidders have equal access to information needed to prepare bids. The Bid Review and Analysis Team, which includes representatives from the Construction Division, analyzes the submitted bids to determine conformance with specifications. If the Bid Review and Analysis Team finds no irregularities, the Team recommends award of the project. NDOT then awards the project to the lowest responsible and responsive bidder.

The project then passes from the design project manager to the Resident Engineer. The project manager remains involved as a resource for design related issues. The project manager leads public outreach efforts, and monitors compliance with environmental, design, and right-of-way commitments.

3-202 CONSTRUCTION PHASE

After the project is assigned to the Resident Engineer, the Construction Division provides technical and administrative support to the Resident Engineer. The support includes answering questions and resolving issues regarding administration, quality assurance, constructability, and labor compliance. To establish and maintain a clear and consistent statewide construction program, the Construction Division has developed this *Construction Manual*.

This *Construction Manual* communicates the policies of the Construction Division and presents guidance to field personnel. The Chief Construction Engineer is responsible for maintaining a current *Construction Manual*. To maintain a current manual, the Chief Construction Engineer periodically issues updates. Updates will contain the revision date on each revised page. Users of the manual may request a revision to the manual by forwarding a written request to the Chief Construction Engineer. The Chief Construction Engineer will review the request and take appropriate action. Between manual updates, the Chief Construction Engineer may issue interim Construction Division policy memorandums that would be incorporated into the next manual update.

For projects with federal funding, the FHWA is available to provide support to the Construction Division. The role FHWA plays on a project may vary depending on the type, scope, and complexity of the project. However, for all federally funded projects, Title 23 of the United States Code of Federal Regulations (23CFR) governs and guides FHWA.

3-202.1 ADMINISTRATION

On a construction project, the Resident Engineer administers the project using Construction Division procedures. These procedures are uniform for each project throughout the state. The Construction Division Administration Section guides and serves as a resource for the Resident Engineer in setting up the administrative processes for records, inspection reports, testing reports, contract pay items, forms, correspondence, and other documentation for each project. Examples of these processes include the organization of the filing system, contractor payments, standard forms for contract change orders, typical letters to the contractor, and formats and organization of field books, most of which is addressed in the *Documentation Manual*. The Administration Section is available to the Resident Engineer to respond to questions relating to contract administration. .

In addition to supporting the Resident Engineer's general administrative functions, the Administration Section plays an active role in processing contract change orders and contractor pay requests. A contract change order is a process in which NDOT and the contractor agree on a change in the scope of the project, such as character of the work, payment, or schedule. Following action by the Resident Engineer and District Engineer, the Administration Section processes the contract change order within the headquarters and FHWA.

The change order processing includes a review to ensure that all required elements of a change order are present, such as description of the change, method of measurement and payment, and analysis of costs. The Administration Section ensures that the necessary divisions review the change order. On projects that receive federal funds, the Administration Section provides the Chief Construction Engineer with guidance on whether the proposed contract change orders may be eligible for federal funding. The Chief Construction Engineer can recommend projects for federal funding participation to the FHWA; however, the FHWA makes the final determination on federal funding eligibility. The Assistant Construction Engineer coordinates with the FHWA regarding technical details of a change order. Additionally, if other funding sources are involved, approval of the change may require approval from the funding sources.

Based on the processing completed by the Administration Section, the Chief Construction Engineer transmits the change order to the Director's office for approval. The Director can delegate the authority to execute change orders to the Assistant Director of Operations. If the Assistant Director of Operations is not available, the Assistant Director of Engineering has authority to execute change orders. Only with the Director's approval is the construction contract modified in accordance with the change order. Section 3-403 gives guidance on change orders and other modifications to the construction contract.

As the project progresses, the Resident Engineer prepares progress payments for acceptable work completed by the contractor and for materials that the contractor incorporated into the work. The Resident Engineer prepares progress payments every two weeks and submits them electronically to the Administration Section. The progress payments are based on quantities documented by NDOT inspectors. The Administration Section reviews the quantities submitted by the Resident Engineer and forwards the progress payment request to NDOT's Accounting Division for payment.

During construction, the Administration Section may periodically review the documentation and record-keeping on a project. The purpose of the review is to assist the Resident Engineer in maintaining complete and consistent records. At the end of a project, a representative of the Administration Section will visit the field office to complete a final audit and collect the project records. The records are then delivered to NDOT's Administrative Services Division Central Records Section for storage.

3-202.2 QUALITY ASSURANCE

One of the principal functions of the Construction Division Quality Assurance Section is to provide technical support to the Resident Engineer, inspectors, and testers. The technical support relates to construction materials and construction techniques utilized by the contractor to complete the work. The Quality Assurance Section also provides technical support by providing specialized classes to train personnel and to establish competency and maintain uniformity among inspection and testing personnel. Additionally, the Quality Assurance Section is available to respond to informal questions or to provide on-the-job training. If a Resident Engineer is unfamiliar with a material or technique, the Quality Assurance Section is available to provide guidance on inspection and testing requirements.

Because specifications cannot address every situation that occurs during a construction project, the Resident Engineer must exercise judgment when interpreting specifications. Statewide, Resident Engineers may treat similar situations differently. The Quality Assurance Section provides guidance to Resident Engineers in interpreting specifications to maintain uniformity in enforcing the specifications.

The Quality Assurance Section performs periodic inspection audits. The audits provide an independent verification that the Resident Engineer is performing a thorough inspection of the contractor's operations. If opportunities exist to improve the inspection efforts or the quality of finished products, the Quality Assurance Section offers guidance and support.

The Quality Assurance Section directs the Independent Assurance testing program. Section 5-600 of the *Construction Manual* describes the Independent Assurance program. Generally, the Independent Assurance program verifies how tests are performed in the field by monitoring and auditing tests, and by conducting parallel tests on materials incorporated into a project. The Independent Assurance testers are located in each District office and are under the direct supervision of the Quality Assurance Section.

An important element of the field-testing program is the use of nuclear density testing equipment. Federal law requires a single individual be accountable for ensuring compliance with safety regulations. This individual is designated as the Corporate Radiation Safety Officer. Refer to Section 5-500, Nuclear Testing Program, of this *Construction Manual*.

3-202.3 CONSTRUCTABILITY

The Construction Division Constructability Section provides input in developing construction documents. Construction documents must be adequate for contractors to prepare reasonable bids and to construct the project. The Constructability Section provides guidance during the design process on issues relating to specifications, construction details, plan interpretation, payment methods, and traffic control. Additionally, the Constructability Section provides assistance during construction on issues relating to design, scheduling, and traffic control. The Constructability Section provides support in researching claims. If a dispute is not resolved at the initial stage and escalates to a construction claim, the Constructability Section provides support in defending or otherwise resolving the claim.

The Constructability Section assists the Resident Engineer during the review and approval process of the contractor's schedule. As construction progresses, the contractor must submit updated schedules that revise or modify the sequence and timing of construction operations. The Constructability Section is available to assist the Resident Engineer in assessing the impacts of the schedule changes, including the contractor's resources to meet schedule requirements of the specifications.

A project is typically designed with a sequence of operations and a traffic control plan that allows that sequence of operations. If a contractor proposes to construct the project differently from the design, the Constructability Section may support the Resident Engineer in reviewing the contractor's proposed traffic control plan and sequence of operations. If the contractor proposes revisions to the traffic control plan, the Constructability Section can assist in evaluating impacts and possible delays caused by the proposed revisions.

When the construction phase is complete, the project may be evaluated in a post-construction review to identify opportunities for improvement on future projects. The Constructability Section coordinates post-construction reviews, as described in Section 3-409, Post-Construction Review.

3-202.4 CONTRACT COMPLIANCE

The Construction Division Contract Compliance Section provides guidance and support in determining a contractor's compliance with the following:

- Conforming to legal, contractual, and regulatory requirements regarding subcontractors
- Paying prevailing wage rates, including appropriate overtime rates, to the contractor and subcontractors
- Providing proper documentation of payments to subcontractors and ensuring the subcontractors are paid promptly in accordance with state and federal laws
- Providing NDOT with proper documentation of contractor and subcontractor Equal Employment Opportunity and employment practices

Because NDOT is required to monitor contracts to ensure compliance with wage and labor regulations, the Contract Compliance Section provides guidance to field personnel. Principal programs in which the Contract Compliance Section provides support are as follows:

- Contractor/Subcontractor Requirements – Ensuring that the contractor performs a majority of the work (51 percent or more), and that proper approvals are obtained for subletting work to subcontractors
- Employee Wage Requirements – Ensuring that the contractor and all subcontractors pay employees at least minimum wage rates established by the contract documents
- Equal Employment Opportunity Requirements – Ensuring that the contractor and subcontractors report required Equal Employment Opportunity and Affirmative Action information
- Disadvantaged Business Enterprise Program – Ensuring contractors follow the Disadvantaged Business Enterprise program rules and regulations
- Title VI of the Civil Rights Act – Ensuring that discrimination does not occur on the basis of race, color, or national origin in programs or activities receiving federal financial assistance

For each of the areas listed, the contractor must complete required federal and state forms, which the Resident Engineer reviews and verifies. The Contract Compliance Section assists the Resident Engineer in the verification process.

3-300 DISTRICT

The District Engineers are the principal administrators for the operations of NDOT. While many of the NDOT divisions in headquarters support the mission of the Department, the Districts implement the mission. The majority of each District's work deals with construction and maintenance of the state's transportation facilities.

With specific regard to construction functions, the District Engineer becomes involved when a project first becomes a concept. Because the District Engineer has an intimate knowledge of the roadways in the District and because of relationships with community leaders within the District, a District Engineer may initiate a project. Once a project is approved as a concept, it then moves into the planning and design phase.

3-301 PLANNING AND DESIGN PHASE

As the project moves through the planning and design phase, the design project manager maintains the leadership role. Several Divisions provide continuing input. The District Engineer's role is important in bringing an understanding of the project locality and of the community. This understanding and knowledge may include construction materials, historical maintenance, drainage and safety issues, and public concerns about the project. The District Engineer may assign a Resident Engineer to provide a local perspective.

At every stage of the design phase, the District personnel provide input. The District personnel are the primary resources for information on local factors that influence the project, such as the following:

- Drainage
- Safety
- Existing structural section
- Maintenance issues
- Traffic patterns
- Community concerns
- Special events during construction
- Localized weather patterns
- Short term local traffic impacts

The District Engineer provides information continuously during the project design and at several key milestones. The preliminary and intermediate design reviews are two important milestones during which the District Engineer provides input. The District Engineer's input is reflected in the plans and, more importantly, in the specifications. When the plans and specifications are substantially complete (typically at 90 percent), the District Engineer thoroughly reviews the project documents to ensure that local conditions are incorporated.

After review and comment by the District Engineer, the project documents are then finalized and the project is advertised to solicit bids. When the project is advertised for bids, the Resident Engineer typically receives the plans and specifications. If the Resident Engineer finds an issue of significant concern, the Resident Engineer notifies the Chief Construction Engineer for input and, if necessary, the Chief Construction Engineer requests a supplemental notice to the contract documents.

3-302 CONSTRUCTION PHASE

As a project enters the construction phase, the District Engineer becomes responsible for the successful completion of the project. An Assistant District Engineer commonly acts on behalf of the District Engineer on construction matters. The District Engineer's field representative to administer the project is the Resident Engineer. The District Engineer ensures that the Resident Engineer has sufficient staff, equipment, and supplies to administer the project in accordance with NDOT policies and procedures.

The District Engineer conducts periodic reviews during project construction. During the reviews, the District Engineer is a valuable asset by bringing a perspective that may be broader than that of the Resident Engineer. Typically, a District Engineer reviews safety considerations, inspection operations, materials testing, and traffic control. In addition to on-site reviews, the District Engineer reviews project records and documentation to monitor the progress and quality of the work.

For clarification regarding technical issues, the Resident Engineer confers with the Construction Division or other appropriate divisions. When interpretation of the plans and specifications escalates and becomes an issue, the Resident Engineer confers with the District Engineer to determine the appropriate action or decision. If the Resident Engineer's interpretation differs from that of the contractor, the Resident Engineer and contractor work to resolve the issue. If the Resident Engineer and contractor cannot resolve the issue, the District Engineer analyzes the situation and attempts to resolve the issue. If the issue is not successfully resolved, the District Engineer will confer with the Construction Division for evaluation and resolution. The contractor may initiate a formal claim at any time.

Disputes may be resolved with a change order that modifies the scope or character of the work, schedule, payment, or other element of the contract. Although every change order requires the approval of the Director, in certain situations, the District Engineer may authorize the contractor to proceed with work before the Director signs the change order. This authorization, or approval, is called a "prior approval." The prior approval must be in writing on NDOT form 040-002, "Record of District Engineer's Authorization to Proceed with Contract Revision," and signed by the District Engineer before the contractor starts work. Levels of authority are discussed in Section 3-403.5.

A Letter of Authorization, change order, or supplemental agreement can modify the contract documents. Section 3-403.5 describes Letters of Authorization, change orders, and supplemental agreements. The District Engineer has commitment authority to make contract changes using a prior approval. Although the District Engineer has commitment authority, it is limited as described in Section 3-403.5.

For prior approvals on changes outside of the District Engineer's authority, the Resident Engineer sends the request to the Construction Division. The Construction Division will prepare a prior approval for the Director's approval.

After construction operations are complete, the District Engineer performs a final field review. If the District Engineer determines that the project has been constructed in accordance with the project plans and specifications, the District Engineer will accept the project for maintenance. This acceptance is not to be confused with final acceptance. Only the Director is authorized to make the final acceptance. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a District Engineer's relief of maintenance letter that is sent to the contractor.

3-400 FIELD

As NDOT's principal field representative, the Resident Engineer administers the construction project, ensuring the contractor completes the project as detailed in the plans and specifications. Directly supervised by the District Engineer, the Resident Engineer supervises an Assistant Resident Engineer, survey crew, inspectors, testers, and office personnel.

The Resident Engineer is also responsible for the professional development of the crew. Developing a technically proficient crew includes formalized training, on-the-job training, and mentoring. The Resident Engineer is responsible for maintaining each crew member's training records. A training matrix is available that shows recommended training for positions assigned to a field crew. To access the training matrix, refer to the following NDOT intranet site (SharePoint), http://trainsrv/Forms/defaultforms.asp. For other human resource forms, refer to the Human Resources Division intranet site (SharePoint), http://sharepoint1/077/default.aspx.

The Resident Engineer and field crew, supported by the Design Division and other NDOT divisions, oversee the contractor's construction of the project. Oversight requires knowledge of materials, construction techniques, safety, environmental practices, traffic control, right-of-way matters, and labor laws and regulations.

3-401 FIELD PERSONNEL

Initial staffing discussions take place between the District Engineer and the Chief Construction Engineer. Based on resource and staffing needs and availability, the District Engineer and Chief Construction Engineer determine if sufficient NDOT personnel are available or if an engineering consultant is required. If the project is staffed with an NDOT Resident Engineer, the Resident Engineer and District Engineer confer on the unique technical aspects of the project, complexity of the project, duration, and availability of NDOT personnel. NDOT personnel, engineering consultants, or a combination of both can administer the project.

3-401.1 CREW ORGANIZATION

Certain functions and tasks of administering a construction project are common to all NDOT projects. The basic organization of a field crew accomplishes these functions and tasks. The number of personnel may increase based on the size and type of the project, but the basic organization remains constant. A typical field crew is comprised of approximately 12 people, as follows:

1 – Resident Engineer

1 – Assistant Resident Engineer

1 – Office person

1 – Survey crew chief

8 – Inspectors, testers, and surveyor crew

While a typical field crew may consist of 12 people, the variety of project sizes and types requires flexibility in staffing within a crew and among crews within the District. As the Construction Division assigns projects to the Resident Engineer, project-staffing needs may require the District Engineer, in consultation with the district Resident Engineers, to optimize the allocation of staff by temporarily transferring personnel from one Resident Engineer to another. The District Engineer transfers staff to ensure sufficient contractor oversight or to provide technical expertise during certain construction activities.

Often, the Construction Division assigns several projects to a Resident Engineer, requiring crew members to work on multiple projects. Typically, a Resident Engineer assigns each inspector to a specific project. The remaining staff, testers, survey crew, and office staff, may work on several projects. Again, the Resident Engineer's crew size depends on the size, type, and number of projects administered by the Resident Engineer.

3-401.2 USE OF CONSULTANTS

The Construction Division, District Engineer, and Resident Engineer determine the most appropriate way to fulfill staffing needs. If the staffing need is fulfilled with a consultant, the consultant will provide support staff to work directly for an NDOT Resident Engineer (construction engineering-augmentation), or will provide a field crew consisting of a Resident Engineer and field staff (construction engineering-full administration).

If a consultant is retained to administer a construction project, the Construction Division retains the consulting firm, including negotiation and execution of a consulting agreement. The administration, oversight, and supervision of the consultant depend on the role that the consultant is fulfilling.

When NDOT retains a consultant to support NDOT's construction program, the consultants are agents of NDOT and perform the same tasks as NDOT crews. The consultant uses knowledge and experience to perform duties, as though an NDOT employee. The difference between an NDOT employee and a consultant is NDOT may terminate a consultant at any time, with or without a reason.

3-401.2.1 AUGMENTATION

Augmentation of NDOT construction crews includes providing individuals to perform construction inspection, testing, surveying, and contract documentation for projects administered by the NDOT Resident Engineer. The consultant's role may range from supplying one tester, including all required testing equipment and vehicles to perform assigned duties, to supplying several testers, inspectors, office personnel, and survey crew. Consultants may also provide people with specialized expertise, such as scheduling, fabrication inspection, and structural construction techniques.

When an NDOT crew retains a consultant to augment a project, the Resident Engineer directs the consultant's work activities. The Resident Engineer administers and monitors the consultant's performance, consistent with the terms of the consultant agreement. The Resident Engineer must also review the competency of individuals proposed by the consultant to work on the project. Regarding individuals that the consulting firm proposes to assign to the project, the Resident Engineer has the authority to accept or reject an individual, or to reassign an individual's duties. The Resident Engineer also has authority to remove an individual assigned to the project.

3-401.2.2 FULL ADMINISTRATION

Full administration consists of providing a Resident Engineer (a professional engineer licensed to practice in Nevada), an Assistant Resident Engineer, and a sufficient number of individuals to perform inspection, testing, surveying, and contract documentation. A consultant administers an NDOT project in the same manner as an NDOT field crew. The consultant provides sufficient staff possessing experience, knowledge, and character to perform the duties adequately and meet the agreement requirements. The consultant also provides the field office, equipment, vehicles, and supplies necessary to administer the project.

Under a full administration assignment, the District Engineer and Chief Construction Engineer review the competency of individuals proposed by the consultant to work on the project. The consultant's staff must possess knowledge and experience to monitor the various activities of the construction project. Individuals proposed by the consultant must become familiar with NDOT policies, procedures, and standard practices.

The consultant's administration of the field office must comply with NDOT's *Construction Manual* and *Documentation Manual*. Additionally, field personnel, including inspectors, testers, and survey crew, must perform duties in accordance with NDOT documentation procedures.

An NDOT Resident Engineer or Assistant District Engineer monitors the consultant Resident Engineer and serves as a resource for the consultant, providing guidance and assistance with NDOT standard practices and procedures. For issues relating to the administration of the construction project, the consultant Resident Engineer commonly confers with the Assistant District Engineer.

Unlike NDOT Resident Engineers, consultant Resident Engineers do not have access to NDOT's financial computer system to process contractor progress payments. Therefore, consultant Resident Engineers prepare a contractor pay request and transmit this information to the NDOT Resident Engineer for input into the NDOT financial system. Additionally, consultant Resident Engineers do not have authority to make financial commitments on behalf of the Department, nor may the consultant use Department letterhead.

3-401.2.3 INVOICE PROCESSING

Consultants submit invoices to NDOT for payment. On augmentation projects, the consultant sends the original invoice with supporting documentation to the Resident Engineer. On full administration projects, the consultant sends the original invoice with supporting documentation to the District Engineer or the District Engineer's designee. The consultant also sends a copy to the Administrative Services Division. The Administrative Services Division logs the date of receipt and forwards the invoice to the Construction Division.

The Resident Engineer or Assistant District Engineer reviews the invoice for accuracy and consistency with the consultant agreement. In reviewing the consultant's original invoice, the following items must be included:

- A summary sheet for the invoice
- A detailed breakdown of costs
  - Labor (positions, hours, and agreed rates)
  - Overtime (dollars and hours)
  - Overhead and fixed fee, or direct rates
  - Direct expenses (listed by category)
  - If the consultant is working on more than one project, the detailed breakdown must be provided separately for each project
- For agreed price items, the line item must include the quantity of items being invoiced this period, the price per item, and the total dollars
- For invoiced items, supporting documentation must be provided, such as a copy of the invoice, subconsultant invoice, or receipt
- The consultant's original signature

After reviewing the invoice, the Resident Engineer has three options: (1) recommend payment, (2) recommend payment with exceptions that the consultant is directed to correct with the next invoice, and (3) return the invoice to the consultant to be revised and resubmitted. If the Resident Engineer does not return the invoice to the consultant, the signed and approved invoice is sent to the Construction Division with payment recommendation. If the invoice is returned to the consultant, the Resident Engineer notifies the Construction Division of the invoice status.

If the Resident Engineer's review finds no problems, the Resident Engineer signs the consultant's invoice with blue ink to approve the invoice and submits the invoice to the Construction Division. If the Resident Engineer's review identifies errors, three options are available. For minor errors, the Resident Engineer may contact the consultant for an explanation or correction of the errors. Secondly, the Resident Engineer can document the error, notify the consultant, and have the consultant make the correction on the next invoice. The third option is to return the invoice to the consultant for correction and resubmission. If the Resident Engineer addresses errors in the consultant invoice, the Resident Engineer must notify the Construction Division of the error on the invoice and the manner in which it is being corrected.

The relationship between NDOT and a consultant is a professional relationship that has ethical and legal obligations. Consultants provide professional services in good faith, and in return, NDOT must not delay the processing or payment of consultant invoices. State law also places strict time constraints on NDOT to process payments to consultants. The consultant agreement also contains time constraints on payment of the invoice. If NDOT does not pay invoices within prescribed time constraints, NDOT may incur monetary penalties. Therefore, they should make every effort to process invoices in a timely manner.

3-402 FIELD OFFICE

The Resident Engineer's office is commonly referred to as a field office. The project records are maintained in the field office. Also maintained in the field office are copies of personnel records for the personnel assigned to the Resident Engineer.

After the project is assigned to the Resident Engineer, the Resident Engineer begins preparing project records. The Resident Engineer also begins reviewing the plans, specifications, and special provisions, which are specifications unique to the project. When the design process begins, the Chief Construction Engineer, with input from the District Engineer, assigns a Resident Engineer. The Resident Engineer's input during design improves the quality of the plans and specifications. During the review, the Resident Engineer may see opportunities to improve the project or correct problems. Initiating communications with the Design Division establishes a positive relationship for the duration of the project.

In reviewing the plans and specifications, the Resident Engineer should look for items that may delay construction, create disputes during construction, or significantly affect traffic. Examples of such items are constructability issues, insufficient information to construct, conflicting information, and traffic control deficiencies.

3-402.1 PROJECT RECORDS

For every NDOT construction project, records are organized in accordance with the Construction Division *Documentation Manual* and related policies and procedures. These policies and procedures provide uniform organization in each field office throughout the state, ensuring that records organization is familiar to construction staff working in different field offices. Standard processes and procedures protect NDOT from legal disputes, claims, or other actions related to NDOT projects.

Records organization includes a filing system for documents such as correspondence and submittals. Records also include field books, which are organized in a consistent manner. Field books document three principal activities or functions: (1) quantities incorporated into the project, (2) survey information, and (3) materials test log. Field books are permanent project records. Do not use loose-leaf books for permanent records, except as provided for in the Construction Division *Documentation Manual*. The project field office also maintains daily diaries and inspector reports.

The Construction Division *Documentation Manual* describes the organization of the project records. The Construction Division Administration Section can provide additional guidance.

3-402.2 AGREEMENT ESTIMATE BREAKOUTS

Every project requires preparation of a "Preliminary Agreement Estimate," which is an estimate of the construction cost. This estimate allows proper budgeting for the project. Several sources may fund a project. The most common funding sources are the State Highway Fund and the Federal Highway Fund. Examples of other funding sources are city and county governments and private parties, such as utility companies and land developers.

When a project is funded from sources other than the state or federal government, NDOT prepares an agreement with the third party. The agreement identifies the scope, location, and estimated costs of the improvements. The improvements funded by the third party may be all or only a portion of the entire construction project. Likewise, federal funds may only apply to certain items in the project depending on the funding source. For example, funding for bridges apply only to a bridge or several bridges on a project. The estimated cost of these improvements is listed in a document referred to as an "Agreement Estimate Breakout."

During the project startup phase, the Resident Engineer receives a copy of the Agreement Estimate Breakout, which lists the following information:

- Unique Agreement Estimate Breakout number for each funding source
- Beginning and ending stations of the work for each funding source
- Bid item number
- Bid item description
- Bid item quantity
- Total cost of the work

Because the Resident Engineer must monitor the work and costs within a project and because a project may have multiple funding sources, field books are organized by bid items, accounting for different Agreement Estimate Breakouts. The field books provide the documentation for payment from the funding source. Because project funding is based on actual construction costs for specific breakouts, it is important to assign quantities accurately and costs to the appropriate breakout. Additionally, because a breakout may be associated with an agreement between NDOT and other parties, changes to the work within a breakout must be coordinated with the Construction Division. Even apparent minor changes may cause significant impacts to the project funding.

3-402.3 PRELIMINARY SURVEYING

Several survey tasks can be completed using information contained in preliminary plans, and to reduce possible delays, surveyors should complete as much work as possible before the contractor begins work. Once the contractor begins work on the project, surveying should be completed in a timely manner. Refer to Section 4-303 of this *Construction Manual* for additional information.

3-402.4 CONTRACTOR SUBMITTALS

Once a project is awarded, the Administrative Services Division sends a letter, called a Notice to Proceed, to the contractor stating the date to begin construction. The Resident Engineer also receives a copy of the Notice to Proceed. With receipt of the Notice to Proceed, the Resident Engineer schedules the pre-construction meeting, commonly called a Pre-Construction Conference.

Before the Pre-Construction Conference, the specifications require the contractor to submit various documents, such as the following:

- Preliminary progress schedule
- Initial traffic control plans
- Erosion control and river diversion plans
- Pollution control plans
- Safety plans
- Environmental and other permits
- Name and qualifications of contractor's traffic control supervisor
- Names, and certification and qualification numbers of contractor testing personnel
- Contractor representatives that have signatory authority

The Resident Engineer should review the specifications to determine job-specific required submittals.

3-402.5 PROJECT PROGRESS SCHEDULE

A project schedule is a planning tool used to document, measure, and monitor a contractor's progress in completing the project on time. The project schedule identifies activities, durations, logic ties between activities and the critical path. Critical path is the consecutive sequence of activities in a project whose cumulative time requirements determine the minimum total project time. Delay in critical path activities will delay the entire project if other steps are not compressed.

The first schedule that the contractor must submit to the Resident Engineer for approval is the Preliminary Progress Schedule. The specifications require the contractor to submit the schedule to the Resident Engineer at least seven days before the Pre-Construction Conference. The Preliminary Progress Schedule must identify the activities for the first 30 working days of the project. The purpose of the Preliminary Progress Schedule is to describe the sequence of the contractor's activities to complete the project within the specified time. The specifications describe requirements for Preliminary Progress Schedules. Because of the diversity of projects and complexity of schedules, the specifications must be thoroughly reviewed to determine schedule requirements. Copies of all progress schedules must be submitted to the Construction Division.

After the Preliminary Progress Schedule has been accepted by the Resident Engineer, the specifications require the contractor to provide the Progress Schedule that represents all working days with the activities required to complete the project. This progress schedule is the baseline schedule and provides the basis to monitor the contractor's progress and performance throughout the project. This schedule also serves as an analytical tool for evaluating delays, identifying potential claims, and preparing recovery options. The specifications describe requirements for progress schedules.

The Resident Engineer saves, or archives, the progress schedule in electronic format and places a paper copy in the project files. Consult with the Construction Division to determine if a copy of the electronic format should be forwarded to the Construction Division prior to acceptance. Monitor the contractor's ongoing performance as compared to the progress schedule. Critical activities, as identified in the Progress Schedule, should continually be cross-referenced to the actual work being performed.

On projects that are over 120 working days in duration, monthly updates to the progress schedule are required. The specifications describe the requirements for the monthly updates. If the contractor fails to submit an updated schedule as required by the specifications, the Resident Engineer may withhold all or a portion of a progress payment. Before withholding a contractor progress payment, the Resident Engineer must notify the contractor in writing. If the project is determined to be behind schedule, the contractor must submit a Supplemental Progress Schedule as described in the specifications.

A schedule that is developed by the contractor with NDOT input is a more effective planning tool. While developing a schedule through collaboration is beneficial, the Resident Engineer is cautioned not to direct the contractor on how the contractor should schedule the work.

The following items should be discussed with the contractor as they relate to the progress schedule submittal requirements:

- Project complexity
- Critical activities applicable to the completion of the project
- Schedules for all participating organizations
- Durations of physical work
- Limitations
- Project duration

The following are guidelines in reviewing the required schedules:

- Preliminary Progress Schedule
  - Format is established
  - Notice to proceed is identified
  - Material order and delivery information may be identified
  - Submittal timelines are provided
  - Minimum of the First 30 working days of activities are identified and durations are provided
  - All logic ties are identified with predecessor and successor
  - Working days are clearly represented
- Progress Schedule
  - The schedule includes all items necessary to complete the project and they are identified clearly
  - Submittal, procurement, fabrication and delivery timelines each carry their own identification and meet all limitations
  - Mobilization is included as an activity
  - All durations for activities appear reasonable
  - Logic ties are complete and in order
  - Calendars have been defined and applied to meet limitations
  - Schedule completes all required activities within the provided working days
  - Schedule meets all required limitations
  - Artificial limitations or constraints are included in the schedule that may alter the critical path
  - Critical path is easily identified and includes all activity descriptions, durations, and logic for the correct progression of work
  - Identify those activities that are near the critical path to prepare for possible delays
  - Schedule provides correct flow of work activities
  - All concurrent work is achievable
  - Schedule does not have excessive amount of work concurrently

NOTE: Projects with accepted progress schedules showing the completion of the project prior to the contract working days will be subject to change order reducing the contract working days to match the progress schedule.

- Monthly Updates
  - Schedule matches the actual work being done
  - Schedule reflects all delays and critical path has been adjusted
  - Schedule meets all limitations
  - Is a supplemental schedule required

3-402.6 PRE-CONSTRUCTION CONFERENCE

The conference establishes a mutual understanding of project requirements, provides a forum to discuss key elements of the project, and identifies key project personnel. The Resident Engineer coordinates with the Assistant Construction Engineer to schedule the Pre-Construction Conference. The Assistant Construction Engineer typically invites headquarters divisions and the FHWA, as appropriate for the project. The Resident Engineer invites the contractor and local stakeholders, such as representatives from other state agencies, local governments, utility companies, or other concerned parties.

The Assistant Construction Engineer designates a moderator to conduct the Pre-Construction Conference. The Assistant Construction Engineer may serve as the moderator or may designate the District Engineer, Assistant District Engineer, or the Resident Engineer to be moderator. The Resident Engineer arranges the meeting location, ensuring that sufficient space is provided for all attendees to take part in the discussion. The Resident Engineer prepares the agenda and distributes it to attendees. During the Pre-Construction Conference, the moderator completes the necessary information required on the agenda. The completed agenda is submitted to the Construction Division. The Construction Division Contract Compliance Section representative records the entire meeting and makes complete audio copies available to participating parties. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a standard Pre-Construction Conference agenda.

Because the Resident Engineer is in charge of the project, the contractor will likely ask the Resident Engineer specific project-related questions. If the Resident Engineer can not provide an immediate answer and requires additional time to research, it is appropriate to tell the contractor that research is required and that a written response will be forthcoming. A written response provides a record that supplements the recording of the meeting.

Discussions at the Pre-Construction Conference relate mostly to the project's construction details and compliance with labor laws and regulations. The Construction Division Contract Compliance Section provides the contractor with a subcontractor packet shortly after the project is awarded. The following section describes Contract Compliance requirements before construction.

3-402.7 CONTRACT COMPLIANCE

At the project level, the Resident Engineer monitors the contractor's compliance with FHWA and NDOT labor laws and regulations. Section 108 of the specifications lists contractor requirements. The specifications for a specific project also contain FHWA and NDOT contract compliance requirements. The Resident Engineer should be familiar with the labor compliance requirements for the project.

After NDOT awards the contract, the Construction Division Contract Compliance Section, sends the contractor an information packet. This packet contains information on payroll requirements, subcontracts, labor law and regulation compliance provisions, and state and federal notices for posting. The Resident Engineer also receives a copy of the information packet, without the required postings.

The contractor must place the required postings on the jobsite in a place easily accessible to all workers, including those of subcontractors. The contractor typically posts the information on a bulletin board erected on the jobsite. Some projects, such as signal systems, preclude the erection of a bulletin board because of limited space on the jobsite. In these cases, the information may be posted at the contractor's local office.

The contractor must complete NDOT form 052-023, "Request to Sublet," and submit it to the Resident Engineer for all first, second, and third tier subcontractors on the project. Before sending the form to the Contract Compliance Section, the Resident Engineer verifies the following items:

- Correct bid item number
- Quantities listed reflect bid plan quantities (Exceptions are allowed for partial performance of a bid item, expressed as a percentage of the work)
- Item description
- Unit price, which must reflect contractor's unit bid price
- Total dollar amount to be subcontracted

Until authorized and approved by NDOT, subcontractors are not allowed to perform work on the project. Occasionally, a contractor needs the services of a company for a small item of work or for work not specifically related to a particular contract bid item, such as miscellaneous asphalt saw cutting, pavement profile grinding, and street sweeping services. In this situation, the contractor submits NDOT form 052-061, "Request to Utilize Service Provider."

After approval of the Request to Sublet, the Contract Compliance Section sends the Resident Engineer copies of the approval. The Resident Engineer then forwards the approval to the contractor and reminds the contractor to submit two copies of all subcontract agreements for Contract Compliance Section review. The Resident Engineer reviews the subcontract agreements to make sure the subcontractor signed the form, "Inclusions of Contract Provisions in Subcontracts," and attached it to the subcontract agreement. Additionally, Disadvantaged Business Enterprise (DBE) subcontractors must show unit prices in the subcontract agreement.

3-403 PROJECT ADMINISTRATION

After the Pre-Construction Conference and after the Resident Engineer submits and accepts the required documents, the contractor begins work on the project. Preliminary surveying should allow the contractor sufficient information to begin various activities. Inspectors and testers should be prepared to monitor contractor operations, having coordinated with the contractor's staff.

During the life of the construction project, inspectors and testers observe and monitor the contractor's activities to verify that materials and techniques conform to the requirements of the plans and specifications. The Resident Engineer is responsible for forwarding test results to the contractor in a timely manner, typically as soon as the test results are complete but no later than 24 hours after the Resident Engineer receives the results. Every two weeks, the Resident Engineer prepares a contractor progress payment based on acceptable work completed during the preceding two weeks. The Construction Division processes the estimate and pays the contractor. This process occurs throughout the life of the project, and inspectors and testers play significant roles.

3-403.1 INSPECTION AND TESTING

As the principal NDOT representative at the project level, the Resident Engineer significantly influences the successful completion of the project. In addition to administering the project and supervising the NDOT field crew, the Resident Engineer oversees and directs project-wide issues. .

Communication is an important responsibility of the Resident Engineer, inspector, and tester. Not only is communication necessary among the Resident Engineer, inspector, and tester, but with the contractor. Sharing information is important to everyone involved with the project. Sharing information facilitates making and implementing effective decisions. Timely communication among project personnel can avoid delays and costs. For example, the Resident Engineer should communicate test results immediately to the contractor so that the contractor can make adjustments as necessary, reducing costly project delays and improving quality of the work.

Inspectors and testers are involved in every aspect of the contractor's activities. Inspectors monitor the construction techniques, means, and methods to verify the work conforms to the requirements of the specifications and that the work is completed with quality. Similarly, testers monitor the quality of materials incorporated into the work and make sure that the materials conform to the requirements of the specifications.

Inspectors and testers must have a thorough knowledge of the plans and specifications relating to the materials and activities being inspected. Additionally, Section 5, Sampling and Testing, and Section 6, Construction, of this *Construction Manual* provide guidance on most construction activities and materials encountered on NDOT construction projects. For field testers, an additional resource is the Independent Assurance testing staff assigned to work in the District. For insight and guidance, inspectors and testers can always consult the Resident Engineer, experienced coworkers, and the Construction Division Quality Assurance Section. In addition to resources relating to construction details, the Construction Division *Documentation Manual* provides information on proper documentation.

At the most basic level, inspectors do the following:

- Observe progress of work
- Check the quality of work performed
- Document work activities, observations, site visitors, and conversations

To carry out these tasks effectively, inspectors do the following:

- Communicate with the contractor's foremen on a regular basis
- Provide information on matters relating to line, grade, dimensions, test results, and quality of work
- Confer with the Resident Engineer regarding unsatisfactory work
- Communicate with the Resident Engineer on disagreements with contractor staff
- Document pay quantities in field books according to the NDOT *Documentation Manual*

Field testers working on NDOT projects must be qualified by the Nevada Alliance for Quality Transportation Construction (NAQTC), or Western Alliance for Quality Transportation Construction (WAQTC) and American Concrete Institute (ACI). Refer to Section 5-300, Tester Qualification Program, of this *Construction Manual* for additional information. Field testing on NDOT projects must conform with the *Synopsis of Materials Division Testing Manual for Field Testing* and with Table 5.1, "Minimum Required Samples and Tests – Project," in Section 5, Sampling and Testing, of this *Construction Manual*.

NDOT field testers must be NAQTC qualified. Consultants retained by NDOT to perform field testing must be either NAQTC, or WAQTC and ACI qualified. The contractor's testers performing quality control testing on NDOT projects, including testing of aggregate production, must have one of the following qualifications: NAQTC – Aggregate Module, or WAQTC – Aggregate Module and Embankment and Base Module. Contractor personnel sampling asphalt at the hotplant must have the following qualification: NAQTC Specialized Test, AASHTO T-40. Because each qualification program consists of multiple modules for various materials, a field tester must be qualified in the specific module for the material being tested.

Field testers check that the field lab and testing equipment are in acceptable operating condition. Refer to Sections 5-405.2, Field Laboratories and Testing Equipment, and 5-405.3, Equipment Repair, Maintenance, and Replacement, of this *Construction Manual*.

3-403.2 REQUESTS FOR INFORMATION

As questions arise about the plans or specifications, a contractor may submit a Request for Information (RFI) to obtain written clarification. When the contractor submits an RFI to the Resident Engineer, the Resident Engineer must respond as quickly as possible so that the project is not delayed. After the contractor submits an RFI, the Resident Engineer logs the RFI and either responds or coordinates a response from the appropriate party.

If the Design Division receives RFIs from contractors during the bidding phase, the Design Division provides all such RFIs and responses to the Resident Engineer. The Resident Engineer then has a complete record of all RFIs received on the project.

3-403.3 SUBMITTALS

The contractor is required to submit various forms, certificates, and other documents before and during the construction phase. The specifications describe these documents and the times when the contractor must submit them. Before construction begins, most submittals relate to labor regulations, permits, and schedules. Another required submittal may be a contractor traffic control plan. During construction, submittals relate to construction materials, details, and processes.

Maintaining traffic safely through a work zone is a goal of the Department. Policy 07-02 on Work Zone Safety and Mobility addresses roadway safety and mobility. On significant projects, traffic control plans are included in the plans and specifications. On other projects, the specifications require the contractor to prepare a traffic control plan and to submit the plan to the Resident Engineer for review and acceptance. For guidance on contractor traffic control plan submittals, refer to Section 6-624 of this *Construction Manual*.

On large or complex projects, logging and tracking submittals is critical to maintaining clear communications and reducing delays caused by incomplete records and documents. Many submittals are organized and managed using computer software. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a comprehensive list of submittals common to most NDOT projects.

3-403.3.1 MATERIALS

The quality of the project depends on the quality of the materials used. All materials are subject to the requirements of the project plans and specifications. Section 106 and Section 700 of the specifications describe material requirements. The project's special provisions address unique construction materials, techniques, or technologies. The specifications describe the methods used to determine a material's compliance with the specifications.

Aggregate material sources must undergo testing before the material is used on the project. The process of testing the material and determining the material's acceptability is called "Source Acceptance." Refer to Section 6-101, Aggregate Sources, of this *Construction Manual* for additional information on source acceptance.

During the project, there are three methods of determining material acceptance: (1) field testing, (2) sampling, and (3) Certificates of Compliance. Some materials may require more than one method of acceptance. The Materials Division sends the Resident Engineer a "Materials Sampling and Testing Checklist" and a "Certificate of Compliance" form. Although the Resident Engineer may forward copies of the form to the contractor, most manufacturers use their own certificate. The checklist describes the method of acceptance—required samples, tests and Certificates of Compliance—for material incorporated into the work. Although not all materials may be included in the checklist, all materials incorporated into the project must meet the requirements of the plans and specifications. An example of a "Materials Sampling and Testing Checklist" can be found at the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx.

3-403.3.1.1 MATERIAL SAFETY DATA SHEET

Before beginning work, the contractor must submit Material Safety Data Sheets (MSDS) for any hazardous material that will be used on the project. Contractors typically submit MSDS sheets before the pre-construction conference. The contractor must have MSDS sheets readily available on the jobsite, which is a required component of the contractor's safety plan.

3-403.3.1.2 MIX DESIGNS

NDOT projects incorporate several types of composition materials, such as plantmix bituminous pavement and portland cement concrete. These materials are combinations of other construction materials. The specifications describe the type and amount of the materials. The specific combination, or mix, of materials is called a "Mix Design." Three major products require an approved mix design before they are used on the project: Plantmix bituminous pavements, portland cement concrete pavement, and portland cement concrete. The mix design for each product and each component of the mixture must conform to requirements described in the specifications. The Resident Engineer must approve the components of a mixture before submitting the mix design to the Materials Division for review and approval.

3-403.3.1.2.1 Plantmix Bituminous Surface

The development of a plantmix bituminous mix design begins with the contractor submitting the component materials (aggregate and asphalt) to the Resident Engineer. The Resident Engineer verifies the asphalt is the type specified in the plans and specifications. The Resident Engineer's testers confirm that the aggregate sample is representative of the stockpiled material and that the aggregate conforms to the specification requirements. If the aggregate meets specifications, the aggregate and asphalt are sent to the Materials Division, with copies of the test results, for testing and mix design development. If the aggregate fails to meet specifications, the Resident Engineer immediately notifies the contractor.

The Materials Division tests the samples to verify compliance with the specifications, then designs a bituminous mixture using the contractor's requested aggregate proportioning. The Materials Division prepares several test mixtures and selects a mixture that complies with the specification requirements. The Materials Division sends the mix design to the Resident Engineer, who forwards the mix design to the contractor. If the mix design fails to meet specifications, the Materials Division notifies the Resident Engineer.

Because mix design specifications are broad, the Materials Division mix design represents one of many designs that could meet specifications using the aggregates supplied by the contractor. The broad range of values allowed by the specifications could result in variability in the mixture. Therefore, to obtain a uniform mixture, the contractor proposes a mixture based on the Material Division's mix design, but with single target values instead of ranges of values. Although the contractor establishes the target values, the specifications state the required range of operating tolerances for each target value. This mixture is called the "Job Mix Formula."

The contractor submits a proposed Job Mix Formula to the Resident Engineer. The Resident Engineer reviews the contractor's Job Mix Formula, makes any necessary changes, and then establishes the approved Job Mix Formula that the contractor will use on the project. An example of a Resident Engineer's Job Mix Formula letter to the contractor can be found at the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx. Instead of requesting a new plantmix bituminous mix design, a contractor may request to use a mix design developed by the Materials Division within the last year. The Resident Engineer verifies that the mix design is not older than one year. The contractor's request to use a previous mix design requires approval of the Materials Division. For additional information, refer to Section 6-400, Surface Treatments and Pavements, of this *Construction Manual*.

3-403.3.1.2.2 Portland Cement Concrete

A portland cement concrete mix design consists of combining four major components: water, aggregate, portland cement, and admixtures. All components must conform to the specifications. The contractor, based on the requirements stated in the specifications, submits a concrete mix design. The contractor's proposed mix design must be designed by a lab with an accreditation acceptable to the Materials Division. The mix design submittal must include data from the preparation and testing of portland cement concrete trial batches.

Reports on the trial batches and associated test results must contain information required by the specifications. An official of the firm performing the mix design must sign the reports. If the portland cement concrete mixture has been used recently on a construction project other than an NDOT project, the contractor may submit certified test results of the other project in lieu of producing trial batches.

The mix design must meet the requirements of the specifications. In the submittal, the contractor must state the class of concrete for which the mix design is being submitted. The contractor may choose to submit a mix design for a higher quality mixture than the specifications requires. The contractor may also request to use a previously approved mix design, if the approval is less than a year old. The request is considered only if the aggregate source and other pertinent information (proportions of aggregates, amount of water, amount and type of cement, and admixtures) remain unchanged. The request must be accompanied by recent certified test results.

The contractor submits the proposed mix design to the Resident Engineer, who forwards it to the Materials Division for review and approval. The Materials Division approves or disapproves the mix design and notifies the Resident Engineer.

A concrete mix design submittal is required for small quantities of concrete, such as fence posts; curb, gutter and sidewalk less than 100 feet long; small permanent ground-mounted signs; and other minor placements under 1.3 cubic yards. The Resident Engineer may approve mix designs for minor placements. The Resident Engineer may waive trial batch test requirements; however, aggregates must still come from approved sources. The Resident Engineer may also waive any or all field tests relating to minor placements based on visual inspection of the quality of the delivered concrete.

3-403.3.1.3 MATERIAL CERTIFICATION PROCESS

A manufacturer produces a Certificate of Compliance, indicating that the material meets the specification requirements of each corresponding section of the specifications. For example, bituminous materials must be in accordance with Section 703 of the specifications. A generic Certificate of Compliance form is available through the Materials Division and is sent to the Resident Engineer with the Materials and Sampling Checklist. Most manufacturers will have their own certificate form. A manufacturer's representative must sign and date the Certificate of Compliance, and the certificate must be legible. An original certificate is preferred, but the department may accept a copy or fax. The Resident Engineer can discuss questions about the certificate with the Materials Division. Certificates are sent to the Materials Division using NDOT form 020-018, "Transmittal for Test Samples and Certifications." The Resident Engineer should provide a copy of the certificate to inspectors overseeing the item being incorporated into the work. The certificate is retained in the field office records. The manufacturer should also provide the Resident Engineer with any warranties, guarantees, instruction sheets, or parts lists for products incorporated into the work.

3-403.3.1.4 BUY AMERICA CERTIFICATION

For transportation projects using federal funds, the federal government requires that steel and iron materials used in the project be manufactured in the United States. This requirement is called "Buy America." Specifications will state requirements that the contractor must follow to comply with provisions of "Buy America." The Resident Engineer must request a "Buy America" certificate from the contractor. The "Buy America" certificate states that the steel and iron materials were manufactured in the United States.

"Buy America" requirements do not apply to minimal quantities of foreign iron and steel materials incorporated into the work. The specifications will state the quantity limits of foreign materials that may be incorporated into the work. If the contractor plans to incorporate foreign iron and steel materials, the Resident Engineer documents the quantities of foreign material incorporated into the work to verify that the value of foreign iron and steel does not exceed the maximum amount allowed by the specifications.

The "Buy America" program should not be confused with the "Buy American" program. The "Buy America" and "Buy American" programs are separate and distinct Federal Highway Administration (FHWA) programs. The "Buy American" program was created in 1933 and establishes requirements for all direct federal procurements. "Buy American" affects federal agency procurement of approximately 100 products. The "Buy America" program was created in 1982 and establishes requirements for incorporating iron and steel products into federal-aid highway projects. The two programs have different requirements and processes.

The Resident Engineer should include a discussion of the "Buy America" requirements in the preconstruction conference for federal-aid projects.

3-403.3.1.5 QUALIFIED PRODUCTS LIST

The Qualified Products List is a list of manufactured products that NDOT has evaluated and determined suitable for use on NDOT projects. The contractor must use products listed on the Qualified Products List or products that meet specifications. Products listed on the Qualified Products List can be used only as listed on the Qualified Products List and installed only as recommended by the manufacturer.

The contractor may use the products listed on the Qualified Products List, or the contractor may request to use an equivalent product not on the list. The Resident Engineer must approve products not on the Qualified Products List before the contractor incorporates them into the work. Such approval may require additional time for review and approval by other divisions. The Materials Division's "Materials Sampling and Testing Checklist" may be used for guidance as to the testing requirements to gain acceptance on the Qualified Products List. All products from either the Qualified Products List or an approved equal require Certificates of Compliance. The contractor must submit the Certificate of Compliance to the Resident Engineer. The submittal process for Certificates of Compliance is described in Section 3-403.3.1.3, Material Certification Process.

3-403.3.2 SHOP DRAWINGS

The plans and specifications describe the quality of the product that the contractor must incorporate into the project. When the product is complex or has significant public safety implications, NDOT actively monitors the techniques and processes that the contractor will use. In these situations, the contractor may use interim designs or drawings. NDOT review these drawings, commonly referred to as working drawings or shop drawings. Bridges, major structures, and retaining walls are common examples of when the contractor uses working drawings. With few exceptions, the contractor submits shop drawings to the Resident Engineer, who transmits them to the Structures Division for review and approval. On occasion, other divisions or entities will review shop drawings. Following are common shop drawing submittals and reviewing entities:

- Railroads: Structures or falsework that crosses a railroad
- Utilities: Utility installations or relocations
- City or county governments: Construction of improvements owned by a local agency

If the shop drawing is for reinforcing steel, the Resident Engineer reviews the drawing to confirm that the reinforcing steel details conform to the plans and specifications. For all other shop drawings, the Resident Engineer forwards the drawings to the Structures Division for review and approval. The appropriate sections of the specifications cite the required time limitations for reviews and submittals. The contractor may not proceed with work until the relevant shop drawings are approved.

During the review and approval process, shop drawings may be returned to the contractor for revision or modification. An important aspect of the shop drawing submittal process is maintaining a complete, accurate, and current log of shop drawing submittals, revisions, and approvals. The Resident Engineer must ensure that inspectors use the current, approved shop drawings for the work they are inspecting.

Shop drawings are critical to the construction of the project; therefore, all personnel must provide ample time to adequately review shop drawings. The specifications state the minimum time allowed for the contractor to submit shop drawings before beginning work. The Resident Engineer should encourage the contractor to submit shop drawings early enough to allow adequate review time. .

3-403.4 REQUIRED CORRESPONDENCE

NDOT policies and procedures require the Resident Engineer to complete certain types of correspondence. The following list represents letters that the Resident Engineer sends to the Construction Division relating to key project milestones: :

- Work Begins – The Resident Engineer notifies the Construction Division of the date the contractor begins work on the project. If this date is after the date stated in the Notice to Proceed, the Resident Engineer's letter must state the Notice to Proceed date, the date that work started, and the working day represented by the start date.
- Suspension – If unsuitable weather or other conditions prohibit work on the project, the contractor may submit a written request to suspend work. If the Resident Engineer approves the request, the Resident Engineer submits a standard suspension letter, with the contractor's request, to the District Engineer. After the District Engineer concurs with the suspension, the District Engineer forwards the letter to the Chief Construction Engineer, who must also concur. If the suspension occurs during a winter shutdown as may be provided in the specifications, this correspondence is not required.
- Resumption – The Resident Engineer notifies the contractor in writing when the reasons for the suspension no longer exist. The Resident Engineer's letter should state the date when working days will resume. Because of an extended work suspension due to weather, the Resident Engineer should give the contractor sufficient time (typically 10 days) to reorganize labor and equipment. The Resident Engineer notifies the Construction Division using the standard letter for resumption of work. The letter is processed in the same manner as the suspension letter.
- Completion – When the contractor completes work on the project, the Resident Engineer sends a letter to the District Engineer with a copy to the Construction Division stating the completion date and informing them that the project is ready for final inspection. The Construction Division then notifies all appropriate parties of the completion date.

3-403.5 LETTERS OF AUTHORIZATION, CHANGE ORDERS, AND SUPPLEMENTAL AGREEMENTS

The principal elements of the contract documents are the contract, plans, and specifications. During the construction phase, each of these legal documents can be changed with Letters of Authorization, change orders, or supplemental agreements. This section describes each of these methods of changing the contract documents.

3-403.5.1 LETTERS OF AUTHORIZATION

Occasionally, minor construction items that are not anticipated in the original scope must be completed on a project. These minor construction items are incidental construction items, which do not have bid items under the original plans and specifications. A Letter of Authorization is a means to compensate the contractor for incidental construction items for which no bid item is included in the plans and specifications. The Resident Engineer can pay for these incidental construction items with a Letter of Authorization. The Letter of Authorization must contain the following information:

- Contract number and project number
- Letter of Authorization number (numbered consecutively beginning with 1)
- Date of approval
- Reason for work
- Description of work
- Cost of work
- Cost justification for work
    - The Resident Engineer prepares a cost analysis independent of the contractor's cost estimate. The Resident Engineer compares cost analysis with the estimate prepared by the contractor. Any significant differences are resolved with the contractor. Refer to Item 5. Estimate of Cost in Section 3-403.5.2 Change Orders for additional information on preparing a cost analysis.
- Cumulative total of incidental funds used on project, expressed as a dollar amount
- Cumulative amount of incidental funds used compared to incidental funds budgeted, expressed as a percentage
- Signature of contractor and Resident Engineer

The Resident Engineer and contractor must sign Letters of Authorization before the work begins. After signing, the Resident Engineer sends copies to the District and to the Construction Division.

Following are the Resident Engineer's limitations on Letters of Authorization:

- The spending limit per incident is set at $10,000.
- The cumulative total of incidental construction items cannot exceed $40,000 or 1 percent of the original contract bid price, whichever is greater. In no case is the cumulative total of incidental construction items to exceed $150,000.
- A Letter of Authorization cannot grant time extensions.
- A change order is not required for work performed under a Letter of Authorization.

- When the plans or specifications clearly state that the work is incidental to other items of work, or that no direct payment is made for certain work, payment is not made under a Letter of Authorization.
- When the plans or specifications clearly provide bid items to perform the work, a Letter of Authorization is not used
- On state-funded minimum overlay projects, guardrail improvements are not performed under Letters of Authorization.
- Letters of Authorization cannot be used for the following:
- Substantial revisions in geometric design, structural section, or revisions in the geometric design that do not conform to design standards.
- Significant changes on a major structure or pile bearing requirements.
- Changes in material specifications of a Major Item. (Refer to Section 101.03 of the specifications for the definition of "Major Item.")
- Changes involving right-of-way limits or access control.
- Changes that would abolish or nullify a right-of-way agreement or changes to proposed right-of-way work not covered by a prior right-of-way agreement.
- Changes allowing work outside contract limits or outside the right-of-way that are not covered by an agreement to which the state is a party.
- Changes that involve an agreement or contract with a government agency, utility, private or corporate agency, and the proposed change is not addressed in a previous agreement.
- Changes that affect property drainage, water, or other abutting property owner rights that may result in action against the state.
- Changes to the payment method to the contractor. This does not include Force Account or agreed prices that may be necessary to perform Extra Work, but does include changes in the method of measurement or adjustment of a unit bid price.
- Changes that involve settlement of a contractor's claim.

The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains an example of a Letter of Authorization.

Although a Letter of Authorization is appropriate in directing the contractor to accomplish incidental items of work, certain situations exist in which a Letter of Authorization cannot be used. When a Letter of Authorization is not used, a change order or supplemental agreement may be the appropriate process. The following sections discuss change orders and supplemental agreements.

3-403.5.2 CHANGE ORDERS

NDOT has the right to modify a project. Modifications may be required to address changes to plans after the construction contract is signed, to address conditions in the field, or to add items not originally anticipated during the design. Contract change orders are used to make changes to a construction project. Change orders must have four essential elements: description of the work to be performed, cost of the work, time to complete the work (effect on project schedule), and method of payment.

The specifications define a contract change order as "A written order to the Contractor, covering changes in the plans, specifications or quantities, within the scope of the contract, and establishing the basis of payment and time adjustments for the work affected by the changes."

After the Director executes a change order, it becomes part of the construction contract between the contractor and NDOT. Just as the original plans and specifications describe the scope, terms, and conditions of work to be done, the change order is also a formal agreement describing the scope, terms, conditions of work to be done, and funding used by the Department for payment of the work.

Because a change order is legally binding to the contractor and to NDOT, the change order must be prepared with care. The required elements of a change order must be clear, concise, and unambiguous. A change order must be prepared so that a person not familiar with the work can readily interpret scope, terms, and conditions of the work. In the event of a claim or lawsuit, a vague document that requires verbal explanation is no better than a verbal agreement.

The Construction Division, in cooperation with the FHWA, has developed the following standard guidelines outlining conditions that require a change order:

1. Revision of geometric design (main road, ramps, frontage roads, or crossroads).
2. Revision of structural section. Localized corrections to the base due to pockets of unsuitable material do not require a change order. Revision to base thickness is considered a major change in design and requires a change order.
3. Revisions involving addition, deletion, or relocation of major structures.
4. Any change in planned access provisions. (On the Interstate system, changes in planned access require FHWA approval and should be submitted well in advance. These changes include, but are not limited to, such minor revisions as relocating a locked gate to fit an existing road. A sketch showing the original and revised conditions must accompany the order.)
5. Any change that alters the scope of the contract (including deletion or addition of contract items).
6. Any change related to type or quality of materials to be furnished.
7. Changes in specifications or specified construction techniques.
8. Changes resulting in adjustment of bid unit prices or in establishing agreed unit prices for items not contained in the original contract.
9. Design changes, such as providing for a culvert not indicated on the plans or modifying the diameter of a pipe. A change order is not required for changes in pipe lengths resulting from field stakeout.
10. Payment for materials stockpiled out of state, unless otherwise stated in the specifications. The change order requires the address or a description of the stockpile location.
11. Acceptance of material or work that does not conform to the specifications.

In certain situations, routine maintenance may require a change order. If a change order is required to direct the contractor to perform maintenance, limitations on the eligibility for federal funding may apply to maintenance costs. Confer with the Construction Division Administration Section for guidance on federal funding eligibility relating to maintenance activities.

Work provided for in any change order should not begin until the Director approves the order, except when a prior approval has been granted. Refer to Section 3-403.5.2.1, Prior Approvals. If the contractor begins change order work before the Director executes the change order, or without a prior approval, the contractor risks receiving no payment for the work. Because of the reviews required to process a change order, change orders should be submitted well before actual requirements. If FHWA approval is required, additional time may be needed to process the change order.

Occasionally, issues arise between NDOT and a property owner. The issue may be a purported verbal agreement between the property owner and NDOT, or it could involve right-of-way matters. Because a construction contract is between NDOT and the contractor, the property owner is not party to the contract; therefore, a separate written agreement is needed between NDOT and the property owner. If additional work is necessary, two documents are required: (1) An agreement or other document between NDOT and the property owner describing the agreement of both parties, and (2) a change order between NDOT and the contractor directing the contractor to perform the work. On projects receiving federal funding, appropriate agreements or other supporting documentation must accompany change orders addressing right-of-way issues.

When a change order is prepared for work contained in an agreement between NDOT and a property owner, but the work was inadvertently omitted in the plans and specifications, the change order must reference the original agreement. Because of the legal nature of change orders related to right-of-way and property owners, change orders related to right-of-way matters are processed only after all required documents are executed and accompany the change order. No work is allowed outside NDOT right-of-way without proper permanent or temporary easements. Easements describe the limits of the work and the type of work allowed. Section 108.04 of the specifications typically list easements. The Resident Engineer can contact the Right-of-Way Division with questions about easements.

The Resident Engineer should always discuss contemplated changes with the District Engineer and, when appropriate, with representatives of the Construction Division. The Resident Engineer should also discuss changes with FHWA representatives during their regular project inspections.

Changes typically require the Resident Engineer to coordinate with other NDOT divisions for guidance and recommendations. When an NDOT division requests a change, the requesting division submits the request in writing to the Construction Division. The Construction Division reviews the request and, if the Construction Division concurs in the request, forwards it to the Resident Engineer. The Construction Division also sends a copy of the request to the District Engineer. This procedure ensures that all persons involved with the change are informed.

Use NDOT form 040-001, "Contract Change Order" to prepare contract change orders. The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains a checklist to assist in preparing a contract change order. Following is a discussion of the important features of the change order and instructions for preparing the change order.

1. Heading. Fill in this portion of the form completely to identify the project properly. The spaces provided on the form for numbering the sheets of the change order should include all sheets that are part of the order. This includes sheets such as estimate of costs, drawings, revised structure, or guardrail lists. Include prior approvals, analysis of force account, and memos requesting the change order, but do not number them. As an example, a change order directs the contractor to perform certain work. Accompanying the order is an estimate of cost, two sheets of detailed drawings, and a revised guardrail list. The change order form, in the space provided, shows "Sheet 1 of 5 sheets," which is the total number of sheets included in the order.

2. Contract Change Order Number. Consecutively number the orders, beginning with number 1, for each contract. Occasionally, it will be necessary to amend a previously submitted change order. An amended order is not a new order, but an addition, deletion, or modification to a portion of the original order. All provisions of the original order, except the amended section, remain in effect. Any quantities changed by an amended order should reflect only the net change to the original order, and not the net change to the original planned quantity. An amended change order is designated with an "A" after the number, such as "CCO No. 23A." If a second amendment is necessary, it is designated with a "B". When the Construction Division returns a change order to the Resident Engineer for modification before the Director signs it, the same order is resubmitted after the Resident Engineer modifies it. If a change order is voided at the project level after it has been assigned a number, and the number is not later reassigned to a new order, the Resident Engineer should notify the Construction Division in writing to ensure accurate record keeping. The same is true if a number is inadvertently skipped.

3. Change Requested By. Indicate who requested the change. The Resident Engineer, District Engineer, contractor, Design Division, or someone outside NDOT may have requested the change order. Fill in the "Change requested by" space on the form with the individual's name and title.

4. Text. In the body of the form, clearly describe the scope of the change, including location and limits. Include the payment method, such as bid prices, Force Account, or Agreed Prices. If the scope of the change has multiple elements, describe each element separately. If more than one sheet is necessary, use NDOT form 040-001A (non-signature sheet) and NDOT form 040-001 (signature sheet). If more than one payment method is used, clearly define how each portion of the work is to be paid.

5. Estimate of Cost. Indicate how the work to be performed is paid, such as contract bid items, agreed unit prices, force account, or a combination of all. Extra Work is not a payment method; it is any work outside the scope of the contract that is essential to the satisfactory completion of the project. If more than one item or operation is to be provided under Extra Work on the same order, list and define each item or operation separately. Use as many sheets as necessary. When preparing a cost estimate for a change order, the Resident Engineer should follow these guidelines:

- Indicate the payment method for the Extra Work. An analysis is required for each force account or agreed price used.

  If equipment is included, list the manufactured year and the Rate Adjustment Factor used, as described in Section 109.03 of the specifications. For equipment not listed in the "Rental Rate Blue Book," the Resident Engineer should contact the Construction Division for guidance.

  When preparing estimates for force account or agreed prices, use Section 109.03 of the specifications to determine applicable markups. When preparing a cost analysis for Agreed Prices, the Resident Engineer should base the analysis on the following:

  - The average prices, or historical bid prices for similar work, listed in the Construction Division's "Engineer's Estimate of Reasonable Unit Bid Prices."
  - Pricing information provided by other NDOT divisions.
  - Written independent price quotes from other subcontractors or suppliers.
  - Other industry documents can be used in unique circumstances and only after coordinating with the Construction Division.
  - The cost analysis must include invoices or quotes for materials.

- If a change order allows payment for items without an item number, such as Force Account or Agreed Price items, an item number must be created and assigned to each item. For Force Account items, the item number begins with FA0, followed by a dash or space, and a four-digit number, beginning with 0001, such as FA0-0001. For Agreed Prices, a similar numbering system is used, for example, AP0-0001. Item numbering is sequential within each change order. If subsequent change orders create more FA or AP items, start a new numbering sequence for each change order.

  Pay all Rent Construction Signs or Barricade items on a prorated basis and code them with PR0 as the first three digits in the item number. A prorated item created at an Agreed Price is assigned a PR0 number, such as PR0-0001.

- Show the total estimated cost of the Extra Work and the applicable agreement estimate breakout. On all projects, show the agreement estimate breakout for each item of work on the "Estimate of Cost" sheet. If an item of work is in more than one breakout, list it separately for each breakout. If an appropriate breakout is not available, request anew breakout from the Construction Division Administration Section.

Payment for Extra Work can be made in three ways, listed below. Each of these payment methods may provide advantages over the others depending upon the circumstances.

a. FORCE ACCOUNT – Use Force Account when all parties:

   i. Cannot accurately estimate the cost of the work

   ii. Can clearly separate the work from other portions of the work

   iii. Cannot agree on the payment method

   Note: The force account methodology described in the specifications cannot be modified.

b. AGREED UNIT PRICE – Use Agreed Unit Prices when all parties:

   i. Can accurately estimate costs

   ii. Cannot separate the work performance from other portions of work contained in the change order

c. AGREED LUMP SUM PAYMENT – Use Agreed Lump Sum Payment when parties cannot separate work performance from other work and when parties cannot apply agreed unit prices to any definable items

6. Total Cost of Change. This space shows the total dollar amount of the change, indicating whether the change is an increase or decrease because of the change order. If there is no change, insert the word “None.”.

7. Time Extension. If additional working days are justified, provide the justification for additional working days in the text of the order and on the “Estimate of Cost” sheet. Allow additional time only if the additional work extends the original contract time. Regardless of the time required to perform a given change, additional time is not allowed if the completion of the project is not affected. Time extensions are based on impacts to the project completion date, not the duration of the given change. Clearly state if the change order deducts, adds, or does not change the contract time. When a schedule analysis is performed, include the analysis with the change order.

8. Contractor’s Signature. Submit all change orders for the contractor’s acceptance and signature. Note the date of acceptance in the space provided. If the contractor refuses to sign a change order, fully explain the refusal reason in the Resident Engineer’s Cover Letter.

9. Cover Letter. The Resident Engineer’s letter of transmittal, or Cover Letter, is an essential element of processing any change order. The transmittal letter gives complete details and provides justification for the change. If an attempt has been made to renegotiate prices, it must be documented in the transmittal letter. The letter should substantiate in detail any additional working days and explain reasons for the Extra Work. If a prior approval was issued for a change order, the transmittal letter must reference the prior approval. The transmittal letter also indicates who is monetarily responsible for the change order, for example, federal, city, county, or developer. Clear and complete information in the transmittal letter enables the Construction Division to act promptly on the change order request and obtain the necessary approval.

On projects with full federal oversight, the FHWA reviews and approves change orders. Generally, the FHWA does not approve orders involving changes in the specifications unless one of the following criteria is met:

- The specifications, as written, are impossible or impractical to comply with.
- A product equal in all respects to the one specified can be furnished at a savings to the contract.
- A product superior to one specified can be furnished at no increase in cost.

NDOT policy and FHWA regulations require that work necessitating a change order shall not begin until: (1) The change order has been fully executed, or (2) a written Prior Approval authorizing the work to proceed has been granted.

3-403.5.2.1 PRIOR APPROVALS

Change order processing and approval can be expedited and completed in just a few days, especially if change order processing could delay the project's progress or could create an unsafe situation. A prior approval commits the Department to changes and payments for work that the contractor has not accepted or agreed to and the Director has not authorized. Therefore, a prior approval is requested or authorized only after change order preparation is substantially complete

Use prior approvals sparingly. Immediately after a prior approval is authorized, submit the change order for processing. In most situations, the time between prior authorization and a change order submission to the Construction Division should not exceed 30 days.

Prior approvals are not issued for Value Engineering proposals. If the character of the change order requires approval from another division, prior approvals must have the concurrence of the appropriate division.

The Director, the District Engineer, or the Resident Engineer may authorize prior approvals. Prior approval authorization must be on the appropriate NDOT form before the work begins. The appropriate forms are as follows:

- Director: Record of Director's Authorization to Proceed with Major Contract Revision on State-Funded or Certification Acceptance Projects (NDOT form 040-002A)
- Director: Record of Authorization to Proceed with Major Contract Revision (FHWA form FHWA-1365)
- District Engineer: Record of District Engineer's Authorization to Proceed with Contract Revision (NDOT form 040-002)
- Resident Engineer: Record of Resident Engineer's Authorization to Proceed with Contract Revision (NDOT form 040-002B)

Both the Resident Engineer and the District office retain copies of the form, and the Construction Division keeps the original. The commitment authority of the District Engineer and Resident Engineer are as follows:

- District Engineer
  - Projects over $5,000,000: Prior Approval commitment authority: $100,000
  - Projects under or equal to $5,000,000: Prior Approval commitment authority: $50,000
- Resident Engineer
  - Projects over $5,000,000: Prior Approval commitment authority: $50,000
  - Projects under or equal to $5,000,000: Prior Approval commitment authority: $25,000

The following categories are excluded from the District Engineer's and the Resident Engineer's commitment authority, regardless of cost:

1. Substantial revisions in geometric design, structural section, or revisions in the geometric design that do not conform to design standards.
2. Significant changes on a major structure or pile bearing requirements.
3. Changes in material specifications of a Major Item. (Refer to Section 101.03 of the specifications for the definition of "Major Item.")
4. Changes involving right-of-way limits or access control.
5. Changes that would abolish or nullify a right-of-way agreement or changes to proposed right-of-way work not covered by a prior right-of-way agreement.
6. Changes allowing work outside contract limits or outside the right-of-way that are not covered by an agreement to which the state is a party.
7. Changes that involve an agreement or contract with a government agency, utility, private or corporate agency, and the proposed change is not addressed in a previous agreement.
8. Changes that affect property drainage, water, or other abutting property owner rights that may result in action against the state.
9. Changes to the payment method to the contractor. This does not include Force Account or agreed prices that may be necessary to perform Extra Work, but does include changes in the method of measurement or adjustment of a unit bid price.
10. Changes that involve settlement of a contractor's claim.

The Construction Division must request prior approval to proceed with changes that are outside the scope of the District Engineer's authority, as listed above. The Resident Engineer should first review the situation with the District or Assistant District Engineer and, if they decide that the proposed change is outside the District Engineer's authority, they will contact the Construction Division.

Carefully prepare cost estimates for prior approvals, and monitor the cost of the change order work as the work proceeds. If it is apparent that the actual cost will overrun the original estimated cost of the prior approval by 25 percent or $25,000, whichever is the lesser amount, submit a revised prior approval. A revised prior approval will have the letter "R" following the change order number associated with the prior approval. For example, if Change Order No. 3 had a prior approval and the prior approval had to be revised, the revised prior approval would be numbered Prior Approval No. 3R.

Construction Division staff will review the proposed change with the appropriate division, and, if the change is deemed necessary, the Construction Division will issue written prior approval. The FHWA must authorize approval on all full federal oversight projects and changes relating to environmental and right-of-way issues on federally funded projects. The FHWA delegates authority to NDOT to authorize prior approval on federally funded projects. The Construction Division reviews and coordinates proposed changes with the FHWA, when appropriate.

When preparing a prior approval, the following information is required:

- A description of the work to be performed and reason the work is deemed necessary. The reason or justification for the change must be clear and concise, allowing a person unfamiliar with the project to understand the issues and the need for the change.
- The name and title of the person requesting the change, such as District Engineer, Resident Engineer, or contractor.
- The change order number that will be assigned to the work.
- An estimate of cost and proposed payment method, for example, bid items, force account, or agreed prices. The rationale and reasoning for the estimated cost and for the proposed method of payment must be included.

In cases of extreme emergency, when immediate action is required and the Resident Engineer does not have time to contact the District office or Construction Division, the Resident Engineer may proceed with changes. Immediately following the action taken, the Resident Engineer must notify the District office and Construction Division with a complete explanation of the actions taken.

3-403.5.3 SUPPLEMENTAL AGREEMENTS

A supplemental agreement is a written agreement between the contractor and NDOT for work not included in the current project limits or for conditions specifically stated in the specifications as requiring a supplemental agreement. After the contractor and NDOT approve and execute a supplemental agreement, it becomes part of the contract. The Governor executes supplemental agreements, similar to the original contract between NDOT and the contractor. For this reason, supplemental agreements are coordinated with the Administrative Services Division. If a supplemental agreement involves federal funding eligibility, the Construction Division consults with FHWA.

Change orders and supplemental agreements have one key difference. A change order is for work that NDOT has the right, under the specifications, to order performed. In contrast, a supplemental agreement addresses work that NDOT cannot require the contractor to perform under the contract. A supplemental agreement is a negotiated instrument, while a contract change order is a direct order. Any work outside the project limits requires a supplemental agreement. A supplemental agreement is assigned a change order number to facilitate payment under NDOT's accounting system.

After a decision is made to enter into a supplemental agreement, the Construction Division initiates the preparation of the agreement. The Resident Engineer will negotiate prices to be included in the agreement. The Resident Engineer assigns a change order number to the supplemental agreement for processing purposes only. Each force account or agreed price used requires an analysis or justification.

3-403.6 DISPUTES AND CLAIMS

During a construction project, disputes may arise between the contractor and the Resident Engineer. Since litigation and lawsuits are often the most time-consuming and resource intensive ways of resolving disputes, NDOT encourages using alternative dispute resolution methods such as the following:

- Partnering is a process used by NDOT to build an environment of open communication between the contractor and NDOT.
    - Informal partnering is conducted by the Resident Engineer beginning with the "Conflict Resolution Ladder" completed at the Pre-Construction Conference, continuing with weekly project meetings.
    - Formal partnering is conducted by a facilitator who leads quarterly partnering meetings.
- Dispute Resolution Team (DRT) consists of third-party experts selected by NDOT and the contractor that assist in resolving disputes on specific projects.
- NDOT establishes a Contract Claims Review Board after a formal claim is submitted by a contractor.

The foundation of partnering is to resolve disputes at the lowest level of authority. If the dispute is not resolved at one level, the dispute is elevated to the next higher level of authority. The process of elevating disputes to subsequent levels of authority is discussed during the Pre-Construction Conference.

At the Pre-Construction Conference, the contractor and NDOT each designate an individual at each level of authority who is authorized to resolve disputes. Each level of escalation should have different contractor and NDOT representatives than the previous level. The Resident Engineer completes the "Conflict Resolution Ladder" form that identifies each person at each level of authority. On projects that have a formal partnering process, the "Conflict Resolution Ladder" is completed at the partnering meeting instead of the Pre-Construction Conference. To document a dispute and track the resolution process, the Resident Engineer uses a "Conflict Resolution Form." Both forms are included in the example of a Standard Pre-Construction Conference Agenda contained in the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx.

The Resident Engineer should create an environment in which the contractor and NDOT maintain a cooperative working relationship, mutually resolving conflicts at the lowest possible level. Solving issues at lower levels, keeps them engaged, and gives them a "sense of ownership" on a project. This environment fosters cooperation and trust, which reduces disputes, produces a high-quality product, and expedites completion of the project.

The contractor and NDOT must equally commit to a cooperative relationship, either through an informal or formal process. A partnering workshop among major project participants and stakeholders can help establish a formal cooperative relationship.

A Dispute Resolution Team, which encourages the contractor and NDOT to resolve disputes, may be established on large, complex projects. The Dispute Resolution Team is comprised of three members: one selected by NDOT and approved by the contractor, one selected by the contractor and approved by NDOT, and the third, which serves as the chair of the team, is selected by the first two members and approved by NDOT and the contractor. The first two members should be acknowledged experts in the type of construction related to the project.

If the contractor and NDOT cannot resolve a dispute, the Dispute Resolution Team provides an unbiased audience. The Dispute Resolution Team's recommendations are not binding on the contractor or NDOT. However, any records associated with the Dispute Resolution Team, such as written recommendations, and resumes of the members, are admissible as evidence in a formal claim process.

If the contractor is not satisfied with the informal resolution processes, the contractor may proceed with a formal claim, as described in the specifications. The Construction Division notifies NDOT's Administrative Services Division of the contractor's intent to file a claim, and the Administrative Services Division assigns a staff member to be the claim board chairperson. The chairperson will then begin to assemble a board to review and hear the claim. They will also assemble the appropriate documents and supporting documentation for the formal hearing. The Contract Claims Review Board's findings and recommendations are forwarded to the Director, who may accept, reject, or modify the Board's recommendations.

3-404 SAFETY

The Resident Engineer is responsible for the safety of NDOT employees. The Resident Engineer supplies required personal protective equipment, such as hard hats, safety goggles, hearing protection, respiratory protection, and reflective vests, to NDOT personnel. Personnel must use the appropriate safety equipment as required by specific work conditions and current policy. The Resident Engineer can refer to the Human Resources Division Safety Section, for guidance on safety matters. When an accident occurs on an NDOT project, or when an NDOT vehicle is involved in an accident, an "Accident Scene Observations for Counsel" form is completed and submitted to the NDOT's Chief Counsel. Note that no copies are made of the completed form. The NDOT employee having information relating to the accident completes the form.

The contractor is responsible for the safety of his or her employees, including subcontractors and vendors. The contractor must comply with all safety regulations governed by the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) and ensure the safety and convenience of the public throughout the work zone. The contractor must submit a project-specific safety plan to the Resident Engineer before project work begins. At least once during each construction season, the contractor must also complete an OSHA safety checklist form, NDOT form 040-028, "Safety Inspection Checklist – Contractor Operations." The contractor conducts the inspection and completes the form in the presence of an NDOT representative.

Both the Resident Engineer and the contractor are responsible for safety on the worksite. The contractor should hold weekly jobsite meetings with all project personnel to discuss work safety issues. The Resident Engineer should designate a representative to attend the contractor's weekly safety meetings.

Safety is every person's responsibility, and all jobs can be completed safely. On roadway construction projects, personnel regularly handle and move materials and equipment. Therefore, everyone on the project must be alert to all movements—equipment, people, and materials. By being aware of surroundings, you reduce the chances of being struck by a moving vehicle, construction equipment, or the traveling public. Being aware also reduces the risk of placing yourself in an unsafe situation, such as falling into open trenches or other excavations.

Accidents involving equipment and materials on the jobsite are not the only safety concerns. Asphalt hotplants, concrete mixing plants, steel fabrication facilities, and concrete prestressing yards are areas where material and processing temperatures are dangerously high, hoisting operations are ongoing, and chemicals are being used.

3-405 ENVIRONMENTAL

Federal, state, and local agencies establish environmental regulations, and NDOT and its contractors must comply with these regulations. The requirements that relate to water quality, wetlands, endangered species, and cultural resources are identified in the project design phase as part of the National Environmental Policy Act (NEPA). In addition to those environmental issues identified in NEPA, other environmental factors such as dust and noise are evaluated and addressed.

During construction, the Resident Engineer monitors compliance with the environmental requirements, as violations of these regulations can result in civil penalties, criminal penalties, or both. Violations of environmental regulations can also cause construction delays. Resident Engineers should be familiar with the environmental requirements described in the project plans and specifications. The Environmental Services Division is available for guidance on environmental issues. To increase the contractor's awareness of environmental requirements, the Resident Engineer should do the following:

- Include a pre-construction conference agenda item to discuss NDOT's environmental commitments
- Discuss NDOT's and the contractor's environmental mitigation commitments and obligations at weekly contractor meetings

The Resident Engineer should devote special attention to verify the contractor's activities take place on NDOT property or right-of-way. The Resident Engineer must contact the Environmental Services Division to describe the activities and location, and to confirm that no additional environmental permits or clearances are required. Additionally, if any project changes are proposed that would take place on undisturbed land – either within or outside of NDOT right-of-way – the Resident Engineer must contact the Environmental Services Division for guidance.

NDOT has environmental requirements that control erosion and pollution during the life of the finished roadway project and during construction activities. To control pollution that may occur following completion of the project, plans and specifications incorporate measures to reduce erosion, sedimentation, and other environmental damage. For long-term pollution control measures, refer to Section 6-211, Erosion Control, of this *Construction Manual*. For temporary pollution control measures during construction, refer to Section 6-637, Pollution Control, of this *Construction Manual*.

3-406 CONTRACT COMPLIANCE

During the construction phase of the project, the contractor submits various forms required by state and federal regulations. Information contained in the forms helps the Resident Engineer and the Construction Division Contract Compliance Section monitor the contractor's compliance with labor laws and regulations. Contractors must certify that information contained in these forms is accurate. The format of the certification may change from form to form.

Specifications and state law require that all contractors working on NDOT projects submit two copies of certified payrolls on a monthly basis. To comply with Nevada law (NRS 338.060 and 338.070), contractors must submit all certified payrolls for the preceding month to the Resident Engineer by the fifteenth of the following month. Failure to comply with this submittal schedule will result in assessment of monetary penalties against the contractor.

The contractor may use NDOT form 052-009, "Certified Payroll" to provide payroll information, but this form is not required if the contractor uses computer-generated certified payrolls. A signed and dated "Statement of Compliance" must accompany each payroll. The Resident Engineer must date stamp the certified payrolls on the date they are received from the contractor.

When the Resident Engineer receives the certified payrolls, each payroll is checked to verify that all information required by the special provisions is included for each employee. Additionally, the hourly wage stated on the payroll must meet or exceed the minimum wage rate specified in the contract special provisions. The wage rate is the total of the base pay, vacation pay, and fringe benefits. The Resident Engineer documents payroll discrepancies with a letter to the contractor describing the discrepancies. The contractor must make payroll corrections before the Resident Engineer submits the payroll to the Contract Compliance Section. The contractor uses NDOT form 052-031, "Resident Engineers Payroll Transmittal" to transmit all payrolls. The Resident Engineer should sequentially number the payrolls received, even though this number may differ from the contractor's numbering system. Sequentially numbering the payrolls and cross-referencing the weekending date allows accurate payroll tracking.

Once a contractor begins work on the project, the contractor must submit payrolls monthly. If a contractor works on the project, the contractor must submit a certified payroll weekly. If the contractor does not work on the project for a week or more, the contractor must submit NDOT form 052-005, "Non-Performance Payroll Report." Sequentially number non-performance payrolls in the same order as the weekly payrolls. A non-performance payroll may cover more than one week. For example, a contractor began work and submitted two weekly payrolls (Payroll #1 and Payroll #2), and did not work again for four weeks. The entire four-week period may be covered by one non-performance payroll (Payroll #3). The next working weekly payroll would be Payroll #4. To comply with state law, submit non-performance payrolls every month.

NDOT form 052-065, "Fringe Benefit Statement," lists fringe benefits paid to the contractor's employees, which are submitted by each contractor working on the project. This statement lists the hourly dollar amount of fringe benefit for each labor classification employed on the project. This document is used for checking weekly certified payrolls and for calculating force account work. Some contractors pay fringe benefits directly to their employees instead of contributing to a qualified plan; however, paying fringe benefits directly to the employee does not eliminate the Fringe Benefit Form requirement. A contractor may also submit, or be asked to submit, NDOT form 052-062, "Itemized Contributions/Deductions." This form lists itemized deductions for each employee. For information on checking certified payrolls, refer to the NDOT Construction Division's *Documentation Manual*.

The Contract Compliance Section provides self-addressed, postage-paid post cards to the Resident Engineer, who makes them available to every contractor employee working on the project. If a contractor employee believes the wage rate they are being paid is incorrect, the post card may be completed and mailed to the Contract Compliance Section. This card provides an effective means of reporting wage complaints to NDOT.

Subsection 109.08 of the specifications requires the contractor to submit to the Resident Engineer a monthly report of subcontractor payments. This submittal is a federal requirement from Title 49, Code of Federal Regulations, Part 26. The contractor should complete, sign, date, and submit NDOT form 052-060, "Contractor's Monthly Report of Payments to Subcontractors" to the Resident Engineer.

Some federally funded projects contain a bid item called "Training." This item has a unit price and number of hours set by NDOT. When a contractor employs a trainee or an apprentice, the certified payroll identifies the employee as a trainee or apprentice. The trainee's name, classification, employer, and number of hours worked in a particular week are reported on NDOT form 040-042, "Weekly Trainee Report." The contractor must submit a copy of the apprenticeship agreement provided by the Nevada Labor Commissioner's office for each trainee. This Weekly Trainee Report form becomes the source document for the contractor's bi-weekly pay estimate.

Contractors working on federally funded projects must complete an annual manpower utilization report for the United States Department of Labor, federal form PR-1391. Any contractor or subcontractor actively working on the project during the last payroll period in July must complete form PR-1391 and submit it to the Resident Engineer by August 15. The Resident Engineer must forward the form to the Contract Compliance Section by August 30. If a contractor worked during this period and any of the subcontractors did not work during this period, the Resident Engineer must provide the Contract Compliance Section with a notice listing the subcontractors who did not work and stating that they are not required to submit a report.

3-407 FINAL PROJECT INSPECTION

Near the completion of the project, the Resident Engineer conducts a preliminary final inspection. The Resident Engineer should verify that all bid items were constructed or installed according to the plans. If a bid item was not used, the Resident Engineer prepares an explanation of why it was omitted.

During the Resident Engineer's preliminary final inspection, the Resident Engineer prepares a list of deficiencies related to items of work and areas that the contractor must clean up. This list is commonly called a "punch list." The Resident Engineer must provide the contractor with the comprehensive punch list as soon as possible. On large or complex projects, maintaining an ongoing punch list benefits both the Resident Engineer and the contractor, as it reduces the level of effort required to develop a list at the end of the project.

Typically, the Resident Engineer charges working days until all contract bid items are complete. If questions exist regarding whether to charge working days, the Resident Engineer should confer with the District Engineer. The specifications allow time for the contractor to complete final clean up. The count of the clean up days begins at the end of the working day count.

Before the Resident Engineer requests the final inspection, the Resident Engineer must inspect the site used as the aggregate source for the project. If an aggregate source is a commercial source, no action is required. If a contractor-furnished source was used, and it is not a commercial source, the contractor must provide written documentation that the property owner is satisfied that the contractor fulfilled the obligations of the agreement between the property owner and the contractor. If the contractor used an NDOT-furnished material source, the Resident Engineer must contact the local Bureau of Land Management (BLM) office and arranges for a BLM inspection of the material site. If the BLM notes deficiencies, the contractor must correct the deficiencies and notify the BLM official in writing after the material site work is complete.

After all bid item and clean-up work is complete, the Resident Engineer notifies the District Engineer in writing that the project is ready for final inspection. Depending on the project type and location, the District Engineer may invite other individuals to the inspection, such as the following:

- NDOT Maintenance supervisor assigned to maintain the area where the project was constructed
- FHWA representative, if the project used federal funds
- Assistant Construction Engineer
- Local entity representative, if the project included signal system improvements or other improvements to be maintained by the local entity

If the District Engineer notes deficiencies during the final inspection, the Resident Engineer will notify the contractor in writing. After the contractor corrects the deficiencies, the Resident Engineer will inform the District Engineer in writing that all work is complete. The District Engineer then prepares and issues a letter to the contractor stating that the final inspection has been completed and that the contractor is relieved of maintenance responsibilities. The District Engineer's field acceptance is not final acceptance, which only the Director can determine. Final acceptance occurs after completion of project closeout.

3-408 PROJECT CLOSEOUT

At the end of a project, the Resident Engineer reviews and organizes the project records. After the Resident Engineer organizes the project records as described in the Construction Division's *Documentation Manual*, the Construction Division Administration Section is notified that the project records are ready for final review. A representative of the Administration Section will visit the field office to complete a final review and collect the project records. Checklists used by the Administration Section for the project final review are at the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx.

After checking the project documents, the Construction Division will determine the final pay quantities and the Resident Engineer will package the project records for storage. The Construction Division sends the final pay quantity document, called a "Final Report," to the contractor and the Resident Engineer. The Resident Engineer reviews and signs the Final Report. The Resident Engineer then forwards the Final Report to the District Engineer for review and signature. After signing, the District Engineer returns the Final Report to the Construction Division.

After the contractor and Resident Engineer agree on the final quantities, the Construction Division prepares the final payment, including the retention. Before the Construction Division authorizes final payment, they must receive the following documents:

- Acceptance Test Summary Sheet
- Materials Division Clearance
- Construction Division Contract Compliance Clearance
- District Engineer's Project Acceptance Letter
- Final Payroll Letter
- As-Built Plans
- Confidential Past Performance Report
- Letter of Explanation
- Material Source/Property Owner Release
- Material Deposit Usage Report (NDOT form 040-087), except for commercial or private material sources
- Survey Notes (Electronic, field books, and field notes binder)
- Guardrail Inventory

The records are then delivered to NDOT's Administrative Services Division Central Records Section for storage.

If the contractor has not submitted all certified payrolls or material certifications, NDOT cannot make final payment. After NDOT makes final payment to the contractor, the Construction Division provides the Resident Engineer with a Final Report. The document becomes a part of the project records that NDOT retains for three years.

3-408.1 LETTER OF EXPLANATION

At the end of a project, after final measurements are taken and computations are completed, a letter of explanation may be required to explain cost overruns or underruns. Following are the conditions under which a letter of explanation is required:

- Contract Bid Item: Changes resulting in an increase or decrease of over 10 percent and $25,000 (must exceed both) of a contract bid item.
- Change Order Item: Changes resulting in an increase or decrease of over 10 percent and $25,000 (must exceed both) of a change order item.

Items that overrun an amount requiring a letter of explanation will show up on the Bi-weekly Pay Estimate with a double-asterisk. The double-asterisk alerts the Resident Engineer that an item is overrunning and may require a letter of explanation. A letter of explanation must include the item number, item description, percent over/under, quantity over/under, dollar amount of the change, and a complete explanation.

3-408.2 CONTRACT COMPLIANCE

When the project is complete, the Resident Engineer submits to the Contract Compliance Section a letter listing the final payroll number in the payroll sequence, and the corresponding week-ending date for the contractor, subcontractors, and service providers. Refer to Chapter 24 of the NDOT Construction Division's *Documentation Manual* for an example of this letter.

3-409 POST-CONSTRUCTION REVIEW

As a project nears completion, the Construction Division Constructability Section determines whether the project will undergo a construction evaluation—also known as a post-construction review. The post-construction review provides a forum for evaluating the successes and challenges related to the project. The purpose of the post-construction review is to improve future projects through discussion of change orders, field adjustments, plan deficiencies, and constructability issues. Participants evaluate and discuss the challenges and successes of the design, materials, and procedures to identify future opportunities for improvement.

When the project is approximately 85 percent complete, the Constructability Section will schedule the post-construction review. Invitees will include representatives from the FHWA and NDOT divisions who had a substantial role in the project, which may include the following:

Division	Title	Responsibilities
Construction	Assistant Construction Engineer Constructability Section representatives	Schedule meeting location, time, and date. Distribute invitation list. Conduct meeting and record discussion. Participate in discussions. Prepare report for each review that includes findings and recommendations.
District	Resident Engineer Assistant Resident Engineer Senior project staff Maintenance Representative	Provide a list of significant project recommendations with accompanying brief explanations. Submit this list to the Constructability Section at least five days before the post-construction review. Review draft project post-construction report.
Design	Specifications Engineer Senior Design Engineer Designer Senior Hydraulics Designer	Provide input on significant findings. Review and implement process changes based on post-construction review recommendations.
Materials & Testing	Roadbed Design Engineer Geotechnical Engineer	Provide input on significant findings. Review and implement process changes based on post-construction review recommendations.
FHWA (federal-aid projects)	Operations Engineer Area Engineer	Provide recommendations on significant findings.

In addition to the project level post-construction review, the Constructability Section prepares an annual report that summarizes the findings and recommendations from project post-construction reviews held during the preceding year. The annual report includes changes that have been implemented because of the post-construction review recommendations.

3-410 CONTRACTOR'S PAST PERFORMANCE RATING

When a project is complete, the Resident Engineer completes NDOT form 040-044, "Resident's Engineers' Confidential Past Performance Report," and the District Engineer completes NDOT form 040-043, "District Engineers' Confidential Past Performance Report" for the contractor and each major subcontractor. A major subcontractor is any subcontractor performing at least 15 percent or $50,000 of the original contract amount of work on the contract.

3-500 FEDERAL HIGHWAY ADMINISTRATION

3-500.1 GENERAL

The Federal Highway Administration (FHWA) is charged with efficiently and effectively managing entrusted public funds while ensuring that federal highway programs are conducted in compliance with federal laws, regulations, and policies. The FHWA may delegate project approval authority to NDOT on federally funded projects. Approval authority is delegated by FHWA to NDOT through a Stewardship Agreement that describes the roles and responsibilities of NDOT and the FHWA.

3-501 FEDERAL STEWARDSHIP

Federal law establishes the FHWA's level of involvement on federally funded projects, and the Stewardship Agreement describes this involvement. Federally funded projects are categorized as "full oversight" or "non-full oversight."

Following are characteristics of full oversight projects:

- The FHWA does not delegate its authority to NDOT.
- This designation is typically reserved for interstate projects, large or complex projects, and other unique projects described in the Stewardship Agreement.
- The FHWA representatives conduct site visits, approve all contract changes, and actively participate in the project.
- During the design phase, a project is identified as having full federal oversight.

Following are characteristics of non-full oversight projects:

- The FHWA delegates authority to NDOT, requiring NDOT to comply with federal requirements.
- The FHWA reviews and audits NDOT processes and procedures.
- The FHWA retains oversight authority on environmental and right-of-way issues because of the potential for significant impacts.

On full oversight projects, FHWA representatives actively participate in the project, in contrast to non-full oversight projects, in which NDOT performs the FHWA's role. Because of the FHWA's active participation, communication on significant issues or issues that could reasonably become significant—such as change orders or claims—must include the FHWA. For NDOT field personnel on federally funded projects, no difference exists between full oversight and non-full oversight projects. Compliance with federal requirements remains the same for both types of federal oversight. For additional information on contract administration by FHWA, refer to FHWA's core curriculum and reference guide on the internet at http://www.fhwa.dot.gov/programadmin/contracts/core01.cfm.

3-502 NDOT STEWARDSHIP

Just as the Stewardship Agreement between NDOT and the FHWA provides for delegation of the FHWA's authority to NDOT, NDOT also enters into similar stewardship agreements with local agencies. Under NDOT stewardship agreements, local agencies, such as county and city governments, have the authority and responsibilities to comply with regulatory requirements, including federal requirements. A condition of the agreement between a local government and NDOT is that the local government must certify that it complies with federal and state requirements. Not only does the local government certify compliance, but NDOT maintains the responsibility for compliance by the local government. For specific guidance, refer to NDOT's *Stewardship Manual*.

When a local entity project is identified as a stewardship project, NDOT's stewardship coordinator serves as the project manager. The stewardship coordinator develops a stewardship agreement between NDOT and the local entity and coordinates with NDOT divisions that would participate in the particular project. After the stewardship agreement is fully executed, the District Engineer monitors the project.

The District Engineer then assigns the stewardship project to a Resident Engineer. The Resident Engineer is NDOT's representative to monitor conformance with the stewardship agreement. NDOT's responsibility is for oversight only. The local entity is responsible for inspecting, testing, surveying, and other contract administration. The purpose of NDOT oversight is to ensure the efficient and effective management of federal funds entrusted to NDOT.

During the construction phase of a stewardship project, principal requirements of the agreement focus on proper posting of notices for employee and public review, compliance reviews of construction contractor operations and payroll accounting, and compliance with equal employment opportunity requirements. The Resident Engineer is urged to review specific requirements of the stewardship agreement relating to the project. The NDOT *Stewardship Manual* also contains specific record-keeping and documentation. Upon completion of the project, the Resident Engineer must check that the local entity completes and submits required forms and other documentation. The Resident Engineer and District Engineer are also required to complete documentation and forward the documentation to the stewardship coordinator.

SURVEYING

4

4-100 GENERAL

Surveying is basic to all civil engineering projects. In transportation engineering, surveying provides the foundation and continuity for route location, design, land acquisition, and all other preliminary engineering. A survey sets up a basic "framework" of control, or positioning, that contractors and engineers use in constructing and inspecting transportation projects. Surveying is the single engineering function that links all the elements of a project, from conception; through design, land acquisition, and construction; to establishing final survey monuments.

Survey classifications can describe the survey activity (such as construction surveys) or the survey methodology (such as geodetic surveys). Following are some of the types of surveying available:

- Geodetic Surveys – This type of survey has occurred in Nevada since 1965 and establishes control networks on a mathematical datum that closely approximates the shape of the earth. The introduction of the Global Positioning System (GPS) made this type of surveying easier and essential on most projects.
- Control Surveys – This type of survey establishes the horizontal or vertical positions of arbitrary points to be used as a reference in past and future surveys.
- Cadastral/Boundary Surveys – This type of survey retraces and establishes property boundaries, including highway right-of-way. To conform to state law, a Professional Land Surveyor (PLS) must perform these surveys.
- Topographic Surveys – This type of survey determines the ground configuration (contour and relief) and location of physical or manmade objects.
- Engineering Surveys – This type of survey helps to estimate the design and cost of fixed works.
- Route Surveys – This type of survey helps to do the following:
    - Locate, design, and construct transportation facilities.
    - Establish construction control monuments.
    - Establish alignment for proposed roadways, structures, and other appurtenances.
    - Determine the terrain and the location of significant features, such as structures and utilities along the proposed route.
    - Establish the location of the route by survey lines.
- Construction Surveys – This type of survey establishes ground stakes and other reference points at known horizontal and vertical positions. These stakes define the construction location and size, which enables project inspection and provides a basis for payment for work.
- Aerial Survey or Photogrammetry – This is a measurement method applicable to various surveying activities. Normally, it utilizes aerial photographs and specialized office equipment to perform control, engineering, topographic, and other surveys.

Within the Nevada Department of Transportation, both the Location Division and the Construction Division perform surveys.

- The Location Division establishes permanent survey monuments for construction projects and for property lines. To comply with state law (Nevada Revised Statutes, NRS), a Nevada State licensed land surveyor directs Location Division surveys. The Location Division manual, *Special Instructions for Survey, Mapping or GIS Consultants*, is available through NDOT's Web site at http://www.nevadadot.com/business/contractor/GIS_Manual.
- The Construction Division establishes and maintains horizontal and vertical survey controls needed to construct a transportation project. For information about construction surveying and staking, refer to the NDOT *Construction Stakeout Manual*, available from the Construction Division.

4-200 LOCATION SURVEY

The Location Division frequently performs location surveys several years before construction begins. To eliminate extensive surveys during construction, location surveys establish permanent horizontal and vertical construction control points in locations where they are least likely to be disturbed or destroyed. These construction control points, or reference points, are semi-permanent and are stamped with a unique name or number. Orange posts mark the location. These reference points provide the basis for all staking on the construction project.

The specific location of each control point is identified by coordinates. NDOT uses three types of coordinate systems, as follows:

- Geodetic – A coordinate system based on the shape of the earth being approximately a sphere, with coordinates being in latitudes and longitudes (39-15-5.10626, -119-58-24.50336)
- Universal Transverse Mercator (UTM)) – A coordinate system based on the shape of the earth being approximately a cylinder, with coordinates measured in meters (4348892.17, 243412.25)
- State Plane Coordinate System – A coordinate system similar to the UTM, modified to reduce errors due to the curvature of the earth, with coordinates measured in feet (14765156.56, 2231013.09)

A project survey crew establishes the roadway centerline from control points established by the Location Division survey. Control points used in a construction survey commonly are located by reference to a specific point on the roadway centerline (station) and the distance between the centerline and the reference point (offset). The Location Control sheets list information for each control point established by the Location Division for a project. The Location Control sheets are contained in the project construction plans. If control points are found in the field, but not listed in the project control sheets, the control point should not be used, unless approved by the Location Division.

Typically, project location control sheets list coordinates using the Nevada State Plane Coordinate System, which means these coordinates are Northings (identifiers in the north-south direction) and Eastings (identifiers in the east-west direction). To reduce survey errors over large areas, Nevada is divided into three geographic zones: West, East, and Central. State law describes the zone in which each county is located as follows:

East Zone: Clark, Elko, Eureka, Lincoln, and White Pine counties

Central Zone: Lander and Nye counties

West Zone: Carson City and Churchill, Douglas, Esmeralda, Humboldt, Lyon, Mineral, Pershing, Storey, and Washoe counties

Following is an example of a control point listing in a project set of plans:

Control Point Information		Explanation
Name:	763013M	Assigned by Location Division
Northing:	14768375.36	North, or Y, coordinate
Easting:	2231499.45	East, or X, coordinate
Elevation:	6434.721	Elevation above sea level
New Station:	"L" 183+42.46 POC	Centerline station, Point On Curve
Distance:	66.179	Distance right of centerline
Note:	NDOT FENO MONUMENT	Description of monument type

Information relating to a specific control point is based on an important piece of information: the Location Project Number, or LPN. The example above is based on LPN 925. LPNs identify a specific geographical area that the Location Division has surveyed. An NDOT construction project may have control points that are in several LPNs. Exercise care to ensure that control point survey information is consistent with the specific LPN designation.

The location of a roadway and its design elements are influenced by topography, physical features, land use, and surrounding development. The location survey includes measurements that describe physical features such as drainage areas, waterways, buildings, fences, roads, telephone and power lines, and any other features that may influence the design.

Coordinating the horizontal alignment and vertical profile is one of the first important steps in designing a roadway. Proper design coordination increases the utility and safety, encourages uniform speed, and improves the appearance of the constructed roadway.

The Location Division develops the necessary engineering survey data to select and design the most economical and useful route locations. The construction survey crew is primarily concerned with the project area's control point information. The Location Division provides this information through Location Construction Control sheets. These control sheets are generally completed when the design is 30 percent complete. The control sheets are typically included in the 90 percent complete plans.

When control sheets are not available, the construction survey crew must use the original roadway reference monuments previously set by construction. If the crew cannot find the original survey monuments, the Resident Engineer may request that the Location Division establish control.

For many years, the Construction Division established reference monuments at the completion of a construction project. In 1999, the Director established policy that directed the Location Division to set construction control before the project design. Location Division personnel are available as needed during construction to assist with survey needs.

4-300 CONSTRUCTION SURVEY

4-301 GENERAL

The following general surveying concepts provide information for those who are new to NDOT roadway construction. You can find a more detailed discussion of construction surveying and staking in the NDOT *Construction Stakeout Manual* available from the Construction Division.

Construction surveys for roadway projects generally consist of the following operations:

- Staking in preparation of earthwork and structure construction
- Establishing construction limits and construction easements
- Establishing centerline
- Establishing control points
- Setting slope stakes
- Setting clearing stakes
- Staking fence line
- Making initial measurements to provide the basis of payment for items of work
- Pilot lining (or "Marking for pavement striping")
- Staking drainage structures
- Obtaining cross sections
- Setting grade stakes
- Preserving monuments and markers

The Resident Engineer is responsible for surveys performed on a construction project. The Resident Engineer's crew plans and coordinates all surveying efforts with the contractor. To complete the various surveys without delaying construction, the survey crew chief must anticipate the contractor's survey needs. If NDOT does not complete surveys on time, it may be liable for delays.

Construction surveys utilize a variety of specialized instruments. Following are the two most common technologies used for construction surveys:

- Total Station – The Total Station is an instrument that replaces the outdated Transit/Theodolite. It measures angles, electronically measures distances, and provides the ability of robotic survey, in which the user remotely operates the instrument from the area to be staked. It allows the user to include accurate elevation information for every staked point. The Total Station is limited by sight distance and radio strength, but is more accurate than GPS.

- Global Positioning System (GPS) – GPS is preferred because of its mobility and efficiency—only one or two people are required to perform the survey. Because the technology uses satellites, the survey coverage area is extensive.

NDOT has established survey standards for various construction survey activities. Refer to the "Special Instructions for Survey, Mapping or GIS Consultants," prepared by the Location Division. Survey standards identify the accuracy required for various types of surveys.

Construction survey crews and Location Division survey crews have different areas of responsibility. Construction survey crews conduct survey activities within the limits of the construction project. In contrast, Location Division crews survey outside the project limits. For example, Location Division crews survey right-of-way and install property controlling monuments. Construction crews survey right-of-way fences, which may or may not be on the right-of-way, which is a property line.

4-302 CONTRACTOR SURVEYING

Occasionally, NDOT staffing limitations require that outside personnel perform the construction surveying. In these cases, NDOT may hire contract surveyors or allow the contractor's surveyors to conduct the construction surveying. The Resident Engineer assigns NDOT personnel to oversee and crosscheck the work of the contract surveyors.

When performing NDOT surveys, contract survey crews must conform to the guidelines in the *Construction Stakeout Manual* and the *Special Instructions for Survey, Mapping or GIS Consultants*. Contract survey crews may also find beneficial information in this *Construction Manual*. Additionally, when surveying is an item of work under the construction project, Section 200 of the specifications addresses the contractor's surveying activities.

4-303 BEFORE CONSTRUCTION

Several survey activities can be started and even completed before the contractor arrives at the jobsite. The common sequence of survey activities on a construction project is as follows:

1. Establish horizontal and vertical control points
2. Survey the roadway centerline
3. Take cross sections for quantity verification
4. Establish slope stakes

4-303.1 OFFICE ACTIVITIES

For each of these activities, the Resident Engineer relies on the survey crew chief to calculate stakeout data before construction begins. Preliminary plans are commonly submitted to the field crew before the award of the project. The survey crew chief can start and sometimes finish most stakeout calculations before receiving the final plans. The survey crew chief receives the final plans and checks the preliminary stakeout calculations against the final plans for accuracy.

As in all phases of construction engineering, you can create a general order for stakeout computation completion, but the sequence may not apply in all instances. The following list provides a brief overview of some of the initial computations performed by the field office staff and survey crew chief.

- Alignment – Compile construction alignment documents, or field books, as soon as possible. In most cases, you must reproduce the original alignment, note any changes in length, and adjust necessary distance measurements. Calculate and check all curve deflections, tangent lengths, and similar calculations before sending the documents to the field.
- Slope Stake – Prepare and check slope stake data for the roadways. Include all information necessary for the construction crew to set the slope stakes in the field, including engineering stationing, grade percent, vertical curve information, elevations, shoulder distance, ditch, and slope information. Figure 4-303.1 illustrates a typical roadway cross section that provides the data needed for preparing slope stakes. Refer to the *Construction Stakeout Manual* for more details on this subject.
- Structures – Complete structure documents for culverts, guardrails, curbs and gutters, and other roadway appurtenances. Survey data for these types of improvements are significantly important because these improvements are permanent.
- Grade Books – To help the construction crew set "red heads" or grade stakes, complete grade computations by the time subgrade is completed.

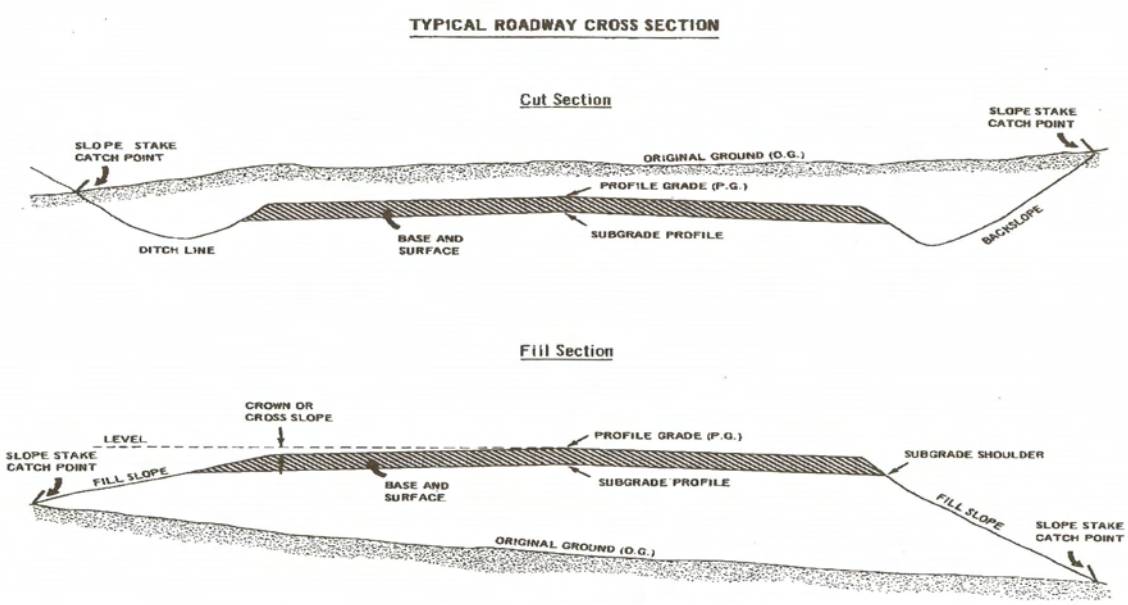


Figure 4-303.1. Typical Roadway Cross Section.

The Resident Engineer should allocate sufficient time to prepare books before stakeout. These books are also available to contractors who must do their own surveying on a project. Either the survey crew chief or contractor then completes the following tasks:

- Compute and print alignment and slope stake data based on the original design information included in the plans
- Prepare grade books (reports) for the roadway section depths (lifts) and distances that the Resident Engineer requests
- Print the computed information on field book-sized sheets

The Resident Engineer or survey crew chief examines the data and spot checks it for accuracy. If the calculated data is incorrect or otherwise unusable, resolve the discrepancies with the Design Division.

4-303.2 FIELD ACTIVITIES

4-303.2.1 ALIGNMENT, HORIZONTAL AND VERTICAL CONTROL

Use the plans to reproduce the roadway centerline and mark them with witness stakes. Drive the stakes on the centerline facing the initial survey station. Witness stakes provide information about adjacent surveyed points. Engineer stationing on projects typically increases numerically from south to north and from west to east.

If the line to be constructed differs from the originally staked line, the line to be constructed should connect with adjacent portions of the original centerline. In staking these revisions, be careful to maintain the relationship between the original and the revised line.

If you find a discrepancy with the plans when you reproduce the centerline, ensure that the Resident Engineer and the Design Division are aware of the discrepancy. Make an equation at the discrepancy point, and carry the plan station forward from that point. This ensures that construction records agree as closely as possible to the project plans and estimates.

You can set reference points when you reproduce the centerline, or immediately thereafter. Establish a sufficient number of control points so you can reproduce the centerline at any time without retracing a long section when you need only a short section.

Place reference points so they are protected from construction operations. Measure and note the following in the appropriate field book:

- Angle-of-intersection between the line to the reference point and centerline
- Horizontal measurements to the reference point

Establish construction benchmarks no more than 500 feet apart. In case a benchmark is disturbed, this spacing provides a nearby benchmark. To preserve benchmarks and reduce the possibility of disturbance, establish benchmarks away from construction activities, such as near the right-of-way line. A benchmark establishes vertical control and is a stable, physical point, such as a length of reinforcing steel driven into the ground or a railroad spike driven into a utility pole, with the elevation of the point written on a witness stake. Benchmarks are usually required near major structures, special construction areas, or where the terrain is rugged and preliminary benchmarks are difficult to reach.

Establishing alignment and horizontal control is one of the initial field activities undertaken by the survey crew. The horizontal control is typically established with Total Station or GPS instruments. Vertical control is established by setting benchmarks using a manual or electronic level. For horizontal and vertical control, the survey accuracy tolerance is 0.02 foot.

Figure 4-303.2. Slope Stake and Guinea.

4-303.2.2 SLOPE STAKES

Set slope stakes at the "catch point"—the original ground locations where the toe of a fill slope and the top of a cut slope begin. Mark the front of the stakes (facing centerline) with the cut or fill and the ratio distance for the planned roadway's typical section. Mark the back of the stakes with the engineer's station of the section staked. Mark the side of the stakes with pertinent information such as subgrade shoulder distance, slopes, or roadway ditch depth. Make sure all markings are large and easy to read. Figure 4-303.2 shows an example of a slope stake and guinea.

Set a guinea at the originally computed catch point elevation. Then, drive the slope stake six inches behind the guinea. Place the slope stake so that cut or fill information faces the centerline of the road.

Guineas do the following:

- Show the contractor where the survey information was taken and identify where construction begins.
- Reestablish the catch point if the slope stake is accidentally destroyed or moved during construction. If a guinea is missing and the slope stake remains, the contractor and the engineering personnel will know it is not a catch point.

The survey crew, under the direction of the Resident Engineer, ensures that slope stakes are set at right angles to the centerline on tangents, and on the radial lines of curves. Place slope stakes at even stations, half stations, and other unique stations that will help the contractor produce a well-contoured roadway.

Measure and record slope stake elevations and distances to the nearest tenth of a foot. Use cloth tapes that are not frayed or well worn.

Following are three common methods of slope staking. The method used depends on variables such as terrain and available survey equipment, as well as the judgment of the survey crew chief and the Resident Engineer.

- Digital Level – This method uses an extremely accurate bar-coded elevation rod. You can read the information quickly and record it on a data collector.
- Total Station – As with digital leveling, you can store information from the Total Station instrument on a data collector. You can maneuver the Total Station from a remote control (Robotics) system, which gives you the freedom to leave the instrument and go to the intended stakeout point. Productivity limitations for this method depend on the terrain and location of control points.
- GPS (Global Positioning System) – GPS allows you to efficiently calculate, place, and document slope stakes. Productivity is limited only by battery endurance.

Another method of slope staking that supports the methods described above uses a level, tripod, level rod, and cloth tape. Use this method to reestablish a slope stake or to slope stake a small area. Sometimes, using a hand level supplements the level-and-cloth-tape method when you cannot set the stakes from the instrument setup.

On projects with substantial excavation or embankment quantities, it is advisable to cross section the area to develop original ground topography. This information provides a basis for checking actual quantities against planned quantities.

4-303.2.3 UTILITIES REFERENCING

In urban areas, utility access points, such as manholes and valve box covers, are commonly located in the roadway. If planned construction will disturb or alter the utility access point, the utility access point must be preserved. To do this, the cover is first lowered and the roadway is constructed. Each access point is then relocated and adjusted to match the final roadway elevation. At times, contractors have not found all of the lowered access points. To help relocate access points, identify and reference the location of existing utility access points before construction begins.

4-304 DURING CONSTRUCTION

The contractor's operations dictate surveying activities during construction. For example, if the contractor is planning to clear and grub, the survey crew completes surveying to support the clearing and grubbing operation. When the contractor begins operations, coordination between the survey crew and the contractor allows work to progress uninterrupted.

This section describes several common construction survey activities. Survey activities in each of the following sections must be documented in field books or other documents. Survey documentation provides information for others to reproduce the initial survey. The *Documentation Manual* and *Construction Stakeout Manual* describe documentation requirements.

4-304.1 CULVERTS AND STRUCTURES

Prepare a structure book with all pertinent data before staking the structure. Set construction benchmarks near culverts. You can expedite the stakeout of culverts and other drainage structures if you establish the location of structure stations when you establish the centerline.

Mark the centerline of culverts with hubs driven on the centerline. Locate them away from the end of the culvert or headwall to protect them from disturbance. After you take elevations on the hubs, determine the cut or fill to the flow line of the pipe or headwall. Clearly mark the relevant information on the stakes. Establish the headwall alignment so the headwalls are parallel to the shoulder of the road.

Establishing sufficient reference points near culverts and large structures allows you to reproduce all stakeout points. Throughout construction, you may frequently call upon the construction survey crew to set grade, establish line, and provide engineering dimensions. By setting sufficient reference points before construction begins, the construction survey crew can readily respond to the contractor's request for survey points.

The contractor, in accordance with the specifications, surveys bridge structures. The Resident Engineer checks and verifies the contractor's survey.

4-304.2 GRADE STAKES

Use grade stakes, or "Red Heads," to control the required grade for subgrade and gravel base courses. Follow these guidelines when setting grade stakes:

- Typically, set grade stakes on the shoulders, centerline, and intermediate points on the roadway.
- Set grade stakes for subgrade at all stations and half stations.
- Set the grade stakes at closer intervals on sharp horizontal curves and vertical curves.
- Always set grade stakes at right angles to centerline.
- Set the top of the grade stakes within 0.02 foot of the desired grade.
- When the roadway grades are less than one percent, also set the grade stakes in the roadway ditch every 50 feet.

Grade stakes for the gravel base course are set on the same stations and half stations as for subgrade.

Grade stakes should be long enough to ensure they will not be moved or pulled out while the contractor is grading. Use a steel pin to make a pilot hole to make driving the grade stake easier.

4-304.3 GRADE FOR MACHINE LAY DOWN

Specifications that require mixing and machine lay down of base and surface aggregates have created the need for more exacting methods of grade and slope control. The specific method used depends on the contractor's preferences and the type of equipment used.

Shortly after construction begins, determine the type of placement equipment that will be used. This information is important for preparing grade books and placing grade controls in the field.

You can use several methods for grade control, depending on equipment or contractor preference. Coordinate between the survey crew chief and the contractor to determine the best grade control method.

For elevation control, drive a metal pin, long nail, or hub with nail in convenient locations near, but outside, the roadway section, at least every 50 feet. In curves, you may need control points at 25-foot intervals. You may need control points on only one side of the roadway. In this case, establish alternate check controls on the opposite side of the roadway at 100-200 foot intervals.

The Resident Engineer and the contractor should determine the transverse location of the control points. In most cases, locate control points in accessible and convenient positions. You can protect the control point by placing the top of the control point approximately 0.1 foot beneath the surface of the subgrade or select material base.

Following are the two methods to set elevation control points. Maintain uniformity with either method.

- Drive them to a specific elevation below finish grade, for example, 25 inches below finish grade (24 inches surfacing, 1 inch beneath subgrade).
- Drive them to a random elevation below finish grade, and compute the fill to the finish grade.

Provide a reference or guard stake for each elevation control point. The reference stake should show the amount of fill to finish grade as well as the cross slope or crown at the particular station. The contractor should be familiar with the information on the reference stake and should ensure that grade setters and equipment operators are also familiar with the information. The Resident Engineer should set elevation control points only once to avoid confusion.

4-304.4 PRESERVING MONUMENTS AND MARKERS

Before or during construction activities, the possible loss or destruction of control points or other survey monuments may be unavoidable. In most cases, the survey control sheets of the plans provide direction on the proper treatment of the monuments. When control points or survey monuments need to be perpetuated, the Location Division or a professional land surveyor (PLS) will perform the perpetuation after construction activities have ended. State law prohibits the willful damage or destruction of survey monuments set by a PLS.

Figure 4-304.1. Section Corner Monument.

Federal law prohibits the willful damage or destruction of monuments established by federal government agencies. The following federal agencies have placed markers throughout the state to establish vertical and horizontal controls for future surveys:

- U.S. General Land Office (Bureau of Land Management) (USGLO)
- U.S. Bureau of Land management (BLM)
- United States Geological Survey (USGS)
- United States Coast and Geodetic Surveys (USC & GS)
- National Geodetic Survey (NGS)

Figure 4-304.2. USGS Benchmark.

During construction, if control points or survey monuments are found that are not listed on the control sheets, construction personnel must make every effort to preserve them. Refer to Transportation Policy 1-9-3 (TP 1-9-3, formerly TP 3-1-3) for information on perpetuating survey monuments. The following provides general guidance on preserving survey monuments:

- NDOT Control Points – NDOT control points are set by the Location Division or by construction survey crews. They are addressed in the control sheets contained in the construction plans. Contact the Location Division to determine the appropriate action to take for a specific point not listed on the control sheets.
- Section Corners and other property-controlling monuments – The corners established by the U.S. General Land Office are either iron pipes with brass caps, or stones. Iron pipes have section numbers and dates stamped on them. Stones have notches on the south and east sides, except quarter corners, which are marked with “1/4” on the south or west side. Figure 4-304.1 shows a typical section corner. If a section corner, property corner, or other property-controlling monument is found within the limits of construction, it must be perpetuated, and required documentation must be filed with the County Recorder. The perpetuation must be done by a PLS and in accordance with state law. The Location Division must be contacted for direction.
- Federal Monuments – Federal agency monuments have unique identifying markings. Monuments placed or established by federal agencies require preservation. Figure 4-304.2 shows a USGS benchmark. If a federal agency monument is destroyed, recover the monument cap and send it to the Location Division.

4-304.5 STRIPING EDGE LINES

Properly placing centerlines and edge lines on the completed roadway adds significant safety to the roadway. The American Association of State Highway Officials has established striping and edge line standards, which are documented in the *Manual on Uniform Traffic Control Devices* (MUTCD). Before striping a roadway project, the Resident Engineer should refer to the plans and MUTCD for the proper placement of striping and edge lines.

4-305 AFTER CONSTRUCTION

After construction is complete, the survey crew chief reviews all survey reports and documents for accuracy and completeness. Sometimes, the Resident Engineer may request that material quantities be checked to resolve questions or issues.

When the project is complete, transfer the final survey documents and reports to the Construction Division. Include notations or corrections made during field stakeout. The survey documentation becomes part of the project permanent records.

SAMPLING AND TESTING

5-100 GENERAL

Sampling and testing on roadway construction projects ensures that materials and construction methods conform to plans and specifications. The contractor and Resident Engineer should discuss the appropriate corrective actions when materials or construction methods do not conform to the plans or specifications. This section describes sampling and testing guidelines.

Consistent sampling and testing procedures are necessary for quality public works projects. In response to the federal government's goal of improving the quality of transportation projects, local, regional, and state public works agencies in Nevada established the Nevada Alliance for Quality Transportation Construction (NAQTC) program. An association of western states has a similar testing qualification program called the Western Alliance of Quality Transportation Construction (WAQTC). If an individual is WAQTC qualified and is American Concrete Institute (ACI) qualified, NDOT accepts the qualifications in lieu of the NAQTC qualification.

Field testers are required to be NAQTC qualified by successfully passing written and performance examinations. Even though NDOT requires NAQTC qualification for all field testers, field testers should be familiar with these specifications and perform all NDOT tests according to the designated test method.

If your project is metric and you need help with metric units, call the Construction Office, Quality Assurance Section (775-888-7226).

5-200 FIELD SAFETY

All sampling, testing and equipment operations will adhere to the safety requirements of Federal and State Occupational Safety and Health Administration (OSHA) standards and Federal and State Mine Safety and Health Administration (MSHA) standards, which can be found at www.osha.gov/SLTC/etools/construction/shprogram.html and www.msha.gov/Accident_Prevention/minetypes.htm.

Testers will adhere to the following safety requirements:

- General:
  - Wear seatbelt while in vehicle
  - Secure testing equipment in vehicle
  - Use strobe light and blinkers when pulling in and out of lane closure
  - Do not park amongst or behind contractor's equipment; keep vehicle visible to equipment operators
  - If parking next to live traffic, remember where traffic is located
  - Wear proper safety gear, such as boots, vest, hat, or hard hat
  - Follow OSHA and MSHA safety procedures

- Trenches:
  - Confirm contractor uses shoring for any vertical wall four feet or higher
  - Confirm contractor shores above the vertical wall
  - Confirm the contractor uses proper ventilation in trench
  - Provide a safe way to lower and raise testing equipment in and out of trench, such as a rope and pulley
  - Contractor must provide access in and out of trench every 25 feet for every worker
  - Coordinate to make sure somebody observes from outside of trench until tester is completely out of trench
- Concrete:
  - Do not set up testing equipment where equipment will be operating
  - Set up equipment with an escape route in mind
  - When sampling from a concrete truck:
    - Make sure truck is parked with parking brake set
    - Make sure driver is out of truck
    - Notify driver that you are taking a sample
    - Notify driver when sampling is completed
  - Listen for back-up alarms and be aware of your surroundings
  - Wear high visibility clothing
  - Use proper lifting techniques when lifting
  - Clean testing site between samples to prevent tripping hazards
- Plantmix Bituminous Mixes:
  - Do not stand in front of paver
  - Wear gloves when taking sample
  - Wear high visibility clothing
  - Use proper lifting techniques when lifting
  - Do not cross windrow directly in front of paver
  - Let paving operator know you are taking samples
  - Be aware of rollers and other equipment in all directions
  - Be aware of traffic passing the work site

- Stockpiles:
  - Before taking sample, inform loader operator of location of samples
  - Listen for back-up alarms
  - Do not climb stockpiles without knowing what is under stockpile
  - Do not climb or stand under stockpiles that have vertical faces
  - Use proper lifting and carrying techniques when moving sample
  - Do not run out from behind a stockpile; equipment could be working on the other side
- Belt sampling:
  - Use lock out and tag out procedures when sampling from the belt
  - If belt sample is required, use a ladder or stairway with hand rails to access belt
  - Use fall protection gear if hand rails are not present
  - If a safe platform with handrails is not available, let qualified contractor personnel take samples; observe to confirm that the samples are properly obtained
  - If a situation is unsafe, do not take sample; let NAQTC or WAQTC qualified contractor personnel take sample
  - Provide a safe system to transport sampling equipment to and from the belt, such as a pulley system
  - Use proper lifting and carrying techniques
- Sampling device:
  - Be sure pinch points are covered to prevent injury
  - Inform plant operator when you take a sample
  - Ensure safe access to sampling device
  - Ensure a safe system to get sampling equipment to sampling device
  - Use proper lifting and carrying techniques

The Resident Engineer will ensure field labs are properly equipped with the following safety items:

- Regulatory signs, all-in-one labor law poster, with current minimum wage.
- Insurance Certificate showing dates of coverage and policy number for Workers Compensation and the Workers Compensation and Insurance Rights Poster.
- Department Safety Manual.
- Emergency evacuation plan with emergency telephone numbers on the wall. (Update each time the lab trailer moves to a new location.)
- Fire extinguishers. Each crew is responsible for checking extinguishers for adequate charge and verifying they are free of leaks. Inspect extinguishers monthly; initial and date the monthly date card. Recharge fire extinguishers annually.
- First aid kit with CPR mask and gloves.
- Eye wash station. The crew must check monthly for leaks in eye wash solution. Record the inspection on the initial and date card. Change eye wash solution every six months. CAUTION: Eye wash solution is susceptible to freezing; therefore, empty it if temperatures in the lab reach below freezing.
- Hazard Communication/Material Safety Data Sheets (MSDS) Manual. Each crew is responsible for updating and maintaining its MSDS Manual for each project. Field labs are required to have an MSDS Manual on site.

Field testers should follow the following lab safety guidelines:

- Use gloves and wear long sleeved clothing when handling hot equipment or samples
- Wear safety glasses or face shield when necessary
- Wear hearing protection
- Shake pycnometer jars at chest level, not in front of face
- Use proper lifting techniques
- Clean the lab when testing is completed to prevent tripping hazards
- Maintain lights in and out of lab
- Keep stairways and doorways clear and free of debris
- Keep fire extinguisher current and ready
- Keep eye wash station clean and clear of debris; change fluid as required
- Keep ground outside of lab clean and free of debris
- Keep lab shed clean and free of debris

5-300 TESTER QUALIFICATION PROGRAM

To improve the quality of materials and construction operations on transportation projects, the NAQTC qualification program was developed. All staff performing field testing on NDOT construction projects must be NAQTC qualified. Although the University of Nevada, Reno (UNR) administers the NAQTC program, NDOT manages the program for NDOT field testers. For additional information refer to NAQTC website at www.naqtc.unr.edu.

NAQTC qualification is valid for five years. The Qualified Technician Registry (http://www.naqtc.unr.edu/techregistary.html) lists individuals qualified under the NAQTC program. Qualified individuals receive identification cards with personal information on the front and qualification information on the back, indicating fields of qualification and expiration dates.

The NDOT qualification program requires that testers successfully complete the modules in the areas where they will perform tests. Although the NAQTC program contains six modules, NDOT requires qualification in only the first four areas listed below.

- Sampling and Density (SD)
- Aggregate (AG)
- Asphalt (AS)
- Concrete (NAQTC does not test for concrete qualification. Instead, it requires American Concrete Institute [ACI] Concrete Field Testing, Grade I Technician certification.)
- Asphalt Extended (AE)
- Specialized Tests (ST)

Each module has a written and a performance examination requirement. With the exception of ACI, the applicant must pass the written exam before taking the performance exam. NAQTC grants qualification upon successful completion of both examinations.

5-301 APPRENTICESHIP

To gain field experience after successfully completing a written exam, an individual may perform testing under the direct supervision of an NAQTC qualified tester. The supervising NAQTC tester may be an NDOT tester or a consultant tester. An exception to this apprentice supervision is when an NSOT apprentice is operating a nuclear density gauge. When an NDOT apprentice is operating a nuclear density gauge, the NDOT apprentice must be supervised by an NDOT NAQTC qualified tester. The NAQTC tester and the apprentice both sign test reports. Under the supervision of a qualified tester, the tester who has not yet completed the performance exam gains experience in performing field tests. This tester is defined as an apprentice tester. The apprentice then becomes NAQTC qualified by passing the performance exam within one year of successfully passing the written exam. Refer to the *Administration Manual* at the NAQTC website at www.naqtc.unr.edu for details on the apprenticeship and qualification program.

5-302 REGISTRATION PROCEDURES

Each Resident Engineer must notify the Construction Division Quality Assurance Section of personnel to send through the NAQTC qualification program. The notification includes the following information:

- Individual's name
- Modules to be taken
- Type of test (written or performance)
- Requested dates
- Requested testing location

The Construction Division Quality Assurance Section will administer the applications. Each candidate for the performance exams must fax a signed copy of the "Rights and Responsibilities Agreement" to the Construction Division office (775-888-7210) and mail the original.

Refer to the UNR Web site (http://www.naqtc.unr.edu/) for the Qualified Technician Registry, the *NAQTC Handbook/Administrative Manual*, and the Exams Calendar/Results.

5-303 TESTER RESPONSIBILITIES

Qualification carries inherent rights and responsibilities. These responsibilities include performing and reporting test results with accuracy and precision expected of the technician in accordance with the required NDOT test procedures outlined in the "Synopsis of Materials Division Testing Manual for Field Testing." Failure to follow the field testing manual may result in suspension from testing duties, or other penalties, including termination of employment.

Each tester must sign the NDOT Responsibilities Agreement for Field Testing form, which follows this page. Additionally, NAQTC requires each tester to sign an NAQTC rights and responsibility agreement. The NAQTC rights and responsibility form is unique to NAQTC and can be found at http://www.naqtc.unr.edu/. Each tester is responsible for completing the form prior to attending the NAQTC performance exam.

5-400 MATERIALS TESTING

The two principal testing categories on NDOT construction projects are acceptance testing and informational testing. The majority of tests performed by the project laboratory are acceptance tests of construction materials. Acceptance testing is required to determine conformance with the specifications. All other tests are considered informational tests.

5-401 TESTING AND SAMPLING FREQUENCIES

Table 5.1 (at the end of this section) presents the required minimum frequencies for sampling and testing for materials commonly used in roadway construction. Sampling frequencies shown are the minimum requirements under ordinary conditions. The sampling frequency may be increased to ensure adequate control. Sampling requirements may vary on some projects according to unique conditions. For off-system projects, the Resident Engineer may waive the "per day" frequencies. Discuss any changes from the frequencies shown in Table 5.1 with the Quality Assurance Engineer. Refer to the Materials Checklist Letter, which the Materials Division distributes for each project, for materials that are either not listed in the table or require alternate sampling instructions. Except as provided in Subsection 106.05 of the specifications, all materials are inspected, and/or tested for acceptance before incorporating into the work.

Table 5.2 presents the required sample weight, based on the size of the aggregate size sampled, for source acceptance. Source acceptance is described in Section 5-402, Source Acceptance Sampling and Testing. Table 5.3 presents the required sample weight for field testing (acceptance testing and informational testing).

Table 5.2 – Sample Size Nev. T200 Source Acceptance

(The size of the source acceptance of processed material depends on the nominal maximum size of the particles according to this table.)

Nominal Maximum Size Of Particles *	Minimum Weight of Field Samples
Sieve Size	Kilograms (Pounds)
90 mm (3 1/2 in)	75 kg (150 lbs)
75 mm (3 in)	60 kg (125 lbs)
63 mm (2 1/2 in)	50 kg (100 lbs)
50 mm (2 in)	45 kg (90 lbs)
37.5 mm (1 1/2 in)	35 kg (70 lbs)
25 mm (1 in)	25 kg (50 lbs)
19 mm (3/4 in)	15 kg (30 lbs)
12.5 mm (1/2 in)	10 kg (20 lbs)
9.5 mm (3/8 in)	5 kg (10 lbs)
4.75 mm (No. 4)	5 kg (10 lbs)
2.00 mm (No. 10)	5 kg (10 lbs)

*For purposes of this test method, "Nominal Maximum Size of Particles" is defined as the smallest sieve that will pass at least 90 percent of the sample.

Table 5.3 – Sample Size Nev. T206 Field Samples

(The size of the field samples of processed material depends on the nominal maximum size of the particles according to this table.)

Nominal Maximum Size Of Particles Aggregate Size	Minimum Dry Weight of Field Samples Grams
100 mm (4 in)	Discretion of Resident Engineer
90 mm (3 1/2 in)	30,000 g
75 mm (3 in)	25,000 g
63 mm (2 1/2 in)	20,000 g
50 mm (2 in)	15,000 g
37.5 mm (11/2 in)	9,000 g
25 mm (1 in)	3,000 g
19 mm (3/4 in)	2,500 g
12.5 mm (1/2 in)	1,500 g
9.5 mm (3/8 in)	1,000 g
4.75 mm (No. 4)	500 g
2.36 mm (No. 8)	250 g

*For purposes of this test method, "Nominal Maximum Size of Particles" is defined as the smallest sieve that will pass at least 90 percent of the sample.

Samples of aggregate for tests are prepared from field samples by quartering or other suitable means to ensure a representative sample.

5-402 SOURCE ACCEPTANCE SAMPLING AND TESTING

5-402.1 GENERAL

On most NDOT construction projects, available sources of aggregate (also referred to as "material site," "a pit," or "a deposit") are made available in the plans and specifications. The Materials Division investigated and identified these material sites. In some situations, the contractor may want to use another site, or expand the limits or boundaries of an approved site. When this situation occurs, the Resident Engineer should contact the Materials Division for guidance. Before an alternate or expanded site is accepted for use by the contractor, the Materials Division may require the Resident Engineer to collect samples and perform informational tests. After the Resident Engineer performs informational testing, the Resident Engineer sends samples to the Materials Division. The Materials Division performs acceptance tests to determine if the source is acceptable for use. Allow sufficient time to accomplish any additional sampling and testing by the Resident Engineer and to obtain approval and written authority from the Materials Division.

5-402.2 SAMPLING MATERIAL DEPOSITS

Typically material sites are sampled at locations selected by Materials Division personnel. Excavate the test holes as deep as possible or until bedrock is reached to characterize the native material. Use a 200 by 300 foot grid when sampling a material deposit.

Follow this procedure to obtain samples from test holes:

1. Obtain a sample of each layer or strata of material observed by channeling the face vertically with a shovel or similar device. Take a separate sample of the overburden in each test hole.
2. Obtain a sample from the floor of the test hole after carefully removing all loose material to prevent contamination.
3. Obtain a composite sample of material from the sides of the test hole, excluding overburden and bottom, in the same proportions as present in the excavation. One way to accomplish this is to channel each layer the same width, such as a shovel blade width, for the full depth of the hole.
4. Ensure that the size of each of the above samples is not less than 25 pounds for sand sizes and 150 pounds for gravel up to three inches in size, when in layers over three feet deep. For layers of gravel less than three feet deep, 75 pounds is a sufficient sample size. Estimate the proportions of 3-inch to 6-inch material and plus 6-inch.
5. Identify and log each test hole as follows:
    - Test Hole Number – usually assigned in the order sampled
    - Depth of overburden
    - Depth of each layer sampled
    - Percentages of oversize material not sampled
6. Identify each sample as follows: (example of Test Hole #1)
    - Overburden sample if present: #1 O.B.
    - First layer beneath overburden: #1
    - Second layer: #1A
    - Third layer: #1B, etc.
    - Bottom of test hole: #1 Btm.
    - Composite sample: #1 Comp.
7. Survey the pit and make a sketch showing the location of all test holes and the distance from the center of the pit to the centerline of the roadway.
8. Stake all test holes for identification.
9. Submit a location sketch, log of holes, and samples to the Materials Division for testing.
10. Testers may use the field laboratory to determine plasticity or other critical properties. However, take samples in the manner described above.

5-402.3 SAMPLING STOCKPILES

Use the following procedure when sampling existing stockpiles. For those stockpiles that the contractor is developing, collect the samples during stockpile construction. Table 5.1 (at the end of this section) provides the minimum frequencies required for sampling.

1. Sample at the top, middle, bottom, and around the circumference. Do not sample exposed material. Be aware of the segregation that usually occurs when material is stockpiled, with the coarser particles rolling to the outside base of the pile.
2. Test separate samples individually, if desired, to show the extent of variation in the stockpile.
3. Combine separate samples, if desired, to form a composite sample to show the overall quality of the stockpile.
4. When possible, use power equipment to expose various levels of the stockpile.
5. Push a board into the pile above the sampling point to help prevent further segregation during sampling.
6. Refer to Tables 5-401.2 and 5-401.3 for sample sizes.

5-402.4 SAMPLING FOR BITUMINOUS MIX DESIGN

Follow these procedures before sampling stockpiles for a mix design:

1. Sample all stockpiles at the same time
2. Verify that stockpiles contain the minimum required tonnage according to the specifications
3. Confirm that the contractor provides the bin percentages to the Resident Engineer, based on the contractor's testing results

The Materials Division performs mix designs for dense-grade and open-graded plantmix. The Resident Engineer's field tester collects aggregate samples for these tests and transports them to the Materials Division. These samples must be accompanied by the field test results, which show that the aggregate samples meet specifications for sieve analysis, liquid limit, plasticity index, fractured face, and absorption. In remote areas that require long transport times for sample delivery, testers can perform the field tests while the split samples are being transported. The Materials Division must receive the field test results by fax or e-mail before the samples arrive.

Completely fill out mix design sample transmittals, including the contractor's proposed bin percentages and asphalt source and type. Attach test results to the transmittal. The transmittal form must be completely filled out and signed by the Resident Engineer or Assistant Resident Engineer. The transmittal must show the source of the material, not necessarily where it is currently stockpiled. For example, if the material originated from Blue Diamond Pit, then was hauled and used at Sunset Plant, the source of the material is Blue Diamond Pit. Incomplete or inaccurate information on a transmittal can cause delays in obtaining a mix design.

When sampling stockpiles, make sure samples represent the whole stockpile. Also make sure that stockpile names are consistent for all sample submittals from the same stockpile. For example, concrete sand, sand, natural sand, and natural fines should not be used to describe the same stockpile.

A stockpile should have only one name. Verify the names of stockpiles with the contractor, ensuring that the contractor and NDOT use the same stockpile name. Per Section 106.08 of the specifications, the Resident Engineer may be required to label stockpiles.

5-402.5 FIELD TESTING FOR SOURCE ACCEPTANCE

Field testers should run informational tests to verify material will meet project control requirements before submitting for Materials Division source acceptance. The Materials Division normally tests for the source acceptance of concrete aggregate. When exceptions to this occur, the Materials Division will request field samples to be taken in accordance with the instructions provided by the Materials Division and the procedures outlined in this manual. Once the Materials Division accepts a source, the Resident Engineer may be asked for additional testing and sampling to verify the continued quality of the materials from a source.

5-402.6 MATERIALS DIVISION TESTING FOR SOURCE ACCEPTANCE

The Materials Division identifies all required testing for source acceptance, performs the tests, and provides all test results to the Resident Engineer. The specifications describe the conditions under which the source is accepted. Occasionally, the Resident Engineer and the field testers may be involved in source acceptance testing. If additional information is needed, the Resident Engineer should contact the Materials Division.

5-403 INFORMATIONAL TESTING

5-403.1 INFORMATIONAL TESTING – NDOT

The following are examples of informational tests conducted by NDOT testers:

- Preliminary tests used for mix designs
- Preliminary tests made on borings or test hole samples during investigation of material deposits
- Samples of aggregate taken during stockpile production
- Moisture content
- Distribution of hydrated lime in marinated aggregate
- Compressive strength test on cement treated base mixtures
- Compressive strength of concrete cylinders other than the 28-day curing period, unless they are specified for acceptance
- Tests on any material taken before the specified acceptance point, as outlined in the specifications

All Independent Assurance (IA) testing is classified as informational, as these tests are used only to provide verification of the project control results and testing procedures. All testing will comply with testing standards, even if they are informational tests, and will be recorded in the appropriate logs, reports, and field books.

5-403.2 INFORMATIONAL TESTING – CONTRACTOR

Section 106 of the specifications describes the contractor requirements for informational testing. NDOT inspectors or field testers can monitor and observe contractor informational tests.

5-403.2.1 QUALIFICATIONS

The contractor's testers are required to be NAQTC qualified in the aggregate module or WAQTC qualified in the aggregate, and embankment and base modules. The contractor's personnel responsible for obtaining asphalt samples shall maintain qualification for AASHTO test T40 in the NAQTC Specialized Testing (ST) module. Testers must provide proof of qualifications to the Resident Engineer. The contractor's testers must also be approved by the IA lab. Tests performed by non-qualified personnel will be considered invalid and will not be included in the required frequency, as per Section 106.

5-403.2.2 CONTRACTOR QUALITY CONTROL TESTS

Contractor performs quality control tests on aggregate materials that are produced for incorporation into the work. Samples of materials are taken and tested on a day-to-day basis by the contractor's testing personnel. Sections 704, 705, and 706 of the specifications list the tests the contractor is required to perform. During production, the results of these tests must be submitted to the Resident Engineer daily. If materials originate from a commercial source, the contractor furnishes test results performed during production of those materials.

5-403.2.3 AUDITS

Per Section 106 of the specifications, the IA lab monitors and audits the contractor's testers. The IA lab testers will visually audit or split samples with the contractor personnel to verify they are completing the tests in accordance with NDOT's test methods. The Construction Division and the IA lab will determine the number of audits required per contractor based on past performance and knowledge of the contractor testers. All contractor informational tests are subject to visual or procedural audits by NDOT field and IA lab testers at any time.

5-403.2.4 REPORT FORMS

The contractor's testers should complete daily reports of test results for contractor informational tests each day the respective work is performed. The contractor is not required to use NDOT test report forms, but the same information that is on the NDOT test forms must be included on the contractor's report forms. The Resident Engineer shall receive the contractor's informational tests on a daily basis, as stated in Subsection 106.04 of the specifications. Original test reports are preferred but not always feasible for a commercial source, as the same test reports may cover several projects.

The office person and Resident Engineer will review the test reports and return any errors or omissions to the contractor for corrections. The Resident Engineer will submit originals or copies of the contractor's test reports to the appropriate District IA lab. The IA lab will review the tests reports and return any errors or omissions to the Resident Engineer for the contractor to correct. Upon satisfactory completion, the IA lab will forward the contractor's test reports to the Construction Division.

5-403.2.5 FILES AND RECORDS

The contractor's lab should maintain copies of all field test reports for contractor informational tests. Staple worksheets with the contractor testers' handwritten initials to each report and file them chronologically by the type of material.

The Resident Engineer will maintain a file for contractor informational test reports.

5-403.2.6 EQUIPMENT

For the required tests, contractor labs should have the same or comparable equipment to NDOT field labs. Deviations from standard testing equipment must be coordinated in advance with the Construction Division.

5-403.2.7 LAB EQUIPMENT CALIBRATION

The contractor's lab equipment must be calibrated once a year or anytime the lab is moved. If questions arise, the Materials Division may assist with calibration of specific contractor equipment. Documentation of the calibration must be kept in the lab for review by the Resident Engineer.

5-404 PROJECT ACCEPTANCE TESTING (FIELD TESTS)

5-404.1 GENERAL

Acceptance tests are the tests conducted at the appropriate locations and times, using methods prescribed in the specifications. Table 5.1 (at the end of this section) lists acceptance tests and frequencies. Tables 5.2 and 5.3 lists sample sizes. The Materials Checklist Letter provided by the Materials Division identifies materials acceptance details for each project. Subsection 5-406, Field Office Record Keeping, outlines specific requirements for reporting test results. The remainder of this section of the *Construction Manual* provides additional instructions.

Project acceptance tests control the quality of the materials being incorporated or proposed for incorporation into the work. Field tests provide the basis for accepting materials incorporated into the project.

5-404.2 FIELD LABS AND TESTING EQUIPMENT

The field labs belong to the Equipment Division and are assigned to the Construction Division. The Construction Division assigns testing laboratories, usually of the mobile "trailer" type, for field use. The Resident Engineer uses and maintains these lab trailers and the equipment assigned to the lab.

5-404.2.1 LAB SETUP

Verify that the lab has water, gas, and electricity. The lab must be sufficiently stabilized to provide satisfactory footing for digital scales, sand equivalent apparatus, and other sensitive equipment. The contractor must provide the utilities for the labs per Section 628, Mobilization, of the specifications.

5-404.2.2 RESPONSIBILITIES

Obtain small testing equipment and certain testing supplies by requisition from the Headquarters Stockroom or a District Stockroom. Contact the Construction Division Quality Assurance Section for a list of equipment and supplies normally needed in a field lab. The Resident Engineer should obtain incidental supplies such as wheelbarrows, shovels, pliers, screwdrivers, and wrenches through the appropriate stockroom. For equipment not available through the stockrooms, the equipment and supplies may be obtained through the District IA Lab or Construction Division Quality Assurance Section.

The Resident Engineer requests equipment over $1,000 in the annual budget request to the District Engineer. If the District and the Construction Division approve the budget, the Construction Division purchases the equipment and distributes it accordingly. For equipment purchases under $1,000, the Resident Engineer submits a request to the District Engineer. The District and Construction Division must approve the request.

The Independent Assurance (IA) lab assigns Troxler Nuclear Density Gauges to construction crews on an “as needed” basis. The Resident Engineer is responsible for security, use, transportation, and care of this equipment during the assignment period. Use exceptional care in handling this equipment, especially while transporting it. Further information and guidance on the Nuclear Density Gauges is in Section 5-500, Nuclear Testing Program.

Only appropriate materials and equipment are authorized in the field lab. The Resident Engineer is responsible for enforcing this policy. No potentially offensive material (pictures, magazines, calendars, posters, etc.) is allowed in the field lab. The District Engineer is responsible for the security of the field lab and equipment when stored by the District. The contractor is responsible for the field lab security at the jobsite. Resident Engineer is required to contact the Equipment Division when the field lab needs to be moved. The Equipment Division will then schedule the move using Department or commercial movers. Coordinate with the Equipment Division to determine required preparation of the field lab and contents. The testers are responsible for stowing the equipment and supplies within the field lab.

5-404.2.3 INVENTORIES

An inventory of testing equipment for each lab trailer is conducted once a year, in June, and reported on NDOT form 040-020, “Inventory of Testing Equipment.” Most of the testing equipment is assigned to a specific lab trailer and the trailer number appears on the inventory. Submit a property adjustment form, NDOT form 072-006, “Property Adjustment,” before transferring testing equipment (property number items) from one trailer to another.

For equipment over $1,000, the Construction Division Quality Assurance Section should schedule and complete inventories for the Purchasing Division once a year.

5-404.2.4 LAB CALIBRATION

The Materials Division is responsible for scheduling equipment calibration within the field labs. They will contact the Resident Engineer to schedule the annual calibration and accomplish the calibration at the field lab site. The Materials Division calibrates ovens and scales annually. Any time a lab is moved, the Resident Engineer must contact the Materials Division (775-888-7792) to recalibrate the equipment.

5-404.3 EQUIPMENT REPAIR, MAINTENANCE, AND REPLACEMENT

Regular preventive maintenance, which is limited to cleaning, is necessary to maintain the field lab equipment in satisfactory operating condition.

Due to the manufacturers' guarantees and warranties and the sensitivity of the equipment, all personnel must strictly adhere to maintenance and servicing policies. Additional servicing or repair work of any kind is not authorized without prior approval from the Construction Division.

The Construction Division has personnel trained to repair equipment. Notify the Construction Division as soon as possible for the following equipment-related needs:

- Maintenance
- Repairs
- Removal of unnecessary equipment

This may include contacting District personnel for repairs to the field lab or contacting the IA lab or Construction Division to repair or replace equipment.

5-404.4 RETESTS

The following procedures apply to the retesting of materials that do not comply with the specifications. If the contractor disputes the test results, the first retest of unacceptable material should determine if the sampling and testing methods were correctly performed. If the retest produces similar results, the contractor should use an appropriate method to correct the unacceptable material.

Before completing further retests, the Resident Engineer should make sure that the contractor made a constructive effort to correct the unacceptable material. In the absence of corrective measures by the contractor, repetitive testing in an effort to get a passing test should not be allowed. Number retests according to the instructions in Section 5-406, Field Office Record Keeping.

For materials that fail to meet specifications but are incorporated into the work, the Resident Engineer must complete NDOT form 040-076, "Acceptance Test Summary Sheet," when the project is complete. Field testers track failing test results in the appropriate material field book by circling the failed test result in red, as described in Section 5-405, Field Office Record Keeping. Test results should be recorded in the field book daily. After the project is complete, the Resident Engineer completes an "Acceptance Testing Frequency Report," which summarizes all materials tested on the project.

5-404.5 MISCELLANEOUS SAMPLES AND TESTS

The Construction Division, District Engineer, or Federal Highway Administration (FHWA) may request that field testers sample and test materials or work that may be in question. Record these tests according to the instructions in Section 5-406, Field Office Record Keeping. .

5-405 FIELD OFFICE RECORD KEEPING

5-405.1 REPORT FORMS

Complete daily reports of test results the day the respective work is performed. Refer to Table 5.4 for the required report forms for various materials and tests. The Resident Engineer's office person checks the test reports. The Resident Engineer then reviews and signs the test reports. The Resident Engineer's signature confirms that the test results are accurate and completed in accordance with NDOT procedures. Once the test reports are completed, distribute them as detailed in Chapter 27 of the *Documentation Manual*.

Distribute all test reports within seven calendar days of test completion. Submit original field test reports to the appropriate District IA lab. The IA lab will review the tests reports and return any errors or omissions to the Resident Engineer for corrections. Upon satisfactory completion, the IA lab will forward the original test reports to the Construction Division.

Immediately notify the contractor of the preliminary test results. Give the final test results to the contractor as soon as possible but no later than seven calendar days after the test is completed.

Table 5.4 – Required Report Forms

Form Number	Report and Use
040-004	"Compaction Report" Relative Compaction of all construction materials
040-007 * 040-026 * 040-004	"Nuclear Compaction Report for Soils and Aggregates"
040-010 * 040-013 * 040-014 * 040-023 * 040-023A	"Daily Report of Tests Made in Field" Select Borrow Backfill Selected Material or Base Drain Backfill Aggregate Base Courses Screenings Sand Blotter Plantmix Aggregate Informationals Open-grade Aggregate Informationals (Aggregate stockpiles other than concrete)
040-011 * 040-050 * 040-053	"Daily Plant Report of Asphalt Mixtures" Plantmix Bituminous Base Plantmix Bituminous Surface Plantmix Bituminous Open-Graded Surface
040-016	"Report of Tests of Portland Cement Concrete Pavement" Flexural Strength Beams
040-017 * 040-017A * 040-017B * 040-030 * 040-048	"Nuclear Thin Layer Compaction Report for Plantmix Bituminous Pavements" Density on Bituminous Mix Pavements
040-035 * 040-013 * 040-006 * 040-023	"Report of Field Tests of Coarse and Fine Aggregate for Concrete" Concrete Pavements Concrete Structures
040-051	"Field Report of CTB Strength Tests" Plantmixed CTB Roadmixed CTB

* If required

5-405.1.1 COMPACTION REPORTS

Consecutively number compaction tests for a particular type of material for all sources. Code compaction tests as follows:

1. The first numbers represent the test number.
2. The next group of letters indicates the material used.
3. The next group of numbers indicates the minimum compaction requirement.
4. When retests are required, the fourth set of digits represents the retest number.

For example, if the test number is 218-S-95-2R, the code indicates test number 218, subgrade material, 95 percent minimum compaction as required by the specifications, and the second retest of the area represented by test number 218

Table 5.5 shows the codes to use for the different types of construction materials. It does not list special compaction requirements. Use of additional coding must be approved by the Construction Division Quality Assurance Section.

Table 5.5 – Construction Material Codes

Type of Material	Code	Specification Reference
Original Ground	OG	203.03.15
Subgrade (includes Roadway Excavation and Common Borrow in the Embankment)	S	203.03.15
Select Borrow	XB	203.03.15
Pipe Backfill	PB	207.03.01
Structure Backfill	SB	207.03.01
Foundation Fill	FF	208.03.01
Drain Backfill	DB	209.03.01
Type 1, Class B Aggregate Base	1B	302.03.06
Type 2, Class B Aggregate Base	2B	302.03.06
Type 3, Class B Aggregate Base	3B	302.03.06
Type 1, Class A Aggregate Base	1A	302.03.06
Type 2, Class A Aggregate Base	2A	302.03.06
Type 3, Class A Aggregate Base	3A	302.03.06
Portland Cement Treated Base	CTB	304.03.05
Roadbed Modification	RBM	305.03.05
Mechanically Stabilized Earth Backfill	MSE	640.03.02

5-405.1.2 NDOT REPORT FORM 040-010, "DAILY REPORT OF TESTS MADE IN FIELD"; 040-051, "FIELD REPORT FOR CTB STRENGTH TESTS"; AND 040-052, "DAILY REPORT FOR CTB MIXTURE"

Consecutively number reports for a particular type of material for all quantities obtained from each deposit (source). Consecutively number each of the two types of samples, informational or acceptance, on a daily basis.

Code test numbers as follows:

1. The first letter is "T" for acceptance test or "I" for informational test.
2. The second set of numbers represents the daily test number.
3. The third set of numbers represents the report number.
4. When retests are required, the fourth set of numbers represents the retest number.

The following are examples of test code numbers:

- Acceptance Test Number T-1-31 represents the first test taken at the acceptance point on Report Number 31.
- Acceptance Test Number T-1-31-R2 represents the second retest, taken at the acceptance point, of material previously tested and pertains to Acceptance sample number 1, Report Number 31.
- Informational Test Number I-1-31 represents the first informational test taken at the plant on Report Number 31.

5-405.1.3 NDOT REPORT FORM 040-035, "REPORT OF FIELD TESTS OF COARSE AND FINE AGGREGATE FOR CONCRETE"

Consecutively number reports for a particular type of material for all quantities obtained from each deposit (source) and for each mix design. Consecutively number each of the two types of samples, informational or acceptance, on a daily basis.

Code test numbers as follows:

1. The first letter is "T" for acceptance test or "I" for informational test.
2. The second set of numbers represents the daily test number.
3. The last set of numbers represents the report number.

The following are examples of test code numbers:

- Acceptance Test Number T-1-31 represents the first sample taken at the acceptance point on Report Number 31.
- Informational Test Number I-1-31 represents the first informational sample taken at the plant on Report Number 31.
- Acceptance Test Number T-1-29-2R represents the second retest, taken at the acceptance point, of material previously tested and pertains to Acceptance Sample Number 1, Report Number 29.

5-405.1.4 NDOT REPORT FORM 040-011, "DAILY PLANT REPORT OF ASPHALT MIXTURES"

Consecutively number reports for a particular type of asphalt mixture for all quantities obtained from each deposit (source). Consecutively number each of the two types of samples, informational or acceptance, on a daily basis.

5-405.2 FILES AND RECORDS

File copies of all field test reports in the field laboratory. Staple compaction retests to their corresponding original failing test. Keep summaries of all project acceptance tests in field books. These material summaries keep track of failing tests and areas to retest. They also allow quick access to test results and frequencies.

Number each page in the book 1 through 80 on the top right corner. Include a title page, a complete index, and an initial key, as shown in the following field book examples.

Submit all field lab books to the office when the project is complete.

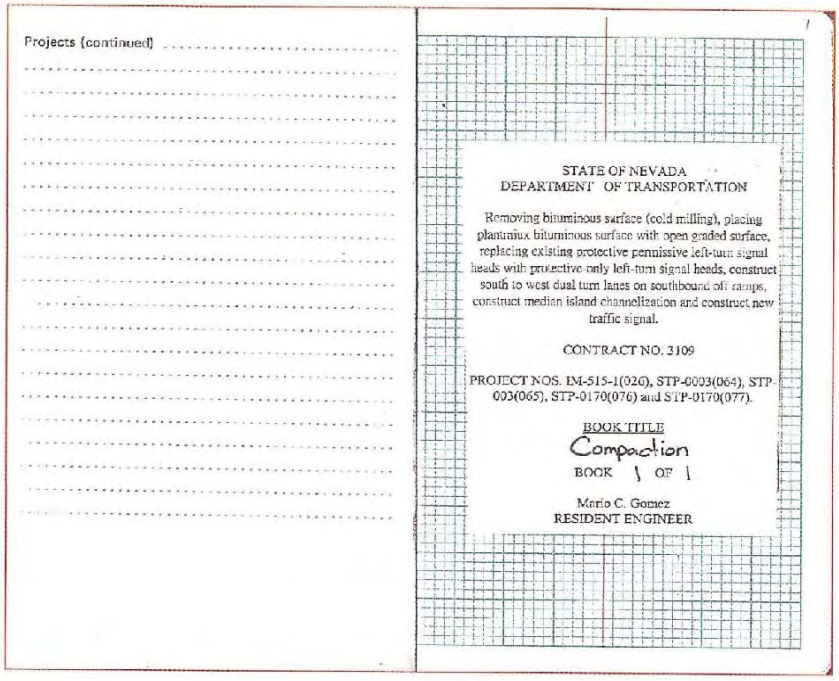
5-405.3 FIELD BOOKS

This section addresses the following three required field books:

- Compaction Book
- Sieve Book
- Concrete Book

5-405.3.1 COMPACTION BOOK

Set up Compaction Books according to the examples in Figures 5-405.1, 5-405.2, and 5-405.3. Record remarks such as an audit, an occasional check of quantities placed, or addition of testing frequencies. Circle all failing tests in red so they can be identified quickly. Document each material in chronological order for test numbering.



Projects (continued) .....

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

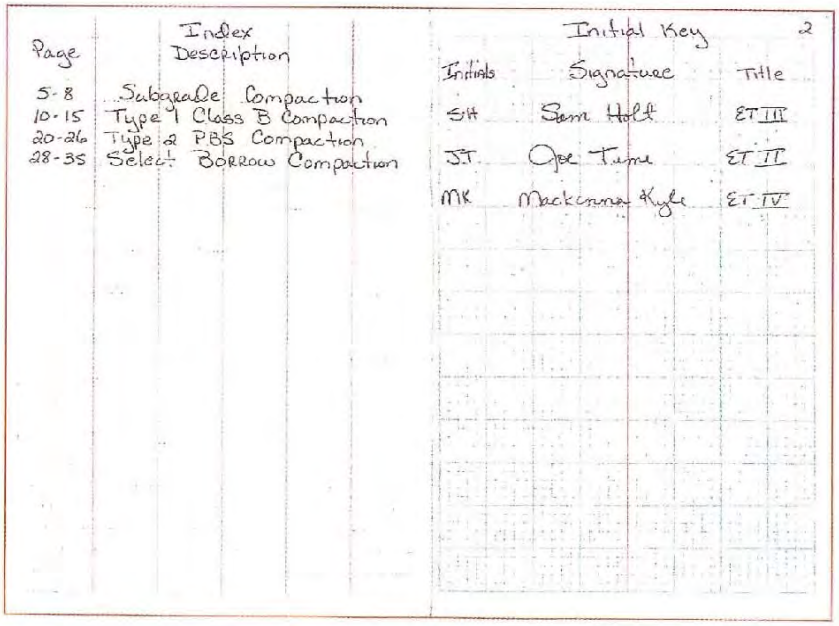
Removing bituminous surface (cold milling), placing plantmix bituminous surface with open graded surface, replacing existing protective permissive left-turn signal heads with protective-only left-turn signal heads, construct south to west dual turn lanes on southbound off ramps, construct median island channelization and construct new traffic signal.

CONTRACT NO. 3109

PROJECT NOS. IM-515-1(026), STP-0003(064), STP-003(065), STP-0170(076) and STP-0170(077).

BOOK TITLE
Compaction
BOOK 1 OF 1

Mario C. Gomez
RESIDENT ENGINEER



Index

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10-15	Type 1 Class B Compaction
20-26	Type 2 PBS Compaction
28-35	Select Borrow Compaction

Initial Key 2

Initials	Signature	Title
SH	Sam Holt	ET III
JT	Joe Tune	ET II
MK	Mackenna Kyle	ET IV

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Figure 5-405.1. Compaction Book Example 1.

Subgrade Compaction S-90 5

Test #	Date	Tested by	Station	Embank Depth	Dist. ℄	% Comp	R-1	R-2	R-3	Remarks
1-S-90	6-10-06	J.T.	"X" 108+10 RT	5'	10'	95				Full curve ran
2-S-90	6-12-06	J.T.	"X" 120+00 LT	4'	12'	89	92			Audit by Prog. Lab. Contractor reworked area retest passed
3-S-90	6-21-06	SH	"X" 105+92 RT	4'	11'	85	89	91		Area reworked 2nd retest passed
4-S-90	7-1-06	J.T.	"X" 115+10 RT	4'	10'	92				Audit By Prog. Lab

Type 1 Class B Base Compaction (1B-95) 10

Test #	Date	Tested by	Station	Embank Depth	Dist ℄	% Comp	R-1	R-2	R-3	Remarks
1-1B-95	7-7-06	J.T.	"X" 90+89 RT	.5'	10'	95				Full curve ran used the gauge core
2-1B-95	7-7-06	mk	"X" 94+75 RT	.5'	8'	96				used for gauge core.
3-1B-95	7-9-06	mk	"X" 92+00 RT	.5'	8'	95				used for gauge core.
4-1B-95	7-12-06	J.T.	"X" 84+72 LT	.5'	10'	95				used for gauge correlation check
5-1B-95	7-14-06	mk	"X" 80+19 LT	.5'	8'	94	96			used for gauge correlation check Audit by Prog. Lab

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Figure 5-405.2. Compaction Book Example 2.

Type 2 PBS Compaction 20

Test #	Date	Tested by	Gauge Set #	C.F.	Station To Station	% Comp	Rice	Remarks
1-Pm-1 To 1-Pm-5	7-7-06	mk	144	1.01	"X" 257+00 To "X" 257+70	95	155.9	Gauge corr w/ Lacres test section passed
2-Pm-1 To 2-Pm-5	7-8-06	mk	144	1.01	"R26" 0+40 To "R26" 2+00 LT	95	156.2	
3-Pm-1	7-8-06	mk	144	1.01	"R26" 0+01 LT	94	156.5	End of day small section
4-Pm-1 To 4-Pm-5	7-9-06	mk	144	1.01	"L" 98+30 To "L" 105+50 LT	94	156.9	

Select Borrow Compaction XB-95 28

Test #	Date	Tested by	Station	Embank Depth	Dist ℄	% Comp	R-1	R-2	R-3	Remarks
1-XB-95	5-12-06	SH	"L" 20+19 RT	6'	12'	95				Gauge Corr. Prog. Lab. audit
2-XB-95	5-12-06	SH	"L" 22+00 RT	6'	12'	97				Gauge Corr
3-XB-95	5-12-06	SH	"L" 24+00 RT	6'	13'	97				Gauge Corr
4-XB-95	5-14-06	SH	"L" 20+19 RT	6'	12'	96				Gauge Corr check
5-XB-95	5-16-06	SH	"L" 18+18 RT	6'	13'	95				Gauge Corr check
6-XB-95	5-17-06	SH	"L" 14+20 RT	6'	11'	93	95			Contractor Reworked mat. passed.

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Figure 5-405.3. Compaction Book Example 3.

5-405.3.2 SIEVE BOOK

Keep summaries of project sieve analysis and other test results for aggregate materials in a field Sieve Book in the following manner:

1. Document each source in its own subsection. Divide each book into sections for each type of material. (Example: Type 1 Class B Aggregate Base, Type 2 Plantmix Bituminous Surface, Plantmix Bituminous Surface Open-Graded, Shoulder Material, Aggregate for Portland Cement Concrete Pavement, Concrete Aggregates)

2. Include the following in each section:

   a. Test Identification – Consecutively list tests and identify each with the date and sample location. (Refer to Section 5-406, Field Office Record Keeping, for test numbering systems.)

   b. Test Results – List numerical results of all acceptance tests; however, do not list sieve analysis results screen-by-screen. If all screens are in the specification, note the results as “P” (passing) or “F” (failing) and explain in the remarks.

   c. Retests and Remarks – Include the date and test number of passing retests with an explanation of the corrective action taken.

3. List only acceptance tests in the Sieve Book. Keep summaries of informational samples in a separate book (Informational Book), if required by the Resident Engineer.

4. Figures 5-405.4, 5-405.5, and 5-405.6 show a sample page from the Type 1 Class B Aggregate Base, Type 2 Plantmix Bituminous Surface, Plantmix Bituminous Surface Open-Graded, Shoulder Material, Aggregate for Portland Cement Concrete Pavement, and Concrete Aggregates. Although other types of material will have different tests listed, follow the same basic arrangement for all materials.

5. Circle all failing tests in red so they can be identified quickly.

Type 1 Cls B Base (Sieves) 5

Test#	Date	Tested by	Station	Course	Grad P/F	L.L.	P.I.	F.F.	Remarks
T-1-1	4-1-06	J.T.	2" 102+50 LT	Top window	P	24	2	92	Progress Lab Audit
T-2-1	4-1-06	J.T.	2" 114+00 LT	Top LT window	F	27	5	80	F.F. FAILED 14% passing #200
T-2-1R1	4-2-06	J.T.	2" 114+00 LT	Top LT window	P	22	2	93	Retest passed
T-1-2	4-9-06	J.T.	2" 129+00 LT	Top RT window	P	24	3	96	
T-1-3	4-10-06	J.T.	2" 149+00 LT	Bottom LT window	P	26	2	95	

Type 2 PBS (Sieves) 16

Test#	Date	Tested by	Mix Design#	JMF#	Gradation P/F	Station	Bit Ratio	Rice	% moist	F.F.	Remarks
T-1-1	6-12-06	SH	BF06-12	1	P	5" 29+00 LT	4.85	155.1	.06	99	Stabilities Submitted
T-2-1	6-12-06	SH	BF06-12	1	P	5" 88+10 LT	5.00	155.1	.04	100	SPLIT w/Proglab
T-3-1	6-12-06	SH	BF06-12	1	P	5" 91+00 LT	4.90	153.7	.04	100	
T-1-2	6-19-06	SH	BF06-12	1	F	5" 31+00 RT	5.40	150.3	.02	100	Stabilities submitted
T-2-2	6-19-06	SH	BF06-12	1	P	3" 62+12 RT	4.90	153.5	.02	100	

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Figure 5-405.4. Sieve Book Example 1.

3/8" Opengrade (Sieves) 27

Test #	Date	Tested by	mix Design #	JMF #	Gradation P/F	Station	Bit Ratio	% moist	F.F	Remarks
T-1-1	7-25-06	SH	BF06-29	2	P	L' 10+20 LT	8.1	.03	100	
T-1-2	7-26-06	SH	BF06-29	2	F	L' 29+00 LT	8.9	.04	100	23% pass #40 out of spec O.L
T-1-3	7-27-06	SH	BF06-29	2R	P	L' 49+00 LT	8.2	.04	99	
T-1-4	8-9-06	J.T.	BF06-29	2	P	L' 72+00 LT	7.9	.02	100	

Shoulder Material (Sieves) 38

Test #	Date	Tested by	Station	Gradation P/F	PF	Remarks
T-1-1	3-13-06	J.T.	'K' 7+29 LT	P	9	
T-2-1	3-13-06	J.T.	'K' 17+31 LT	P	8	
T-1-2	3-17-06	SH	'K' 29+30 LT	P	9	
T-1-3	3-18-06	SH	'K' 30+01 RT	F	16	18% passing #200 12 max P.I. got 16
T-1-3R1	3-18-06	SH	'K' 30+00 RT	P	12	
T-2-3	3-18-06	SH	'K' 10+05 RT	P	9	

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Figure 5-405.5. Sieve Book Example 2.

PCCP Aggs (sieve) mix # 3628 58

Test #	Date	Tested by	Coarse P/F	Fines P/F	Comb P/F	C.V.	S.E.	Fine mod	Base fine mod	Remarks
T-1-1	2-12-06	mk	P	P	P	73	85	2.99	2.99	
T-1-2	2-14-06	mk	P	P	F	89	89	2.60	2.80	#8 + #16 combined Failed on
T-1-2R1	2-17-06	mk	P	P	F	86	88	2.89	2.83	#8 + #16 Rem. stockpile Failed cont.
T-1-3	2-19-06	mk	P	P	P	91	91	2.71	2.80	

DA mod Sieves mix #503 69

Test #	Date	Tested By	Coarse P/F	Fines P/F	CV	SE	Fine mod	Base fine mod	Remarks
T-1-1	9-17-06	J.T.	P	P	85	82	2.51	2.51	
T-1-2	9-18-06	J.T.	P	P	91	81	2.60	2.56	
T-1-3	9-19-06	J.T.	P	P	92	83	2.57	2.56	

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Figure 5-405.6. Sieve Book Example 3.

5-405.3.3 CONCRETE BOOK

Set up Concrete Books according to the example Figure 5-405.7. Document audit remarks or occasional quantities checks. Circle all failing tests in red so they can be identified quickly.

PCCP Fresh Concrete (mix #3628) 5

SET#	Date	Station	Slump	% Air	Unit weight	Beams	Temp	PSI	Tested by	Remarks sample of cement & Fly Ash submitted
1	2-12-06	# at Plant	2.0"	5	127.7	—	71°F	4000	J.T.	
—	2-12-06	# at Plant	3.0"	6	127.6	—	71°F	4000	J.T.	
—	2-12-06	# at Plant	2.0"	5	127.3	1	71°F	4000	J.T	
2	2-12-06	# at Plant	3.0"	5.5	127.6	—	70°F	4000	J.T.	
—	2-12-06	# AT Plant	3.0"	5.5	127.6	—	70°F	4000	J.T.	

DA Mod Fresh Concrete (mix #503) 26

SET#	Date	Station	Before Slump	After Slump	% Air	Unit weight	Temp	PSI	Tested by	Remarks
1	9-17-06	"L" 27+91 LT	1.0"	5"	6	129.2	71°F	3000	J.T.	
—	9-17-06	"L" 28+21 LT	1.0"	5"	6	—	70°F	3000	J.T.	
—	9-17-06	"L" 28+56 LT	1.5"	5"	6.5	—	71°F	3000	J.T.	
—	9-17-06	"L" 28+91 LT	1.0"	5"	6	—	71°F	3000	J.T.	
2	9-17-06	"L" 29+26 LT	1.5"	6"	7	130.2	71°F	3000	J.T.	
—	9-17-06	"L" 29+61 LT	1.5"	5.5"	6.5	—	71°F	3000	J.T.	

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Figure 5-405.7. Concrete Book Example.

5-405.4 TRANSMITTALS

When submitting samples to the Materials Division, verify that they are accompanied by the appropriate transmittal. Completely fill out transmittals. Incomplete and inaccurate transmittals may result in delayed test results. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for copies of the transmittals. Following are the three transmittal forms:

- NDOT form 020-018, “Transmittal for Test Samples and Certifications”
- NDOT form 020-016, “Transmittal for Asphalt Samples”
- NDOT form 020-017, “Transmittal for Concrete Samples”

Following are the standard sample containers available from the Headquarters Stockroom:

- Aggregate and Stone: Sack, sample large cotton canvas, 19" x 32"
- Slurry Backfill, Plantmix Bituminous Surface and Portland Cement Concrete (when the maximum aggregate particle size exceeds 1"): Mold, cylinder plastic 6" x 12"
- Portland Cement Concrete for Structures: Mold, cylinder plastic 4" x 8"
- Liquid Asphalts: Can, rectangular metal, 1 quart, sample with lid
- Fly Ash, Hydrated Lime, and Portland Cement: first bag, sample polyethylene 10"x20" open end, place polyethylene bag inside a sack, sample small cotton canvas
- Water and Emulsified Asphalt: Bottle, plastic wide mouth with lid, 1 quart
- Asphalt Cement, Traffic Paint and Traffic Beads: Can, paint round 1 quart with lid

5-405.5 DISTRIBUTION

File copies of all field test reports in the field laboratory. At the end of each day, the tester forwards original test reports to the Resident Engineer. The office person and Resident Engineer will review the test reports. After review, the Resident Engineer retains a copy of the test report then submits original test reports to the appropriate District IA lab. The IA lab will review the tests reports and return any errors or omissions to the Resident Engineer to correct. Upon satisfactory completion, the IA lab will forward the test reports to the Construction Division. Chapter 27 of the *Documentation Manual* provides additional information on distribution of test reports.

5-406 TESTING PERFORMED BY OTHER DIVISIONS

5-406.1 MATERIALS DIVISION

This section provides contact information for Materials Division testing performed in Carson City and Las Vegas. This section also lists the tests performed at each location. The Resident Engineer and field testers should direct their questions on field lab procedures to the appropriate lab.

5-406.1.1 AGGREGATE LAB

- Carson City (775-888-7791): Borrow, select borrow, aggregate base, backfill, granular backfill, MSE backfill, drain backfill, riprap, riprap bedding, top soil, screenings, deicing sand, plantmix bituminous surface aggregates, portland cement concrete aggregates
- Las Vegas (702-671-6646): Screenings, portland cement concrete aggregates

5-406.1.2 BITUMINOUS LAB

- Carson City (775-888-7872): Dense-graded and open-graded plantmix bituminous surface mix designs, dense-graded plantmix bituminous surface behind the paver samples
- Las Vegas (702-671-6628): Dense-graded plantmix bituminous surface behind the paver samples

5-406.1.3 STRUCTURAL LAB

- Carson City (775-888-7871): Concrete cylinders, reinforcing steel, tensioning strand, concrete aggregates, slurry backfill, concrete cores
- Las Vegas (702-671-6646): Concrete cylinders, reinforcing steel, slurry backfill, metal fence posts, guideposts, chain link fence, corrugated metal pipe

5-406.1.4 ASPHALT LAB

- Carson City (775-888-7879): Refinery samples, asphalt cement, bituminous emulsion, bituminous liquid
- Las Vegas (702-385-6579): Asphalt cement, bituminous emulsion, bituminous liquid

5-406.1.5 CHEMICAL LAB

- Carson City only (775-888-7718): Paint, traffic beads, water, hydrated lime, guideposts, metal fence posts, chain link fence, sign posts, corrugated metal pipe, wire mesh, fly ash, cement

5-406.1.6 PAVEMENT ANALYSIS SECTION

- Carson City only (775-888-7173): Final concrete pavement samples of portland cement concrete pavement

5-406.1.7 R-VALUE LAB

- Carson City only (775-888-7869): Borrow, select borrow, aggregate base, granular backfill, MSE backfill

5-406.2 STRUCTURES DIVISION NON-DESTRUCTIVE TESTING SECTION

5-406.2.1 STRUCTURAL STEEL

The Structures Division Non-Destructive Testing Section is responsible for the inspection and testing of structural steel construction. This section oversees the inspection and testing during erection, welding, and paint application to structural steel. This section is also involved in material certification reviews and visits steel fabrication plants to confirm compliance with specifications. The Resident Engineer coordinates closely with the Non-Destructive Testing Section and Materials Division to ensure inspection, sampling, and testing are accomplished as specified. The Structures Division may also request testing specific samples of structural steel from field sites. The Non-Destructive Testing Section inspector will mark the specific locations of the steel for testing and the contractor will provide that sample for the Resident Engineer to ship to the Materials Division for testing.

Following are general inspection areas for structural steel:

- Structural Steel Fabrication Inspection (includes bridges, column casings, signs, signal bridges)
  - Magnetic particle testing of welds and base metal
  - Dye penetrant testing of welds and base metal
  - Ultrasonic testing of welds and base metal
  - Visual inspection of welds and base metal
  - Radiographic interpretation of x-ray film of welds
  - Dry film paint thickness measurements
  - Bolt testing, field and shop
  - Mechanical tests on steel
- Post-tensioning and Prestressing of Concrete Structures
  - Observe and monitor stressing of tendons with pressure cell and strain gauge and measure elongation
  - Inspect rebar and strand placement in prestressed concrete members at fabrication shop
  - Perform flow cone test
  - Test concrete
- Ground Anchors
  - Monitor stressing of anchors with pressure cell and strain gauge and measure elongation

The Structures Division Non-Destructive Testing Section inspector will also collect samples of nuts, bolts, and washers and coordinate with Materials Division for testing. The Resident Engineer will coordinate with the contractor to make the required materials available.

5-406.3 MATERIALS DIVISION AND STRUCTURES DIVISION NON-DESTRUCTIVE TESTING SECTION

Testing and sampling for soil nail walls and mechanically stabilized earth (MSE) walls are specialized and systematic. Testing is done by the Materials Division and Structures Division Non-Destructive Testing Section. The Resident Engineer is responsible for coordinating the testing activities. The following information is a list of tests that aid in verifying conformance with specifications:

- Plasticity index
- Gradation
- Resistivity
- Chlorides
- Sulfates
- pH Value

Follow these guidelines when performing these tests:

- Obtain certifications from the contractor that meet the requirements of friction angle and magnesium soundness and send to the Materials Division.
- The Resident Engineer's inspector provides samples of Mechanically Stabilized Earth (MSE) backfill to the Materials Division.
- The Resident Engineer sends pile material certifications to the Materials Division for approval.
- Contact Structures Division Non-Destructive Testing Section at 775-888-7731 with any questions.

5-500 NUCLEAR TESTING PROGRAM

The information in this section provides important information relating to NDOT's Nuclear Testing Program and is not inclusive of all policies and procedures required for use of nuclear testing devices. Proper training, licensing, and qualifications are required before operating, storing, and transporting nuclear density gauges.

The Nevada State Health Division (Radiological Health Division), which enforces NRS 459.010, 459.290, and NAC 459, is the state radiation regulating and control agency and provides NDOT with its Radioactive Materials Licenses. NDOT has five licenses (Carson City, Elko, Reno, Winnemucca, and Las Vegas). The NDOT Construction Division is responsible for policies and procedures that are specific to NDOT construction operations and conducts mandatory training. NDOT policy and procedures authority resides with the Construction Office (775-888-7226). The District Radiation Safety Officer (RSO) is the first contact for any non-routine procedures and the first contact for any questions that may arise involving the Nuclear Testing Program and equipment.

NDOT does not allow pregnant women to test with, train with, or transport nuclear density gauges. Allowing anyone who is not certified by the Department to handle, transport, or store nuclear density gauges is a violation of state licensing requirements. State and federal regulations prohibit the storage of consultant gauges at or in NDOT facilities.

5-501 TRAINING AND SAFETY

To transport gauges, individuals must successfully complete a 4-hour class on nuclear density gauge safety. To transport and operate nuclear density gauges, individuals must pass a 40-hour class and then become NAQTC qualified in the Sampling and Density module. The 40-hour training class is divided into two parts: Radiation Safety and Gauge Operation. The Corporate RSO teaches radiation safety, and the District RSO teaches gauge operation. Once this is completed, candidates must pass the written and performance exams for the NAQTC Sampling and Density module. When these requirements are completed, the individual is permitted to operate and transport nuclear density gauges.

NAQTC qualification is required every five years and nuclear density gauge safety training is required every three years. After completing the 40-hour certification class, students receive a white card. After completing the 4-hour safety class, students receive a yellow card.

Every six months, Resident Engineers receive a list of personnel whose certification will be expiring and a posting of the next training class. NDOT also sends an annual reminder to certified individuals, informing them of training received and certification expiration dates.

All field testers must become familiar with basic safety procedures for the operation, storage, and transportation of the gauges. Field testers will become intimately familiar with the safety procedures for operation, storage, and transportation of the gauges. The following are a few safety reminders:

- Remember the importance of radiation safety. Three ways to limit radiation exposure effects are to reduce time exposed, keep a safe distance from the radiation source, and shield yourself.
- Post a copy of the "State of Nevada Radiological Emergency Response Plan" in each field office and field lab.
- Properly store the gauge if it is not in use.
- Do not allow non-certified individuals to operate or handle the gauges. Keep non-certified personnel at least 15 feet from the gauges.
- The Thermal Luminescent Dosimeter (TLD) or Optically Stimulated Luminescent (OSL) badges monitor the occupational dose of radiation. Leave these badges at work in the area of control badges for the crew. Do not leave badges at or near the gauges.
- If the nuclear density gauges are damaged at the jobsite, do not move anything related to the damage. Stop all operations around the site and start the emergency procedure published on the shipping papers.
- Immediately report non-routine incidents to the District RSO (Elko: 775-777-2724, Las Vegas: 702-385-6590, Reno: 775-834-8338, Winnemucca: 775-623-8075).
- When the gauge is not in operation, set the handle to the "SAFE" position.
- Always use the handle to pick up the gauge. Do not reach under the gauge to move it.
- Field testers must carry their certification cards while operating a gauge. They must also properly wear their TLD badge or OSL badge while operating or transporting a gauge.
- Always follow the proper storage, operation, and transportation procedures.
- Testers and transporters must carry the shipping papers in the truck on the seat next to the driver when the gauge is in transport. .

5-502 QUALIFICATION REQUIREMENTS

5-502.1 OPERATION AND TRANSPORTATION CERTIFICATION (WHITE CARD)

Each first-time candidate for qualification and certification and anyone with an expired certification card must complete the following minimum requirements:

1. Attend a 40-hour training class
2. Pass a safety exam
3. Pass an operation and safety exam
4. Qualify through the NAQTC Program (Sampling and Density Module)

To maintain qualification, the individual must:

1. Attend a 4-hour safety class every three years before certification expires
2. Pass a safety exam
3. Maintain NAQTC qualification

Individuals who allow their safety card to expire must meet the same requirements as a first-time certification candidate.

5-502.2 TRANSPORTATION CERTIFICATION (YELLOW CARD)

Individuals must maintain the following minimum requirements to transport the nuclear density gauges:

1. Attend a 4-hour safety class every three years
2. Pass a Safety Exam

5-503 STORAGE AND TRANSPORTATION

The gauges are either in "storage" or in "transport" status. Permanent storage is when the gauge is located in the District storage area. Temporary storage is when a gauge is located in a field lab. The gauges cannot be in temporary storage for more than six months. If the gauge's temporary storage must extend beyond six months, the District RSO will transfer the gauge into permanent storage then transfer it back to the field lab to the temporary storage status.

When in storage, the gauges must maintain three independent physical locks: In the locked field lab; in the locked closet; and in the case provided with the gauge handle locked. Other storage requirements are:

- Notice to Employees – Place beside the outside of the closet door in the field lab.
- Radioactive Material – Place on the right side of each exterior door outside of the field lab.
- The gauges must be stored at least 15 feet from the nearest full time work station.

During transport, follow these rules:

- Strap the gauge to the truck so it cannot move more than a quarter of an inch.
- Constantly watch the gauge during transport
- Maintain the following four locks at all times:
  - Lock on gauge handle
  - Lock on case
  - Case locked to truck bed with bike lock and with locked chain
- Use the tie-down straps, which are supplied with the gauge, when the gauge is in the bed of a truck and the truck is moving.
- Whether the truck moves one foot or 10 miles, the gauge *must* be strapped down.

The United States Department of Transportation (USDOT) identifies NDOT as a "Licensee who transports gauges to and from temporary job sites." USDOT does not distinguish between local or state agencies and civilian transporters of radioactive materials. This establishes the documentation requirements for the transport of NDOT nuclear density gauges; therefore, shipping papers are required to:

- Be on the seat next to the driver when transporting or testing with a nuclear density gauge
- Be gauge specific (each set of shipping papers belongs to a particular gauge)
- Contain emergency procedures and contacts as well as radioactive material description

5-504 OPERATION

NDOT uses Troxler Nuclear Density Gauge Models 3440, 3450, and the 4640-B for conducting density and moisture tests. Find the directions for operating the gauge and taking tests in Nevada Test Methods T101, T102, T103, T104, T324, T335, T336, and T750. Gauge Models 3440, 3450, and 4640-B test density of the materials, while the 3440 and 3450 also test moisture content.

Only qualified personnel may operate the gauges. Field testers will comply with operating instructions as provided by NDOT qualification training.

NDOT provides radiation monitoring badges to all personnel qualified to transport and operate the gauges. Upon completion of the training, each qualified individual receives a badge. Personnel must wear the TLD or OSL badge between the waist and the shoulders. It must be on the torso since this type of badge measures exposure of soft tissue and internal organs.

Reminders:

- Do not allow anyone who is not certified by the Department to operate or handle the gauges.
- Make the tester's certification card easily accessible.
- Wear the radiation monitoring badge properly when transporting and operating gauges.
- Keep gauges in a safe position when not taking measurements.
- Be aware of your surroundings – avoid damage to gauges.
- Always carry gauges by the handle.

5-505 GAUGE REPAIR, MAINTENANCE, AND CALIBRATION

For repair and maintenance, nuclear density gauges require special handling by trained individuals. Transporters and operators are not authorized to provide any maintenance or repairs to the gauges. If the gauges require maintenance or repair, immediately contact the IA lab testers, who will determine the repair level. The IA lab testers located in Las Vegas, Reno, Winnemucca, and Elko may repair the nuclear density gauges as long as the sealed source does not need to be removed. If the source needs to be removed in order to repair the nuclear density gauge, then it will be sent to Carson City to the Corporate RSO for repairs. Under no circumstances will the field testers try to fix a gauge, unless directed by the Corporate RSO. Contact the Corporate RSO at 775-888-7114.

The Corporate RSO maintains and calibrates the gauges every two years. Maintenance will occur earlier if a problem exists with the gauge.

5-505.1 PERIODIC PREVENTIVE MAINTENANCE SCHEDULE

- Inspection and inventory – Twice a year, December or January, and June or July
- Leak tests – January
- Calibration – Every two years
- Source rod inspections – Every two years, or when gauge repairs are required

5-506 INSPECTIONS

Nevada Radiological Health Division enforces the proper use, storage, and transportation of nuclear devices. They will periodically inspect the program at any time and in any location. They accomplish their inspection responsibilities both announced and unannounced and may inspect field testers on the job.

For job site inspections, expect the Radiological Health Inspector to visually observe from a distance and then approach the tester to ask detailed questions to confirm the tester is following all rules, laws, and regulations. Give full cooperation to the Radiological Health Inspector. Ask the Radiological Health Inspector for a business card and identification from their authority. Follow these guidelines when working with the inspector:

- Provide your certification card for verification.
- Allow complete observation and access to documentation and records.
- Answer all questions as accurately as possible.
- Report the inspection to your District RSO immediately.

5-507 FILES AND RECORDS

The gauges are permanently stored in the District storage area. When a construction crew needs a gauge, they contact the District RSO to coordinate required duration and specific needs. The District RSO will then transfer the gauge to the construction crew and complete all the proper paperwork. The construction crew will receive the following required transport documents:

- NDOT form 040-031, “Nuclear Gauge Transfer and Packing Form”
- Shipping papers (gauge specific)
- List of emergency contacts

When the construction crew is finished with the gauge, they return the gauge with the required transport documents. If a gauge is transferred to another construction crew, then transfer documents need to be completed showing this change. The field lab and the construction crew office keep a copy of the transfer documents and send copies to the IA lab. The Corporate Radiation Safety Officer retains the original transfer document.

5-508 RADIATION EXPOSURE MONITORING

The Corporate RSO provides policy on maintaining records for the Radiation Exposure Monitoring program. The District RSO and IA lab retain the individual records for exposure badge results. The exposure that the state monitors is the Occupational Dose; therefore, it is important to maintain the badges and records at the work site.

Every quarter, the Corporate RSO issues a different color badge with a starting date for that quarter. The Corporate RSO sends the assigned badges to the field crew. The field crew assigned the badges wear them while transporting or operating the nuclear density gauges for one quarter (three months). At the end of that quarter, the Corporate RSO sends new badges to the field crew, and the field crew returns the badges from the previous quarter to the Corporate RSO.

Corporate RSO sends these badges to a testing company to determine each person's radiation exposure during that quarter. The testing company sends a report to the Corporate RSO, who then sends the report to the IA testers. The results are available to the individuals upon request.

Every District RSO receives two visitor badges every quarter. If any non-certified person will be working within 15 feet of the gauges, they will need a visitor badge assigned to them. The visitor must complete the Visitor Badge Assignment form supplied by the District RSO. This badge will be assigned to the individual for the entire quarter; however, if the individual no longer needs the badge before the quarter is over, it should be returned to the District RSO. This visitor badge cannot be assigned to any other person.

5-600 INDEPENDENT ASSURANCE PROGRAM

The Independent Assurance (IA) sampling and testing program independently verifies the reliability of the results of field sampling and acceptance testing. It also verifies contractor and state testing procedures. The IA lab, located in each District facility, is responsible for checking all projects within the District. The IA lab and its testers are not associated with the project field testers, which are under the supervision of the Resident Engineer. This assures an independent check on the field crew testing procedures. IA lab test results are not used to determine the quality and acceptability of the materials and workmanship directly.

5-601 RESPONSIBILITIES OF THE INDPENDENT ASSURANCE TESTERS

The IA lab is responsible for auditing field testers in accordance with the "Minimum Required Samples and Tests - Independent Assurance." This consists of the following:

- Performing visual audits as well as direct splits
- Maintaining testing consistency throughout the District by verifying that NDOT's testing procedures are utilized and performed correctly by NDOT, consultant, and contractor testing personnel
- Verifying that all personnel testing on NDOT projects possess the necessary NAQTC or WAQTC and ACI qualifications
- Performing inspections on NDOT, consultant, and contractor field labs to verify that equipment meets the requirements of the test methods and is in good working condition
- Performing field lab safety inspections twice a year and completing NDOT form 040-055, "Field Lab Safety Equipment Inspection"
- Performing requirements as District RSO
- Reviewing test reports for accuracy and completeness
- Acquiring and distributing testing equipment to field testers as needed
- Providing training for the NAQTC/ACI written and performance exams and instructing NDOT's Testing School
- Assisting in yearly equipment budget request
- Providing equipment repair and maintenance

5-601.1 RELATIONS WITH FEDERAL HIGHWAY ADMINISTRATION (FHWA)

FHWA Area Engineers may collaborate in sampling and testing.

5-602 INDEPENDENT ASSURANCE SAMPLES AND TESTS

IA testers or field testers should perform sampling in the presence of and at the locations indicated by the IA tester. The IA tester should continually retain custody of the samples from the time they are taken until they are delivered to the IA lab.

The minimum frequency schedule in Table 5.7 (at the end of this section) outlines the materials to be sampled, sample locations, and tests to perform. When Table 5.7 allows more than one test method for a particular test, the IA testers must use the same method used by the field crew tester.

Table 5.7 also outlines the minimum frequency requirements. Use these frequencies when field testing procedures are observed to be correct (audits) and good correlation exists between the field crew and IA test results. Whenever these conditions do not exist, increase the frequency of IA samples and tests to provide greater control.

IA testers should try to sample each project uniformly throughout the construction period to avoid testing numerous samples at one time. Since sampling depends on how much material has been produced or processed since the previous sampling, IA testers should stay informed of the work on each project, organize their work, and work efficiently. For projects that are located some distance from the lab, call before leaving to eliminate wasted trips. The Resident Engineer should keep the IA lab informed of any schedule changes and coordinate testing requirements throughout the duration of the project.

At the request of the Construction Division, District Engineer, or Federal Highway Administration, the IA lab may sample and test the following items

- Compaction tests
- Concrete tests
- Specific gravity
- Deposit (pit) samples
- Any other informational tests pertaining to materials on an active or proposed project

Record these test results according to instructions in Section 5-607, Independent Assurance Files and Records.

Section 5-603, Split Samples, summarizes the typical split sample tests that the IA lab performs.

5-603 SPLIT SAMPLES

As a part of the regular IA sampling and testing program, most samples are split regularly between the field testers and the IA labs (two-way splits), or among the field testers, IA labs, or third party (three-way splits). The IA lab's test results provide an additional way to check the accuracy of the field testing procedures. Samples may also be split in other ways, such as with the contractor's lab or other field labs.

5-603.1 RESPONSIBILITY

The IA lab is responsible for administering the split sample program among the various labs. This involves supervising the sampling, splitting, and distribution of the samples and collecting and reporting the results of the tests.

5-603.2 TWO-WAY SPLITS

Two-way splits are performed on the following materials:

- Select Borrow
- Selected Material
- Granular and Drain Backfill
- Base Aggregates
- Aggregate for Treated Base
- Asphalt Treated Permeable Base
- Plantmix Bituminous Surface
- Plantmix Bituminous Open-Graded Surface
- Screenings
- Concrete Aggregates
- Aggregates for Plantmix Bituminous Surface, Open-Graded Surface, and permeable base

5-603.3 OBTAINING SAMPLES

Take split samples at the same locations as regular project samples. IA testers or field testers should sample in the presence of and at the locations indicated by the IA testers. Both the project and IA labs can use the split sample to satisfy frequency requirements of their regular project acceptance or IA samples. The sample should be large enough so that each lab will have enough material for testing according to Table 5.3, Minimum Weight of Field Samples.

5-603.4 SAMPLE PREPARATION

Split the sample with both the project and IA testers present, using an approved method, so each portion is representative of the original sample and is as similar to other portions as possible. Always use a sample splitter or quartering canvas. Carefully obtaining and preparing split samples allows for correlating testing accuracy, when comparing test results between labs. This also allows testers to quickly identify the causes of poor test result correlation.

5-603.5 TESTS PERFORMED

Split sample tests are the same tests that are run on regular project samples. Table 5.7, Minimum Required Samples and Tests – Independent Assurance (IA) (at the end of this section), lists the required tests. Labs may run other tests for informational purposes.

5-603.6 REPORTING PROCEDURES

Each field lab shall report the results of the tests performed to the corresponding IA lab. When the IA lab receives all reports, they will submit the results on a single form for comparative purposes. Be sure to submit timely field lab reports, no later than 7 days after receipt, to the IA lab so the reports include all field lab data when forwarded to the Construction Division. Report all split samples, regardless of whether they are more or less than a three-way split, to the IA lab in this manner. Refer to Section 5-607, Independent Assurance Report Forms.

5-603.7 TOLERANCES AND CORRECTIVE ACTION

When split samples vary more than the allowable tolerances shown in Table 5.6, IA Audit Tolerances, confirm that testers are following proper testing procedures. The IA lab testers will obtain and test additional split samples and perform visual audits as soon as possible, and continue this procedure until the problem is resolved. If IA lab testers cannot meet allowable tolerances with the additional audits, then the IA lab will notify the Construction Division for further action.

Table 5.6 – IA Audit Tolerances

Test	Control	Tolerance Range (Plus or Minus)
Sieve Analysis	Percent Passing 3" to 1" sieves	7%
	Percent Passing 3/4" to 3/8" sieves	6%
	Percent Passing No. 4 Sieve	5%
	Percent Passing No. 8 to No. 16 sieves	4%
	Percent Passing No. 20 to No. 50 sieves	3%
	Percent Passing No. 60 to No. 200 sieves	2%
Fractured Face	Percent Fractured Faces	7%
Sand Equivalent	Sand Equivalent Value	4%
Atterberg Limits	Plasticity Index	3
Density	Calculated Maximum Density	3 lbs/cu.ft.
Slump	Slump of Concrete	1 inch
Air Content	Percent of Air in Concrete	0.5%
Unit Weight	Pounds per cubic foot	1.5 lbs
T.M.D. (Rice)	Density	2 lbs/cu.ft.
Ignition Oven	Bitumen Ratio	0.3%

5-603.8 RECORDS

The IA lab maintains accurate records to confirm the following:

- Proper frequency of splits
- Splits are reported immediately
- Corrective action is taken when necessary
- Test documentation is maintained

Refer to Section 5-607, Independent Assurance Files and Records.

5-604 VISUAL AUDITS OF FIELD TESTING PROCEDURES

The IA lab may visually audit field sampling and testing procedures to verify the accuracy of field methods.

Audits may include the following:

1. Inspection of any or all of the following:
    - Sampling procedures
    - Sample splitting procedures
    - Sample preparation
    - Testing procedures
    - Calculations
    - Reports
    - Equipment use and procedures
    - Field books and files (lab)
2. Discussion of the audit with the individual(s) whose testing is being audited and with the Resident Engineer before leaving the job site, if corrective action is necessary.
3. Report the audit on NDOT form 040-072, “Report Form for Two Way Audits,” which includes the following information:
    - Date of audit
    - Contract No.
    - Name of tester(s) audited
    - Name of auditor
    - Procedures audited
    - Remarks and recommendations
4. Verify that field lab safety procedures are being followed

A follow-up audit is required for any failing or unsatisfactory audit, visual or procedural, to verify conditions have been corrected.

5-605 INDEPENDENT ASSURANCE TESTING FREQUENCIES

Table 5.7, IA Minimum Required Samples and Tests, (at the end of this section) summarizes the requirements for sampling and testing of construction materials by Independent Assurance (IA) lab testers. The table includes the following information for each type of material or product:

- Tests that are usually performed together, with the applicable Nevada test number
- Required sampling frequency
- Required location or time that samples should be taken or tests made

Frequencies as shown are intended as the minimum requirements under normal conditions. Increase these frequencies when necessary to ensure adequate control.

The frequency schedule is a general guide for all projects. For some materials, the sampling instructions may vary according to conditions on a particular project. Not all of the tests listed for a particular type of material or product are always required. In these cases, refer to the Materials Checklist Letter to determine the applicable procedure and frequency.

5-606 INDEPENDENT ASSURANCE REPORT FORMS

Complete IA test reports daily, and distribute them to all appropriate divisions within seven days. Submit the IA test results even if the IA tester has not received the test results from the field tester. The only exception to this policy is an additional five days for two- and three-way audits. The following is a list of the report forms that the IA tester completes for various tests and audits.

- NDOT form 040-005, “Audit Report Form for Compaction Curve” – Use this form to report the field and IA moisture density curve and to report the findings of the compaction audit.
- NDOT form 040-022, “Field Lab Inspection Report” – Use this form when the IA lab inspects the field lab.
- NDOT form 040-065, “Inspection Report: Material and Testing – Project and Progress.” Use this six-page form to report field and IA lab results for testing of:
    - Compaction
    - Sieve analysis
    - Flexural (beams and cylinders)
    - Cement content
    - Ignition oven

- NDOT form 040-070, "Audit Report Form for Concrete Aggregates" – Use this form to compare the approved tolerances with the results of sieve testing for concrete coarse and fine aggregates for structures and pavements by the field and IA labs.
- NDOT form 040-071, "Audit Report Form of Concrete Tests" – Use this form to compare the field and IA lab results for slump, air content, and unit weight.
- NDOT form 040-072, "Report Form for Two-way Audits" – Use this form to report the sample test results of the following materials:
    - Select borrow
    - Backfill
    - Drain backfill
    - Selected material
    - Aggregate base courses
    - Cement treated base aggregates, plantmixed and roadmixed bituminous mixtures
    - Screenings
- NDOT form 040-079, "Visual Audit Report Form" – The IA lab uses this form to report results of the field lab in the following areas:
    - Test procedures
    - Reports and files
    - Equipment
    - General lab condition
- NDOT form 040-080, "Audit Report for Absorption and Specific Gravity for Coarse and Fine Aggregates" – Use this form to compare the specific gravity and percent absorption results between the field and IA labs.
- NDOT form 040-085, "Temporary Storage of Radioactive Material Field Lab Inspection Form" – Use this form to record the results of the IA lab inspection of the field lab for security and storage of the nuclear density gauge testing equipment.
- NDOT form 040-086, "Nuclear Certified Personnel Inspection Form" – Use this form to record the results of the IA lab inspection of the procedures used by the field crew's certified field testers:
    - Shipping papers
    - Certification card
    - Monitoring device
    - Gauge secure during transportation
    - Locks
    - Gauge condition

Consecutively number the IA tests of each principal structure material for each type of material per project. Use the following information when numbering tests: District number, abbreviations (IA), and the consecutive number of the test for each type of material sampled. For example, test number 2-IA-5, indicates District Two, IA, and the fifth test for a particular project.

Consecutively number IA compaction audits and miscellaneous tests for all types of material for a particular type of project. Use the following information when numbering tests: District number, abbreviation (IA, "M" for miscellaneous tests, or the compaction materials code), and the consecutive number of the test. For example, test number 1- IA-1B-40 on a compaction audit report indicates District One, IA, Type1 Class B Aggregate, and the fortieth compaction audit for a particular project.

5-607 INDEPENDENT ASSURANCE FILES AND RECORDS

Keep all IA test worksheets and reports on file in the IA lab, and forward all original reports to the Construction Division. Staple worksheets with the IA testers' handwritten initials to each report and then file them chronologically by the type of material or audit.

Keep summaries of IA tests in a separate field book for each project. When the project is awarded to a contractor, create a summary of the number of tests and split samples to be taken. Note this information in the book for easy reference. The book is divided into four sections. The sections are described below.

5-607.1 SECTION ONE

Section one is a summary of test results for each material that has a testing frequency requirement, for example:

- Type 1 Aggregate Base
- Type 2 Aggregate Base
- Concrete Aggregate
- Cement Treated Base Aggregate
- Select Material (Base & Surface)
- Roadmix Base and Surface Aggregate
- Select Borrow
- Plantmix Bituminous Base and Surface
- Plantmix Bituminous Open-Graded Surface
- Screenings
- Backfill

Section one is divided into separate sections for each of the materials listed above. For each material test summary include the following information:

- Test number
- Date sampled
- Location of sample
- If sample is a split, indicate who the sample was split with and the corresponding test numbers
- Indicate tests run on each sample (test results not required here)

5-607.2 SECTION TWO

Section two summarizes compaction test audits. For each compaction test summary include the following information:

- District test number
- Corresponding field test number
- Type of material
- Name of individual(s) audited
- Name of auditor
- Portion or portions of test observed (in-place and/or moisture density curve)

5-607.3 SECTION THREE

Section three summarizes general audits. General audits are performed by IA testers for any sampling or testing procedure performed by field testers. Record the following information concerning the audit in section three of the field book for future reference:

- Date
- Names of individual(s) audited
- Name of auditor
- Test or procedure audited
- Remarks concerning audit and recommendations

5-607.4 SECTION FOUR

Section four summarizes audits on nonstandard tests sampled and tested by the IA testers, or special tests run at the request of the Resident Engineer, District Engineer, or FHWA personnel. For example, this section might contain compaction tests, unit weight, specific gravity, and deposit samples. Consecutively number the tests per material.

5-700 TESTING DISPUTE RESOLUTION

The section provides guidance on resolving testing disputes at the lowest level possible. All personnel must strive to solve test disputes quickly to ensure quality work with quality materials. Most testing differences can be solved in the field. Occasionally, the Construction Division or Resident Engineer may require referee testing by the Materials Division. Section 106 of the specifications describes a procedure for the contractor to follow when disputing NDOT's test results.

5-701 RESIDENT ENGINEER RESPONSIBILITY

When a test is questioned or disputed, the Resident Engineer should first conduct the test using a different tester on the same crew. If the results are still in dispute, then the Resident Engineer should immediately request an audit from the IA lab. If the IA lab audit and field test results match, then they review the results with the contractor.

If the results of the IA lab and field tester do not match, then they will perform an additional audit. This second audit will consist of the IA lab and field tester running the test side by side. Once this step has been completed, they will review audit findings and recommendations with the Resident Engineer and field testers for implementation.

If these steps do not resolve the dispute, then the Resident Engineer and IA lab will confer with the Construction Division for further guidance.

If the contractor requests independent testing or any other testing, an NDOT representative must be present during sampling and testing, as stated in Subsection 106.04 of the specifications. If the contractor provides independent testing, the Resident Engineer must notify and confer with the Materials Division.

5-702 INDEPENDENT ASSURANCE RESPONSIBILITY

When tests are disputed, the IA lab must first verify testing procedures and equipment used. If no deficiencies are noted, then the IA lab will coordinate and monitor a split sample with the Resident Engineer and field tester. Once the audit is complete, the IA lab will compare and discuss the test results with the Resident Engineer and testing staff.

If the IA lab results and field results are within the allowable tolerances, they will consider field test results valid and review them with the contractor. If the IA lab results and field results do not match, then the IA lab testers and field testers will perform an additional audit, running their tests side by side. Once this step is complete, the Resident Engineer and field testers will review the audit findings and recommendations for implementation.

5-703 MATERIALS DIVISION RESPONSIBILITY

The Materials Division performs referee testing when requested by the Resident Engineer or Construction Division.

If the contractor requests independent testing or any other testing, the Materials Division will coordinate with the Resident Engineer, and all testing will be in accordance with Subsection 106.04 of the specifications.

5-704 CONTRACTOR-REQUESTED TESTING

The contractor may request to have independent testing performed. Section 106.04 of the specifications describes the procedure that the contractor must follow when disputing acceptance testing. The contractor must coordinate with the Resident Engineer before additional testing is performed.

Sampling will not begin until the Resident Engineer provides written permission. The contractor must provide the following information before receiving approval for an information test:

- Purpose of testing
- Specific tests to be performed
- Procedures proposed for sampling and testing
- Schedule of proposed sampling and testing
- Name of firm and personnel to perform the sampling and testing

5-800 ACCEPTANCE OF MATERIALS BY OTHER MEANS

Except as provided in the specifications, all materials will be inspected and tested for acceptance before being incorporated into the work. Using untested and unaccepted materials without approval or written permission runs the risk of being considered unacceptable and unauthorized and not to be paid in accordance with Section 106.04, Samples and Tests, of the specifications.

5-801 CERTIFICATES OF COMPLIANCE

Section 106.05, Certification of Compliance, of the specifications allows certain materials to be used before sampling and testing if accompanied by a Certificate of Compliance. Certificates of Compliance are a way of accepting materials before testing. A manufacturer produces a Certificate of Compliance, indicating that the material meets the specification requirements of each corresponding section of the specifications. For example, bituminous materials must be in accordance with Section 703 of the specifications.

A generic Certificate of Compliance form is available through the Materials Division and is sent to the Resident Engineer with the Materials and Sampling Checklist. Most manufacturers will have their own certificate form. A manufacturer's representative must sign and date the Certificate of Compliance, and the certificate must be legible. An original certificate is preferred, but the department may accept a copy or fax. The Resident Engineer can discuss questions about the certificate with the Materials Division.

Certificates are sent to the Materials Division using NDOT form 020-018, "Transmittal for Test Samples and Certifications." The Resident Engineer should provide a copy of the certificate to inspectors overseeing the item being incorporated into the work. The certificate is retained in the field office records. The manufacturer should also provide the Resident Engineer with any warranties, guarantees, instruction sheets, or parts lists for products incorporated into the work.

If certification of materials is delaying project completion, the Resident Engineer must notify the contractor in writing. This written notification must specify the missing certification and must inform the contractor that payment for the affected items will be deducted if it is not received within 10 working days. Send copies of this letter to the Chief Construction Engineer and the District Engineer.

The Materials Sampling and Testing Checklist that the Materials Division issues for each project identifies products and materials that may be accepted by a Certificate of Compliance. Following is a partial list of construction materials that may be accepted based on Certificates of Compliance. This list is not all-inclusive and is subject to change:

- Diesel Fuel
- Traffic Control Items
- Sign Materials
- Striping
- Guideposts/Object Markers
- Signal and Lighting
- Irrigation Systems
- Landscaping
- Water Line Systems
- Pipes and Drains
- Engineering Fabrics
- Polymer Concrete
- Precast Concrete
- Cattleguards
- Guardrail
- Barrier Systems
- Structural Steel
- Paint, Stain and Graffiti Coating
- Miscellaneous Metals
- Fencing
- Mailbox

If the contractor submits an item for use that may require a Certificate of Compliance but is not on the Materials Sampling and Testing Checklist, contact the Materials Division Lab Services for verification (775-888-7792).

5-802 ACCEPTANCE OF SMALL QUANTITIES OF CONCRETE

The Resident Engineer may approve concrete mix designs for small concrete placement quantities in the following areas and under the following conditions:

- Areas
  - Breakaway Cable Terminal (BCT) posts
  - Sign posts, excluding overhead signs
  - Fence posts
  - Curb and Gutter, up to 100 linear feet maximum
  - Other minor placements to a maximum of 1.3 cubic yards per placement
- Conditions
  - Resident Engineer may waive the trial batch requirements, if the Resident Engineer decides that the mix design is appropriate.
  - Aggregates must still come from approved sources.
  - A Resident Engineer should obtain a copy of the mix design from the concrete supplier and submit it to the Materials Division, for record only.
  - The Resident Engineer may waive any or all field tests (slump, air, unit weight, cylinders, and aggregate tests) if the Resident Engineer, after visual inspection, decides that the material is acceptable.
  - The Materials Division will assist the Resident Engineers, at their request, on any questions or concerns they may have on the acceptability of a mix design.

5-900 OFF-SYSTEM CONTRACT SAMPLING AND TESTING

Off-system construction projects are divided into two basic categories: (1) those performed by the local entity forces on force account, and (2) conventional contracts awarded to a contracting firm.

The sampling and testing schedule follows Table 5.1. For off-system projects, the Resident Engineer may waive the “per day” frequencies. Discuss any changes from the frequencies shown in Table 5.1 with the Quality Assurance Engineer. All other aspects will follow procedures outlined in this manual.

5-901 STEWARDSHIP PROGRAM

Refer to Section 3-502, NDOT Stewardship for a more detailed explanation of the NDOT Stewardship Program. The assigned NDOT Resident Engineer monitors the local government's federal contract compliance responsibilities and verifies compliance with the required sampling and testing at the appropriate times and frequencies as outlined in the stewardship agreement between NDOT and the local government. NDOT's Stewardship Coordinator can provide a copy of the agreement to the Resident Engineer. The Resident Engineer coordinates with the local agency's project manager to confirm that sampling and testing requirements are scheduled and met. Following are specific procedures that the Resident Engineer monitors:

- The local agency must coordinate with the Construction Division to determine testing frequencies.
- The local agency must hire a qualified testing firm or have sufficient qualified staff to meet the established testing frequencies.
- The local agency must develop IA procedures based on the quantities and testing frequencies.
- The local agency's staff or a separate consultant from the construction administrator must implement IA procedures. Use NDOT's *Construction Manual* as a guide.
- The Construction Division must review and approve IA procedures.
- On NDOT-maintained facilities, NDOT's testing frequency and documentation must be followed per NDOT's *Construction Manual* and *Documentation Manual*.
- The local agency must maintain a summary of the tests that passed or failed, and in the case of failure, what the corrections were (for example, liquidated damages, remove and replace).
- Tester qualification (NAQTC, or WAQTC with ACI certification) is required only on stewardship projects that are on the National Highway System (NHS) or facilities that NDOT would maintain after project completion.
- NDOT's Materials Division will review and approve plantmix, open-graded, and concrete mix designs on stewardship projects that are on the state-maintained system.
- If needed, the Materials Division can provide mix design assistance. If the local agency is doing work off the State system in accordance with NDOT specifications, the Materials Division can provide assistance in making recommendations.
- The Resident Engineer will coordinate with the Materials Division on any special requirements or testing concerns.

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Borrow / Embankment	115	Resistance "R" value	One per 40,000 m^3 (50,000 yd^3) or fraction thereof for qualifying the materials	Source Requirement Test	Sample one full, large canvas sample sack	Submit to Materials Division for testing
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required
	104	Specific Gravity				
	102 or 103	Density	One per 4,000 m^3 (5,000yd^3) of embankment, but not less than one per day, per lift	After final compaction		
Select Borrow	115	Resistance "R" value	One per 40,000 m^3 (50,000 yd^3) or fraction thereof for qualifying the materials	Source Requirement Test	Sample one full, large canvas sample sack	Submit to Materials Division for testing
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required
	104	Specific Gravity				
	102 or 103	Density	One per 4,000 m^3 (5,000 yd^3) of embankment, but not less than one per day, per lift	After final compaction		
	206	Sieve Analysis	One per day		Table 5.3	
Original Ground and Base of Cuts	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required
	104	Specific Gravity				
	102 or 103	Density	One per 3,350 m^2 (4,000 yd^2), but not less than one per day; or one per structure for footings, pipes, headwalls,etc.	After final compaction		

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Backfill	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required.
	104	Specific Gravity				
	102 or 103	Density	One per 750 m^3 (1,000 yd^3) or fraction thereof per structure, or one per lift	At the discretion of the Resident Engineer		
	206	Sieve Analysis	One per 750 m^3 (1,000 yd^3) or fraction thereof		Table 5.3	
Granular Backfill	206	Sieve Analysis		Source Requirement Test	Sample one full, large canvas sample sack	Submit to Materials Division for testing
	210/211/212	Atterberg Limits		Source Requirement Test		Submit to Materials Division for testing
	AASHTO T289 AASHTO T288	pH Value Resistivity		Source Requirement Test		Submit to Materials Division for testing. Indicate on the transmittal whether concrete, aluminum or steel are being used with a culvert or structure
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required.
	104	Specific Gravity				
	102 or 103	Density	One per 750 m^3 (1,000 yd^3) or fraction thereof per structure, or one per lift	At the discretion of the Resident Engineer		
	206	Sieve Analysis	One per 750 m^3 (1,000 yd^3) or fraction thereof		Table 5.3	
	210/211/212	Atterberg Limits	One per 750 m^3 (1,000 yd^3) or fraction thereof			
MSE Backfill	206	Sieve Analysis	One per 7,650 m^3 (10,000 yd^3), one per stockpile minimum	Source Requirement Test	Sample on full, large canvas sample sack	Submit to Materials Division for Testing

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
MSE Backfill Cont.	210/211/212	Atterberg Limits	One per 7,650 m^3 (10,000 yd^3), one per stockpile minimum	Source Requirement Test		Submit to Materials Division for testing
	AASHTO T289 AASHTO T288 AASHTO T291 AASHTO T290	pH Value Resistivity Chlorides Sulfates	One per 7,650 m^3 (10,000 yd^3), one per stockpile minimum	Source Requirement Test		Submit to Materials Division for testing. Indicate the type of reinforcement (Metallic or Geogrid) on the transmittal.
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required.
	104	Specific Gravity				
	102 or 103	Density	One per 750 m^3 (1,000 yd^3) or fraction thereof per structure, or one per lift	At the discretion of the Resident Engineer		
	206	Sieve Analysis	One per 750 m^3 (1,000 yd^3) or fraction thereof		Table 5.3	
	210/211/212	Atterberg Limits	One per 750 m^3 (1,000 yd^3) or fraction thereof			
	AASHTO T289 AASHTO T288 AASHTO T291 AASHTO T290	pH Value Resistivity Chlorides Sulfates	One per 750 m^3 (1,000 yd^3) or fraction thereof			Submit to Materials Division for testing. Indicate the type of reinforcement (Metallic or Geogrid) on the Transmittal.
Slurry Backfill	206	Sieve Analysis	One per 750 m^3 (1,000 yd^3) or fraction thereof		Table 5.3	
	428	Compressive Strength	One per 150 m^3 (200 yd^3) or fraction thereof	See Nev. T425, Standard Method of Test for Sampling Fresh Concrete.		Three 6" X 12" cylinders (28 day) are required for each sample. More may be made for information. Submit to designated lab for testing
	431 or 432	Air Content by Volumetric or Pressure	One per 150 m^3 (200 yd^3) or fraction thereof	First test to be taken within first two loads		
	438	Slump	At the discretion of the Resident Engineer			Slump is run whenever consistency is questionable. See Section 207

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Drain Backfill	AASHTO T96	% of Wear (500 rev.)		Source Requirement Test	Sample two full, large canvas sample sacks	Submit to Materials Division for testing
	206	Sieve Analysis	One per 750 m^3 (1,000 yd^3) or one per project minimum	At time of use, jobsite stockpile	Table 5.3	
Types 1, 2 and 3 Base (For Type 3, See Special Provisions)	115	Resistance (R Value)		Source Requirement Test	Sample two full, large canvas sample sacks	Submit to Materials Division for testing
	AASHTO T96	% Wear (500 Rev.)		Source Requirement Test		Submit to Materials Division for testing
	206	Sieve Analysis	One per day or one per 1,800 t (2,000 tons) when non-uniform material	Class A: From roadway directly behind spreader Class B: From processed windrow, just prior to final lay down	Table 5.3	For small quantity, location and frequency of sample are at the discretion of the Resident Engineer
	210/211/212	Atterberg Limits	One per day or one per 1,800 t (2,000 tons) when non-uniform material			For small quantity, location and frequency of sample are at the discretion of the Resident Engineer
	230	Fractured Face	One per day			For small quantity, location and frequency of sample are at the discretion of the Resident Engineer
	112	Moisture	One per day or one per 1,800 t (2,000 tons) when non-uniform material	Moisture tests should be taken from the windrow or stockpile after the material has been weighed, but prior to adding any additional water in the field		Results for payment purposes. Moisture tests need to represent what was weighed
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required. For small quantity, location and frequency of sample are at the discretion of the Resident Engineer. For Type A only: Depth checks taken during density test but for information only. Record depths on Daily Construction Report.

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Types 1, 2 and 3 Base (For Type 3, See Special Provisions) Cont.	104	Specific Gravity				
	102 or 103	Density	One per 1800 t (one per 2,000 tons) or fraction thereof or one per lift	On roadway, after trimming and final compaction		
		Straightedge Tolerances Section 302	One per lane km (two per lane mile)	Finished surface		Record results on Daily Construction Report
Aggregate for Portland Cement Treated Base	AASHTO T96	% of Wear (500 rev.)		Source Requirement Test	Sample four full, large canvas sample sacks	Submit to Materials Division for testing
	206	Sieve Analysis	One per 900 t (1,000 tons)	Road mixed: From processed material, prior to adding cement Plant mixed: From conveyors, prior to adding cement	Table 5.3	Sample aggregate during production
	227	Sand Equivalent	One per day or one per 900 t (1,000 tons) when questionable material			
Cement Treated Base (Road mixed or Plant mixed Method)	237	Compressive Strength	Three on the first day of production, one per day thereafter. If questionable material, more tests may be required at the discretion of the Resident Engineer			Compressive strength for information only.
	112	Moisture	One per 1,800 t (2,000 tons)			Record moistures on Daily Construction Report
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required. Depth checks taken during density test for information only. Record depths on Daily Construction Report
	104	Specific Gravity				
	102 or 103	Density	One per 1,800 t (one per 2,000 tons) or fraction thereof or one per lift	On roadway, after trimming and final compaction		

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Cement Treated Base (Road mixed or Plant mixed Method)		Straightedge Tolerances Section 304	One per lane km (two per lane mile) per lift	Finished surface		Record results on Daily Construction Report
Pulverized Base and Surface (Roadbed Modification)	112	Moisture	One per 5,900 m^2 (7,000 yd^2) or fraction thereof	On roadway, after final compaction		Record moistures on sieve analysis form
	108	Proctor	108 and 104 (when rock correction is required) to be run every 25 compaction tests, minimum	Material obtained from 200		108 and 104 to be run concurrently when rock correction is required. Depth checks for information only. Record depths on Daily Construction Report
	104	Specific Gravity				
	102 or 103	Density	One per 5,900 m^2 (7,000 yd^2) or fraction thereof	On roadway, after final compaction		
	206	Sieve Analysis	One per 5,900 m^2 (7,000 yd^2) or fraction thereof	After final pulverization by removing a composite sample of the pulverized surface at randomly selected sites prior to adding cement	Table 5.3	
		Cement Distribution	One per lane km (two per lane mile)			Phenolphthalein test for information only. Record results on Daily Construction Report
		Straightedge Tolerances Section 305	One per lane km (two per lane mile) per lift	Finished surface		Record results on Daily Construction Report
Shouldering Material	112	Moisture	One per day or one per 1,800 t (2,000 tons)			Record moistures on Daily Construction Report
	206	Sieve Analysis	One per day or one per 1,800 t (2,000 tons) when non-uniform material; one per day for coldmilled material	At belt or stockpile. Coldmilled material from windrow.	Table 5.3	
	210/211/212	Atterberg Limits	One per day or one per 1,800 t (2,000 tons) when questionable material			

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Blotter Sand, Sand in Stockpile	206	Sieve Analysis	One per project per source	At belt or stockpile	Table 5.3	
Aggregate for Plantmix Bituminous Base, Surface, Open-Graded, Permeable Base and Premix	AASHTO T96	% of Wear (500 rev.)		Mix Design Submittal and/or Source Requirement Test	Sample two full, large canvas sample sacks from each size for each mix design	Submit to Materials Division for testing
	206	Sieve Analysis		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	210/211/212	Atterberg Limits		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	230	Fractured Face		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	AASHTO T104	Soundness, Sodium	Coarse and fine aggregate	Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	T111	Absorption	Coarse aggregate	Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	T493	Specific Gravity	Fine aggregate	Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	T111	Specific Gravity	Coarse aggregate	Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Aggregate for Plantmix Bituminous Base, Surface, Open-Graded, Permeable Base and Premix Cont.	206	Sieve Analysis	One per 4,500 t (5,000 tons) of each size produced, minimum one test per five crushing days for each size aggregate	From belt or stockpile	Table 5.3	Tests must be run prior to marination. For information only
	210/211/212	Atterberg Limits	One per 4,500 t (5,000 tons) of each size produced, minimum one test per five crushing days for each size aggregate	From belt or stockpile		Tests must be run prior to marination
	230	Fractured Face	One per 4,500 t (5,000 tons) of each size produced, minimum one test per five crushing days for each size aggregate	From belt or stockpile		Tests must be run prior to marination
	111	Absorption of Coarse Aggregate	One per five crushing days per size	From belt or stockpile		Tests must be run prior to marination
	112	Moisture	Minimum one per size per week	From belt of stockpile during marination		Record moistures in Marination Diary. For information only.
		Lime Distribution	One per size per project. If questionable material, more tests may be required at the discretion of the Resident Engineer	From belt or stockpile during marination		Phenolphthalein test during production. Record in Marination Diary
Recycled Asphalt Pavement (RAP) for Plantmix Bituminous Surface	AASHTO T30	Mechanical Analysis of Extracted Aggregate		Mix Design Submittal	Sample two full, large canvas sample sacks from each size for each mix design	Submit to Materials Division for testing
	AASHTO T164	Extraction of Asphalt Binder		Mix Design Submittal		Submit to Materials Division for testing
	206	Sieve Analysis	One per 4,500 t (5,000 tons) of each size produced, minimum one test per five production days for each size aggregate	From belt or stockpile	Table 5.3	Verify material meets specified sieve requirements

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Permeable Base (Asphalt Treated)	206	Sieve Analysis	One per 1,800 t (2,000 tons), or one per day minimum	Section 303	Table 5.3	Material remaining from Nev. T761
Permeable Base (Asphalt Treated)	761 306	Bitumen Ratio Moisture Content	One per 1,800 t (2,000 tons), or one per day minimum			
		Straightedge Tolerances Section 303	One per lane km (two per lane mile)	Finished surface		Record results on Daily Construction Report
Premix	AASHTO T269	Percent Air Voids of Compacted Mixture	One per project	From jobsite stockpile	Three full 6" X 12" cylinders, this sample will cover AASHTO T269 and Nev. T303	Submit to Materials Division for testing
	303	Stabilometer	One per project	From jobsite stockpile		Submit to Materials Division for testing
	206	Sieve Analysis	One per 1,800 t (2,000 tons) or one per day minimum	From coldfeed belt at plant during production	Table 5.3	
Plantmix Bituminous Base and Surface	206	Sieve Analysis	One per 900 t (1,000 tons) or one per day minimum.	Section 106	Table 5.3	Material remaining from Nev. T761
	112	Moisture	One per day	From coldfeed belt at plant during production		For information only, record moistures on testers portion of Daily Plant Report
	761 306	Bitumen Ratio Moisture Content	One per 900 t (1,000 tons) or one per day minimum. NOTE: Immediately test another sample to verify the results before making plant adjustment	Composite sample from behind the paver, prior to rolling		
	325	Theoretical Maximum Specific Gravity (Rice)	One for each one-half day of production (a.m. and p.m.)	Composite sample from behind the paver, prior to rolling		For Method B compaction only

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Plantmix Bituminous Base and Surface Cont.	AASHTO T269	Percent Air Voids of Compacted Mixture	Sample first three days of paving; then one per 9,000 t (10,000 tons) or twice per week, whichever is less		Three full 6" X 12" cylinders, this sample will cover AASHTO T269 and Nev. T303 and T341	Submit to Materials Division for testing
	303	Stabilometer	One per 9,000 t (10,000 tons) or twice per week, whichever is less; sample first three days of paving			Submit to Materials Division for testing
	341	Indirect Tensile Strength and Retained Strength	One per 9,000 t (10,000 tons) or twice per week, whichever is less; sample first three days of paving			Submit to Materials Division for testing. Materials Division will determine the frequency of performing the test
	335 or 750	Density	Section 402	Random locations per Test Method		See specifications for required test method and density requirements. Nev. T336 will be used to correlate the thin layer density gauge (Nev. T335)
		Straightedge Tolerance Section 402	One per lane km (two per lane mile)	Finished surface		Record results on Daily Construction Report
	446	Evaluation of Profiles	Section 402	Section 402		Complete within 48 hours after placement
Plantmix Bituminous Open-Graded Surface	206	Sieve Analysis	One per 900 t (1,000 tons) or one per day minimum	From augers at paver or windrow in front of paver	Table 5.3	Material remaining from Nev. T761
	112	Moisture	One per day	From coldfeed belt at plant during production		For information only, record moistures on testers portion of Daily Plant Report
	761 306	Bitumen Ratio Moisture Content	One per 900 t (1,000 tons) or one per day minimum	From augers at paver or windrow in front of paver		

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Plantmix Bituminous Open-Graded Surface Cont.	325	Theoretical Maximum Specific Gravity (Rice)	One for each one-half day of production (a.m. and p.m.)	From augers at paver or windrow in front of paver		
		Straightedge Tolerance Section 402	One per lane km (two per lane mile)	Finished surface		Record results on Daily Construction Report
	446	Evaluation of Profiles	Section 402 and 403	Section 402 and 403		Complete within 48 hours after placement
Cold Recycle	206	Sieve Analysis	One per lane km (two per lane mile)	Windrow	Table 5.3	Verify material meets specified sieve requirements
	750	Density	Section 404	Random locations per Test Method		
	112	Moisture	Two per day	Windrow		One in a.m. and one in p.m., for information only. Record moistures on Daily Construction Report
	112	Moisture	See Section 404	Section 404		(Moisture for cores)
	759	Field Viscosity Section 404	One per truck and one per trailer	Approximate midpoint / mid depth of the load		Sampled by contractor and observed by NDOT representative
		Straightedge Tolerance Section 404	One per lane km (two per lane mile)	Finished surface		Record results on Daily Construction Report
Surface Treatment Screenings (Chips)	AASHTO T96	% Wear (500 Rev.)	One per project, per source, per supplier	Source Requirement Test	Sample two full, large canvas sample sacks per source per supplier	Submit asphalt and aggregate to Materials Division for testing
	209	Stripping	One per project, per source, per supplier	Aggregate source and asphalt supplier specific	1 gallon of asphalt	Submit 1 gallon of asphalt and aggregate sample to Materials Division for testing

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Surface Treatment Screenings (Chips) Cont.	206	Sieve Analysis	One per 1,800 t (2,000 tons)	From jobsite stockpiles	Table 5.3	
	228 (CA T227)	Cleanness Value	One per 1,800 t (2,000 tons)	From jobsite stockpiles		
	230	Fractured Face	One per 1,800 t (2,000 tons)	From jobsite stockpiles		
	759	Field Viscosity Section 408	One per truck and one per trailer	Approximate mid depth / midpoint of the load		Sampled by contractor and observed by NDOT representative
Micro-Surfacing	AASHTO T96	% Wear (500 Rev.)	One per project per source	Mix Design Submittal and Source Requirement Test. Minimum of 20 working days before use.	Sample two full, large canvas sample sacks of aggregate.	Submit to Materials Division for testing
	AASHTO T104	Soundness, 5 cycle sodium sulfate	Coarse and fine aggregate	Mix Design Submittal and Source Requirement Test. Minimum of 20 working days before use.	Sample two full, large canvas sample sacks of aggregate.	Submit to Materials Division for testing
	206	Sieve Analysis		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	210/211/212	Atterberg Limits		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	227	Sand Equivalent		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing
	230	Fractured Face		Mix Design Submittal and/or Source Requirement Test		Submit to Materials Division for testing

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Micro-Surfacing Cont.	206	Sieve Analysis	One per 1,800 t (2,000 tons) or one per day minimum	From Jobsite Stockpiles	Table 5.3	
	210/211/212	Atterberg Limits	One per 1,800 t (2,000 tons) or one per day minimum	From Jobsite Stockpiles		
	227	Sand Equivalent	One per 1,800 t (2,000 tons) or one per day minimum	From Jobsite Stockpiles		
	230	Fractured Face	One per 1,800 t (2,000 tons) or one per day minimum	From Jobsite Stockpiles		
		Straightedge Tolerance Section 418	One joint per lane km (two per lane mile)	Finished Surface		Record results on Daily Construction Report
Concrete Aggregates	AASHTO T112	Clay Lumps	Pavement: One per size per 6,000 m^2 (7,000 yd^2) of pavement or fraction thereof Structures: One per size per 225 m^3 (300 yd^3) of concrete or fraction thereof		Sample one full, large canvas sample sack for each size	Submit to Materials Division for testing
	206	Sieve Analysis	Pavement: One per size per 6,000 m^2 (7,000 yd^2) of pavement or fraction thereof Structures: One per size per 225 m^3 (300 yd^3) of concrete or fraction thereof	Belt sample whenever possible. Structures: Sample stockpiles before beginning concrete production	Table 5.3	
	227	Sand Equivalent	Pavement: One per size per 6,000 m^2 (7,000 yd^2) of pavement or fraction thereof Structures: One per size per 225 m^3 (300 yd^3) of concrete or fraction thereof			Fine Aggregate
	228 (CA T227)	Cleanness Value	Pavement: One per size per 6,000 m^2 (7,000 yd^2) of pavement or fraction thereof Structures: One per size per 225 m^3 (300 yd^3) of concrete or fraction thereof			Commercial sources to be tested two days prior to anticipated use. Coarse Aggregate
	112	Moisture	Minimum of one per day per size	Prior to beginning concrete production		For information only

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Concrete Aggregates Cont.	492	Specific Gravity	Minimum of one per source per mix design			For information only
	493	Absorption	Minimum of one per source per mix design			For information only
Portland Cement Concrete for Structures (For precast boxes and MSE panels, testing freq. can be doubled if cast from a certified facility)	428	Compressive Strength	One set per 75 m^3 (100 yd^3). Minimum one set per pour	See Nev. T425, Standard Method of Test for Sampling Fresh Concrete. At the discretion of the Resident Engineer		Three cylinders (28 day) are required for each sample. Two additional cylinders (7 day) will be required for MSE panels. More may be made for information. Submit to designated lab for testing
	431 or 432	Air Content by Volumetric or Pressure	One per 75 m^3 (100 yd^3) or fraction thereof	First test to be taken within first two loads		
	438	Slump	One per 75 m^3 (100 yd^3) or fraction thereof	First test to be taken within first two loads		Slump is run concurrently with fabrication of cylinders; also whenever required or consistency is questionable. If failing results, vehicle should stop unloading, test results verified and corrective action taken
	435	Unit Weight	One per 75 m^3 (100 yd^3) or fraction thereof		0.03 m^3 (1 ft^3)	Unit weight is run concurrently with fabrication of cylinders
		Field Measurements of concrete cover on deck reinforcement Section 502	Minimum of 12 measurements for each section of deck pour	Six measurements are to be taken before placing concrete and six measurements at the same locations shall be taken after concrete has been placed		Record measurements on Daily Construction Report
Pneumatically Placed Concrete Aggregates (Shotcrete Aggregate)	206	Sieve Analysis	Minimum one per day	Sample during production	Table 5.3	

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Pneumatically Placed Concrete (Shotcrete)	ASTM C42	Compressive Strength for Cores	Special Provisions, Section 660	Special Provisions, Section 660		Submit cores to Materials Division for testing
Self Consolidating Concrete (SCC)	416	Compressive Strength	One set per 75 m^3 (100 yd^3) or fraction thereof. Minimum one set per pour	See Nev. T416, Standard Method of Test for Sampling Fresh Concrete. At the discretion of the Resident Engineer		Three cylinders (28 day) are required for each sample. More may be made for information. Submit to designated lab for testing
	416	Air Content	One per 75 m^3 (100 yd^3) or fraction thereof	First test to be taken within first three loads		When possible, fabrication of cylinders, air content, unit weight, slump flow and j-ring to be run concurrently
	416	Unit Weight	One per 75 m^3 (100 yd^3) or fraction thereof			
	417	Slump Flow / VSI (Visual Stability Index)	One per 75 m^3 (100 yd^3) or fraction thereof	Test first three loads then one per 75 m^3 (100 yd^3)	0.03 m^3 (1 ft^3)	
	418	J-Ring / Slump cone	One per 75 m^3 (100 yd^3) or fraction thereof	First test to be taken within first three loads		
Portland Cement Concrete for Pavement	442	Flexural Strength	One per day	Platform at the plant or on roadway when using transit trucks		Three strength specimens are made from each sample and are broken in the field. Break one beam at age of 10 days and one beam at age of 28 days. The spare beam should be used in case of faulty break or if it is desired to vary the breaking schedule
	438	Slump	One per 600 m^3 (750 yd^3) but not less than one per day	Platform at the plant or on roadway when using transit trucks		Slump is run concurrently with fabrication of cylinders; also when consistency is questionable
	435	Unit Weight	One per 600 m^3 (750 yd^3) but not less than one per day	Platform at the plant or on roadway when using transit trucks	0.03 m^3 (1 ft^3)	Unit weight and air content to be run concurrently on different portions of the same sample
	431 or 432	Air Content by Volumetric or Pressure	One per 600 m^3 (750 yd^3) but not less than one per day	Platform at the plant or on roadway when using transit trucks	0.03 m^3 (1 ft^3)	

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Portland Cement Concrete for Pavement Cont.	428	Compressive Strength	One per 600 m^3 (750 yd^3) but not less than one per day	Platform at the plant or on roadway when using transit trucks		Concurrent with other tests. Three cylinders (28 day); more may be made for information
	446	Evaluation of Profiles	Section 409	Section 409		
		Straightedge Tolerance Section 409	One per lane km (two per lane mile)	At the discretion of the Resident Engineer		Record results on Daily Construction Report
	ASTM C174	Length of Drilled Cores	One per 300 m (1,000 ft), or fraction thereof, traffic lane, auxiliary lane or shoulder	At random locations		Cores taken by Materials Division after profile grinding
		Dowel Bar Placement Section 409				Contact Materials Division for testing.
Grout for Post Tensioning Ducts, Soilnails, Shear Keys, Dowel Holes and Ground Anchors	ASTM C939	Fluidity	Section 503	At the point of discharge		Performed by Contractor and observed by NDOT
	427	Compressive Strength	Special Provisions, Section 503, 643 or 644	Special Provisions, Section 503, 643 or 644	Three 4" X 8" cylinders	Submit to Materials Division for Testing
Polymer Concrete	ASTM D4263	Moisture by Plastic Sheet Method	One per 90 m^2 (1,000 ft^2) or portion thereof	At the discretion of the Resident Engineer		
	ACI 503R	Surface Soundness and Adhesion	One per 50 m^2 (60 yd^2) or portion thereof	At the discretion of the Resident Engineer		Pull Off test
	446	Evaluation of Profiles	Section 496	Section 496		
		Straightedge Tolerance Section 496	At the discretion of the Resident Engineer	At the discretion of the Resident Engineer		Record results on Daily Construction Report

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Stone for Riprap, Aggregate for Riprap Bedding and *Stone for Grouted Riprap	AASHTO T96	% Wear (500 Rev.)		Source Requirement Test	Sample two full, large canvas sample sacks	Submit to Materials Division for testing. For riprap larger than Class 150, contact Materials Division
	104	Specific Gravity		Source Requirement Test		Submit to Materials Division for Testing
		Gradation		Visual Inspection, Section 719		
		*Gradation and Grout Penetration	Section 719			
Asphaltic Products (Cutback Asphalts and Emulsions)			One sample for each delivery (this sample represents truck and trailer).	From shipping vehicle after arrival on job and before or at time of unloading, approximately midpoint/mid depth of load.	1 liter (1 qt.)	Submit to Materials Division for testing. To be sampled by contractor and observed by NDOT representative.
	759	Field Viscosity	For field viscosity testing, take one sample from each truck and one from each trailer.	Approximately midpoint/mid depth of load.	1 liter (1 qt.)	
Asphalt Cements			Section 106 for applicable frequencies	Samples of asphalt cement from a hotplant shall be taken from bituminous feed line at a suitable location between storage tank and bituminous metering device	1 liter (1 qt.)	Submit to Materials Division for testing. To be sampled by contractor and observed by NDOT representative
Quicklime (Cold Recycle)	ASTM C977		One sample per contract per supplier	During unloading at jobsite	2.5 kg (5 lbs)	Submit to Materials Division for testing. A certificate of compliance for each load is required, per the specifications. Samples are taken by the contractor's representative and witnessed by an NDOT representative.

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Portland Cement	ASTM C150		Pavement: One sample per 100,000 m^2 (120,000 yd^2) of pavement Structures: One sample per type of cement per project per supplier	During unloading at jobsite	2 kg (4 lbs), one 4" X 8" cylinder may be used	Submit to Materials Division for testing. A certificate of compliance for each load is required, per the specifications. Cement is accepted for immediate use on the basis of Certificate of Compliance. Manufacturer's test report is required. Samples are taken by the contractor's representative and witnessed by an NDOT representative. Small quantities, at discretion of Resident Engineer.
Water (Cold Recycle, Concrete, Micro-Surfacing, etc.)		Section 722	One sample per source	Submit according to specifications	Refer to specifications	Submit to Materials Division in clean glass or plastic container.
Reinforcing Steel		Section 713	Two samples of each bar size per manufacturer, per project, per year and two samples of each bar size for every 90 t (100 tons) thereafter.	Supplier shall furnish 2 samples of each bar size for testing. Random samples may be taken as provided for in Section 505	0.75 m (30 in)	Submit to Materials Division for testing. Show heat numbers on transmittal and state test procedure needed ASTM A706 or AASHTO M31. Certified mill tests used for acceptance at jobsites
Prestressing Bars, Steel Strand, Wire, Anchorage Assemblies and Bar Couplers		Section 713	Sample per size and heat for prestressing bar; sample per manufactured reel for prestressing steel strand; sample per coil for prestressing wire; and sample per lot for anchorage assemblies and bar couplers	Section 713	Refer to specifications	Submit with each sample, a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished
Corrugated Metal Pipe (CMP) and Structural Plate Pipe	AASHTO T65	Spelter Coating	Two per 150 m (500 ft) or fraction thereof	Random samples throughout shipment after delivery to job	50 mm (2 in) triangle	Submit to Materials Division for testing. Tests on base metal performed periodically in addition to coating test. Show mill analysis and heat number
Reinforced Concrete Pipe (RCP)		Fabricator Certificate				Fabricator must have yearly certification by Materials Division

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Permanent Sign Posts		Section 716	One sample per project per supplier	After delivery to jobsite	0.3 m (1' – 3')	Submit to Materials Division for testing
Metal Fence Posts		Section 724	One sample per project per supplier	After delivery to jobsite	0.3 m (1' – 3') Submit one full T-Post.	Submit to Materials Division for testing. Include grade and class on transmittal
Guide Posts		Section 721	One sample per project per supplier	After delivery to jobsite	One full post	Submit to Materials Division for testing
Object Markers		Section 721	One sample per project per supplier	After delivery to jobsite	One full post	Submit to Materials Division for testing
Chain Link Fence		Section 724	Two pieces for each lot shipped to jobsite	Random samples from random spools after delivery to jobsite	0.3 m (1 ft) wide full height	Submit to Materials Division for testing
Woven Wire and Barbed Wire		Section 724	Woven Wire: Two pieces per 50 rolls or fraction thereof. Barbed Wire: Four pieces per 50 rolls or fraction thereof	Random samples from random spools after delivery to jobsite	Woven: Two sections wide full height. Barbed: 900 mm (3 ft) long	Submit to Materials Division for testing
Traffic Paint		Section 729	One per contract per manufacturer's lot	Upon delivery to jobsite	1 liter (1 qt) wide mouth metal can	Submit to Materials Division for testing. Sample each color. Plural component paints (epoxy and polyuria). Sample each component. Include the manufacturer product code and batch on the transmittal. For waterborne paint, specify Type I or Type II
	511	Retroreflectivity Section 632	One per lane kilometer (two per lane mile) of stripe. Average five readings per location, minimum	1-2 weeks after application		

TABLE 5.1 – MINIMUM REQUIRED SAMPLES AND TESTS - PROJECT

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	SIZE OF SAMPLE	REMARKS
Traffic Paint Cont.	510	Thickness Section 632	Two per day per color			Measured without beads
Concrete Paint, Concrete Stain, Structural Steel Paint and Fine Surface Finish		Section 502 Section 714	One per contract per manufacturer's lot	Upon delivery to jobsite	1 liter (1 qt) wide mouth metal can	Submit to Materials Division for testing. Sample each color. Plural component paints (epoxy and polyuria). Sample each component. Include the manufacturer product code and batch on the transmittal.
Pavement Marking Film (Tape)	512	Adhesion Section 634	One per lane kilometer (two per lane mile); miscellaneous items - arrows, only's, crosswalks, stop bars, etc. will be at the discretion of the Resident Engineer	Test within 48 hours of placement		
Traffic Beads		Section 730	One per project per manufacturer's lot	Upon delivery to jobsite	1 liter (1 qt) wide mouth metal can	Submit to Materials Division for testing. Include manufacturer's lot number and type on the transmittal

TABLE 5.7 - MINIMUM REQUIRED SAMPLES AND TESTS - INDEPENDENT ASSURANCE (IA)

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	REMARKS
Borrow / Embankment	108	Proctor	One per 1,250,000 yd^3	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 1,250,000 yd^3	Split samples with project	
	102 or 103	Density	One per 50,000 yd^3		Visual audit of testing procedures
Select Borrow	108	Proctor	One per 1,250,000 yd^3	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 1,250,000yd^3	Split samples with project	
	102 or 103	Density	One per 50,000 yd^3		Visual audit of testing procedures
	206	Sieve Analysis	One per 50,000 yd^3	Split samples with project	2-way splits required
Backfill	108	Proctor	One per 250,000yd^3	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 250,000yd^3	Split Samples with project	
	102 or 103	Density	One per 10,000yd^3		Visual audit of testing procedures
	206	Sieve Analysis	One per 10,000yd^3	Split samples with project	2-way splits required
Granular Backfill and MSE Backfill	108	Proctor	One per 250,000 yd^3	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 250,000 yd^3	Split samples with project	
	102 or 103	Density	One per 10,000 yd^3		Visual audit of testing procedures
	206	Sieve Analysis	One per 10,000 yd^3	Split samples with project	2-way splits required
	210/211/212	Atterberg Limits	One per 10,000 yd^3	Split samples with project	2-way splits required
Slurry Backfill	206	Sieve Analysis	One per 10,000 yd^3	Split samples with project	2-way splits required
	431 or 432	Air Content by Volumetric or Pressure	One per 2,000 yd^3	Same location as project control samples	Side by side audit

TABLE 5.7 - MINIMUM REQUIRED SAMPLES AND TESTS - INDEPENDENT ASSURANCE (IA)

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	REMARKS
Types 1, 2 & 3 Base (For Type 3 See Special Provisions)	108	Proctor	One per 500,000 tons	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 500,000 tons	Split samples with project	
	102 or 103	Density	One per 20,000 tons		Visual audit of testing procedures
	206	Sieve Analysis	One per 20,000 tons		2-way splits required
	210/211/212	Atterberg Limits	One per 20,000 tons	Split samples with project	2-way splits required
	230	Fractured Face	One per 20,000 tons		2-way splits required
Aggregate for Portland Cement Treated Base	206	Sieve Analysis	One per 10,000 tons	Road mixed: From processed material, prior to adding cement Plantmixed: From conveyors, prior to adding cement	2 -way splits required
	227	Sand Equivalent	One per 10,000 tons		2-way splits required
Cement Treated Base (Roadmix or Plantmix Method)	108	Proctor	One per 500,000 tons	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 500,000 tons	Split samples with project	
	102 or 103	Density	One per 20,000 tons		Visual audit of testing procedures
Pulverized Base and Surface (Roadbed Modification)	108	Proctor	One per 1,750,000 yd^2	Split samples with project	Compaction audits required
	104	Specific Gravity	One per 1,750,000yd^2	Split samples with project	
	102 or 103	Density	One per 70,000 yd^2		Visual audit of testing procedures
	206	Sieve Analysis	One per 70,000 yd^2	Split samples with project	2-way splits required

TABLE 5.7 - MINIMUM REQUIRED SAMPLES AND TESTS - INDEPENDENT ASSURANCE (IA)

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	REMARKS
Shouldering Material	206	Sieve Analysis	One per 20,000 tons	Split samples with project	2-way splits required
	210/211/212	Atterberg Limits	One per 20,000 tons	Split samples with project	2-way splits required
Aggregate for Plantmix Bituminous Base, Surface, Open-Graded and Permeable Base	210/211/212	Atterberg Limits	One per project per stockpile		2-way splits required P.I. tests to be performed prior to marination
	230	Fractured Face	One per project per stockpile		2-way splits required
	111	Absorption of Coarse Aggregate	One per project per stockpile		2-way splits required
Permeable Base (Asphalt Treated)	206	Sieve Analysis	One per 20,000 tons	Split samples with project	2-way split required
	761	Bitumen Ratio	One per 20,000 tons	Split samples with project	
Plantmix Bituminous Base and Surface	206	Sieve Analysis	One per 10,000 tons	Split samples with project	2-way split required. First audit and split to be conducted on the first day of operations
	325	Theoretical Maximum Specific Gravity (Rice)	One per 10,000 tons		
	761	Bitumen Ratio	One per 10,000 tons		2-way splits required. First audit and split to be conducted on the first day of operations
	335 or 750	Density	One per 100,000 yd^2		Visual audit of testing procedure. First audit to be conducted on the first day of paving operations.
Plantmix Bituminous Open-Graded Surface	206	Sieve Analysis	One per 10,000 tons	Split samples with project	2-way split required. First audit and split to be conducted on the first day of operations
	325	Theoretical Maximum Specific Gravity (RICE)	One per 10,000 tons		

TABLE 5.7 - MINIMUM REQUIRED SAMPLES AND TESTS - INDEPENDENT ASSURANCE (IA)

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	REMARKS
Plantmix Bituminous Open-Graded Surface Cont.	761	Bitumen Ratio	One per 10,000 tons	Split samples with project	2-way split required. First audit and split to be conducted on the first day of operations
Cold Recycle	750	Density	One per 70,000 yd^2		Visual audit of testing procedures
	759	Field Viscosity	One per 20,000 tons		Visual audit of Saybolt Furol testing procedures
Surface Treatment Screenings (Chips)	206	Sieve Analysis	One per 20,000 tons	Split samples with project	2-way splits required
	228 (CA T227)	Cleanness Value	One per 20,000 tons	Split samples with project	2-way splits required
	230	Fractured Face	One per 20,000 tons	Split samples with project	2-way splits required
	759	Field Viscosity	One per 20,000 tons		Visual audit of Saybolt Furol testing procedures
Micro-Surfacing	206	Sieve Analysis	One per 20,000 tons	Split sample with project	2-way splits required
	210/211/212	Atterberg Limits	One per 20,000 tons	Split sample with project	2-way splits required
	227	Sand Equivalent	One per 20,000 tons	Split sample with project	2-way splits required
	230	Fractured Face	One per 20,000 tons	Split sample with project	2-way splits required
Concrete Aggregates	206	Sieve Analysis	Pavement: One per 70,000 yd^2 Structure: One per 3,000 yd^3	Split samples with project	2-way split required
	227	Sand Equivalent	Pavement: One per 70,000 yd^2 Structure: One per 3,000 yd^3	Split samples with project	2-way split required
	228 (CA T227)	Cleanness Value	Pavement: One per 70,000 yd^2 Structure: One per 3,000 yd^3	Split samples with project	2-way split required

TABLE 5.7 - MINIMUM REQUIRED SAMPLES AND TESTS - INDEPENDENT ASSURANCE (IA)

MATERIAL OR PRODUCT	NEV. TEST NO.	TEST	SAMPLE FREQUENCY	LOCATION OR TIME OF SAMPLING	REMARKS
Portland Cement Concrete for Structures	431 or 432	Air Content by Volumetric or Pressure	One per 1,000 yd^3	Same location as project control samples	Side by side audit
	438	Slump	One per 1,000 yd^3	Same location as project control samples	Side by side audit
	435	Unit Weight	One per 1,000 yd^3	Same location as project control samples	Side by side audit
Portland Cement Concrete for Pavement	431 or 432	Air Content by Volumetric or Pressure	One per 7,500 yd^3	Same location as project control samples	Side by side audit First audit on first day of operations
	438	Slump	One per 7,500 yd^3	Same location as project control samples	Side by side audit First audit on first day of operations
	435	Unit Weight	One per 7,500 yd^3	Same location as project control samples	Side by side audit First audit on first day of operations
Self Consolidating Concrete (SCC)	416	Air Content and Unit Weight	One per 1,000 yd^3	Same location as project control samples	Side by side audit First audit on first day of operations
	417	Slump Flow / VSI (Visual Stability Index)	One per 1,000 yd^3		Visual audit of testing procedures First audit on first day of operations
	418	J-Ring / Slump Cone	One per 1,000 yd^3		Visual Audit of testing procedures First audit on first day of operations

Note 1: When utilizing coldmillings, follow the frequency for which the material is being used for, and refer to the Contract Special Provisions for additional specifications.

Note 2: Visual audits (040-079) may be done in lieu of 2-way splits or side by side audits at a frequency not to exceed 10% of minimum required IA frequencies. (Example: minimum of 5 audits required per contract x 10% = .5 = 1 visual audit can be completed for this material on this contract.)

CONSTRUCTION

6-100 GENERAL

After bids are solicited for a transportation project, the contract is awarded to a contractor, and the administration of the contract is transferred from Headquarters to the District. The District oversees the construction of the project in accordance with NDOT policies and procedures, and as described in the plans and specifications. This section provides guidance to the Resident Engineer and crew in monitoring the contractor's materials and construction activities used in constructing the transportation project.

The plans and specifications are the directions that NDOT provides to a contractor to construct a project. The plans are drawings, and specifications are written directions. In addition to the written contract between NDOT and the contractor, the following contract documents are used on NDOT construction projects:

- Standard specifications – Written directions that are common to NDOT projects
- Standard plans – Drawings that are common to NDOT projects
- Supplemental specifications – Specifications that are issued by NDOT in Supplemental Notices after a project is advertised for bids and before the bid opening
- Plans – Drawings of specific details and dimensions for an individual project
- Special provisions – Specifications covering conditions peculiar to an individual project

In case of discrepancy, plans govern over specifications, supplemental specifications govern over specifications, and special provisions govern over both specifications and plans.

Specifications are organized in three principal sections: General Requirements (Section 100), Construction Details (Section 200 through 600), and Materials Details (Section 700). Section 6 of this *Construction Manual* is organized to correlate with the numbering system in the specifications. For example, information on clearing and grubbing is found in section 201 of the specifications and section 201 of this *Construction Manual*.

This *Construction Manual* communicates the policies of the Construction Division and presents guidance to field personnel. The Chief Construction Engineer is responsible for maintaining a current *Construction Manual*. Updating of the *Construction Manual* is discussed in Section 3-202, Construction Phase, of this *Construction Manual*.

6-101 AGGREGATE SOURCES

Aggregate materials for a project come from a material source, commonly called a pit. The material source can be either privately owned or publicly owned. During project development, Materials Division personnel locate material sources that most economically meet the project needs.

On most NDOT construction projects, the material sources are designated in the plans and specifications. In some situations, the contractor may want to use an alternate site, or expand the limits or boundaries of an approved site. When this situation occurs, the Resident Engineer must confirm that the material is acceptable for use on the project. Source acceptance is determined by the Materials Division, based on test results of aggregate samples collected by the Resident Engineer. The contractor should allow at least 30 days for completion of the additional sampling and testing. For sampling and testing guidance, refer to Section 5, Sampling and Testing, of this *Construction Manual*. The contractor must comply with the requirements stated in the specifications for furnishing materials from a source not listed in the specifications. Fulfilling the requirements for an alternate source may require additional time that the contractor must consider so that the project is not delayed.

The plans and specifications list the contractor's requirements regarding the material supply. See Section 106 of the specifications for information relative to material sources, state-furnished materials, material storage, and defective materials.

A contractor may process and stockpile aggregate before incorporating the material into the work. When this happens, the contractor may request payment of the stockpiled material. The Resident Engineer's Survey Crew Chief measures the stockpile, documents the measurement, and the Resident Engineer completes NDOT form 040-015, "Request for Payment for Materials on Hand." The Resident Engineer processes the request for payment only if the contractor's informational test results show conformance with specifications. Refer to the *Documentation Manual* for additional guidance on measurement and payment of stockpiled material.

6-101.1 STATE-PROVIDED SOURCES

After the contractor proposes a material source, the Resident Engineer should consider the following:

- Source location and access roads
- Right-of-way limits of source
- Haul routes on city or county roads and related requirements, such as weight restrictions
- Improvements that need to be removed, reset, adjusted, or protected, such as power lines or fences
- Slopes to maintain
- Areas to protect from dust, such as crops or buildings
- Conformance with environmental restrictions
- Avoidance areas

At times, the contractor will produce and stockpile materials before incorporation into the work. The contractor must preserve the integrity of the material when constructing the stockpile. Generally, the contractor constructs stockpiles in the following two ways:

- Construct stockpiles at the end of production belts.
- Haul the produced material from production belts to stockpiles.

With both methods, the contractor's objective is to reduce segregation or degradation of the materials.

The contractor typically constructs stockpiles as follows:

- Stockpile Area – Before starting production, the contractor levels the storage or stockpile area and, if necessary, spreads and compacts a leveling course of the material to be stockpiled. This provides a uniform surface on which to place the stockpile material. If the contractor plans to request payment for stockpiled materials, the Resident Engineer's Survey Crew Chief establishes elevations on the stockpile storage surface before stockpile construction.
- Stockpile Placement – When stockpiling material as it leaves the production belt, the contractor should minimize material handling with equipment. When using a dozer for spreading, the repeated abrasive action may segregate and degrade the material. When transporting material to the stockpile, the contractor should unload it so that the spreading equipment at the stockpile location will mix the material. For example, "belly-dump" vehicles are unloaded parallel to each other and the dumped loads are leveled before dumping a second layer of material. "End-dump" vehicles are unloaded in a similar manner. "End-dump" vehicles should only be unloaded on horizontal surfaces, not on the stockpile edge, to reduce excessive material segregation.
- Stockpile Contamination – When stockpiling different aggregate types in the same general area, the contractor must provide a means to separate the stockpiles. The contractor may use walls to separate aggregate types.

6-101.2 COMMERCIAL SOURCES

At a commercial source, the material supplier must test the material being produced to verify conformance with the requirements of the specifications. The Resident Engineer requests copies of the test results to confirm compliance with the specifications. Although the material source may be a commercial source, for concrete aggregate the source must undergo an annual testing process to confirm that the source is acceptable for use on NDOT projects. For other aggregate sources, the source undergoes sampling and testing only if the source is in use or proposed for use. This material source sampling and testing process is called "source acceptance." The Resident Engineer consults with the Materials Division to confirm that the material source proposed for use by the contractor has received source acceptance approval. For additional information on source acceptance testing, refer to Section 5-403, Source Acceptance Sampling and Testing, of this *Construction Manual*.

The contractor may request stockpile payment for material at a commercial source. The stockpile must be separated from other stockpiles and clearly labeled, so it is not used for other projects. The Resident Engineer's Survey Crew Chief measures the stockpile, documents the measurement, and the Resident Engineer completes NDOT form 040-015, "Request for Payment for Materials on Hand." The Resident Engineer processes the request for payment only if the contractor's informational test results show conformance with specifications. Refer to the *Documentation Manual* for additional guidance on measurement and payment of stockpiled material.

6-201 CLEARING AND GRUBBING

6-201.1 GENERAL

Clearing and grubbing consists of removing objectionable material from the construction areas and right-of-way. On environmentally sensitive projects, the specifications may require the contractor to stockpile material from the clearing and grubbing operation for reuse on the project. A thorough and organized clearing operation can directly affect the project's final appearance. Debris and excess materials left on jobsites can affect maintenance costs. Debris from the clearing and grubbing operation can clog drains or create additional maintenance activities.

6-201.2 BEFORE CONSTRUCTION

The contractor should protect existing roadway improvements, utility facilities, adjacent buildings, fences, and landscaping. The plans and specifications describe the elements to protect during the clearing and grubbing operation. The Resident Engineer should mark improvements or items that the contractor must protect.

The inspector should do the following before clearing and grubbing begins:

- Confirm the appropriate authority has approved the contractor's water pollution control plan. Review the plan to make sure that clearing and grubbing is consistent with the approved plan. Confirm that the contractor has all required environmental permits before work begins.
- Discuss with the contractor the marking of special locations such as environmentally sensitive areas and other specified avoidance areas.
- Before the contractor disposes of material outside of the right-of-way, review Section 107.14 of the specifications to determine the contractor's responsibilities.
- Before the contractor handles any hazardous waste materials, the contractor must contact the Nevada Department of Conservation and Natural Resources, Division of Environmental Protection for specific information and assistance.
- Confirm that the contractor has installed Best Management Practices (BMP) measures before activities begin, and complete NDOT form 040-054, "Weekly NDOT Construction Site Discharge Inspection Checklist."

6-201.3 DURING CONSTRUCTION

Slope staking is completed before clearing and grubbing operations begin on a project. Slope stakes guide clearing operations. The Resident Engineer ensures that the clearing operation limits are sufficiently marked, including areas near drainage structures or other appurtenances.

During construction operations, the contractor is responsible for protecting existing property or areas. To prevent damage to certain property or areas on the project, the contractor may erect protective fencing or other barriers. The contractor can place timbers around existing trees and shrubs to protect the bark from equipment or falling rocks. Unless specifications state that the protective measures are to be paid for, as pay items, the cost of providing protective measures is included in other items of work, and not paid for directly.

For clearing and grubbing operations, contractors may use a variety of equipment. The contractor selects the appropriate types of equipment for each operation. The contractor's equipment must have the required safety devices to protect personnel, and spark arresters to reduce fire hazards.

The inspector should consider the following when monitoring the contractor's clearing and grubbing operations:

- Observe that the contractor's operations do not create hazards. If necessary, require traffic control to provide for safety.
- Monitor adjacent property and environmentally sensitive areas to observe that the contractor's operations do not damage the areas.
- Monitor the contractor's compliance with to permits and agreements. Document any deviations, and inform the Resident Engineer and the contractor of required corrective action.
- Review the specifications to determine if fallen timber or salvaged items are the property of others.
- If the specifications allow burying debris within the right-of-way, confirm the following:
    - Debris will not act as an impermeable layer
    - Debris does not block drainage
    - Debris will not interfere with maintenance
    - Material is not buried within the roadway prism
    - Organic material is not buried within the right-of-way
- Keep accurate records when disposing of solid wastes adjacent to the roadway. Also, show this information on the as-built plans.
- Do not dispose of debris by burning it.
- If necessary, provide a list of incomplete clearing locations in the final project stages.

6-201.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the Construction Division *Documentation Manual*. Keep accurate records of cleared and grubbed areas in the form of sketches and measurements. Make payments only for those areas shown in the plans. If the contractor does not complete the work within one pay period, determine a method of partial payment that provides for payment based on a percentage of work completed.

6-202 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

6-202.1 GENERAL

This section provides information about removing structures and other materials within the construction limits. Examples of structures to be removed include buildings, foundations, fences, guardrails, pavements, culverts, curbs, sidewalks, masonry, monuments, manhole and valve covers, and bridges. Some structures may include hazardous materials with specific handling requirements. Removed structures and materials may be disposed or salvaged, depending on the specifications.

Coldmilling is a technique for removing a portion of the asphalt or concrete pavement. Coldmilling (also called rotomilling) involves specialized equipment that removes the material to a desired depth to restore the surface to the grade and slope shown in the plans. Pavement material picked up during the coldmilling process can be recycled for use on the same job or on future projects. When removing surface materials using methods other than coldmilling, the inspector should give attention to the removal method and removal limits identified in the plans and specifications.

6-202.2 BEFORE CONSTRUCTION

Before work begins, the Resident Engineer, inspectors, and the contractor should discuss the work to be performed. These personnel should discuss special situations or details and resolve issues regarding limits of removal, salvage, storage, and disposal of obstructions and materials.

The inspector or survey crew should stake or mark structures and obstructions designated for removal. Structure removal may include coldmilling of concrete and asphalt pavements. The Resident Engineer should coordinate with the contractor for disposal or reuse of the milled materials.

When blasting is necessary to remove obstructions, the contractor prepares a safety plan in accordance with the specifications. Everyone involved with the blasting operation must understand the plan. Although the contractor is liable for damage incurred by the blasting operations, the Resident Engineer and inspectors should point out to the contractor any unsafe or hazardous conditions that might exist.

6-202.3 DURING CONSTRUCTION

Follow these guidelines for disposing of objectionable material during construction:

- Refer to Section 107 of the specifications for procedures when disposing of material outside the right-of-way.
- When disposal areas are within the right-of-way, the specifications will describe the disposal requirements. In addition to the specifications, the material should appear finished and be covered with soil.
- In mountainous areas, be aware that disposal sites above the roadway grade may present sliding or maintenance problems. Before approving disposal sites above roadways, the Resident Engineer should evaluate the potential for slides and maintenance problems.
- Avoid disposing of material in a manner that alters existing drainage patterns.

- When removing concrete pavements, curb, and sidewalk, existing joints are sawcut to provide a clean separation between remaining and removed concrete. The plans and specifications require the contractor to sawcut existing bituminous surface at the limits of removal. The Resident Engineer may modify removal limits based on field conditions.

When removing asphalt by coldmilling, refer to Section 202 of the specifications. The inspector should observe the following additional guidelines:

- Monitor the coldmilling depth to confirm compliance with plans.
- Verify that stockpiles of milled material do not become contaminated.
- Confirm that the contractor disposes of milled materials as stated in the specifications.
- The Resident Engineer may request the contractor to perform additional coldmilling as required by the specifications to remove delaminated areas.
- Discuss coldmilling texture, depth uniformity, delaminations, grade control, cross-slope, transitions, and sawcuts at intersections with the contractor.

Removal of a bituminous pavement from a bridge deck involves removing the bituminous surface while protecting the remainder of the bridge deck. The Resident Engineer confers with the contractor to determine the procedures that the contractor will use. The inspector observes that the contractor exercises care and does not damage the bridge deck.

When removing materials or obstructions for salvage, the plans describe the removal and storage conditions. Store salvaged materials in designated areas.

6-202.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the Construction Division *Documentation Manual*. Sawcuts are typically not measured or paid for, as they are included in other items of work. Painted line removal is measured and paid by the linear foot. Gaps in painted lines are included in the linear foot measurement.

6-203 EXCAVATION AND EMBANKMENT

6-203.1 GENERAL

Excavation and embankment consists of excavating soil or similar material and constructing embankments. More specifically, it may include furnishing, hauling, stockpiling, placing, disposing, sloping, shaping, compacting, and finishing embankment material. This work may also consist of performing slope scaling and placing geotextile fabric as required in the specifications.

6-203.2 BEFORE CONSTRUCTION

Inspection of embankment and excavation operations requires monitoring of several concurrent activities. Effectively monitoring these activities requires the inspector to become familiar with the following:

- Slope staking
- Profile sheets, ditch sheets, and cross sections
- Material sources
- Drainage improvements
- Testing requirements

Before the contractor begins work, the survey crew typically takes cross sections every 1,000 feet to verify the original ground elevations used for the design. In variable terrain, field checks are performed at closer intervals. Cross sections taken before the contractor begins work are useful in resolving disputes relating to excavation quantity.

During the design phase, the Design Division may identify a need for embankment material. When material is excavated, the volume increases because the material is loose or uncompacted. The difference in volume, expressed as a percentage, is called the swell factor. When material is compacted, the volume decreases. This difference in volume is called the shrink factor. Shrink and swell factors are calculated based on soil type.

Shrink and swell factors are listed in the plans. Typically, excavation quantities are calculated based on the amount of embankment required. The amount of excavation is estimated by determining the amount of embankment required, then dividing the embankment amount by the difference of one hundred percent and the shrinkage factor.

When conditions such as unsuitable material are within the project limits, placement of a geotextile or a geogrid may be required. Geogrids and geotextiles are made of synthetic (manmade) material, typically polypropylene. Geogrids are synthetic materials with uniform openings that look like netting. Geotextiles are permeable fabrics manufactured using one of following methods: woven (looks like burlap), non-woven (looks like felt), and heat bonded (looks like ironed felt). A geogrid is used to reinforce soil. Geotextiles are used as follows:

- Separation – the geotextile separates and prevents mixing of two layers of soil having different particle sizes or properties
- Drainage – the geotextile collects water and drains it
- Filtration – the geotextile acts as a filter between soil and a drain material, allowing water and small soil particles to pass through the filter
- Reinforcement – the geotextile provides strength to reinforce soil

Geotextiles and geogrids must conform to the requirements contained in the specifications. The specifications describe the physical characteristics such as tensile strength, stretch or elongation, puncture strength, average opening size, weight, and ultraviolet resistance.

During construction, unsuitable and unexpected material may be encountered. Review the specifications to determine what options are available. If the specifications do not describe options, the Resident Engineer discusses the material type and conditions with the Materials Division.

the contractor intends to use over-sized vehicles, the Resident Engineer can find information regarding over-sized vehicles and permit information at www.nevadadot.com/business/trucker/overdimensional/. Use NDOT form 040-000, "Vehicle Weight Limit," to record dimensions of the contractor's vehicles to verify that they do not exceed legal limits.

Contractors typically use scrapers and motor graders to excavate roadways and large ditches. On projects with significant excavation, dozers may push scrapers to increase the scraping depth. Scrapers are particularly adapted to granular materials, softer grades of rock, and long hauls with flat to mild grades. Scrapers are also used on new alignments where accommodation of existing traffic is not an issue. Trucks loaded by shovels or loaders are used when material must be hauled on existing roads or streets, or when haul distances are very long and are regulated by weight restrictions.

Many types of compacting equipment are available. Common roller types include sheepsfoot, rubber-tired, vibrating, oscillating, grid, segmented, and steel wheel. Some types of equipment handle certain types of material better than other types of equipment. Specifications typically describe acceptable equipment that the contractor may use for compaction.

For various soil types, the contractor selects the appropriate equipment, such as the following:

- Steel wheel roller (vibratory or non-vibratory) – For granular materials, the contractor may use vibratory steel wheel rollers. The vibratory roller effectively compacts clean, granular soils containing little or no clay particles. The vibratory roller can vibrate a uniform, granular soil to high density. The vibratory roller becomes less effective, however, as the amount of clay particles increases.
- Sheepsfoot roller – These most effectively compact clays and silts. They work well in cohesive soils, but will compact most soils containing granular material if the soil contains a reasonable proportion of cohesive material. Tamping foot and sheepsfoot rollers can operate in only about a 6-inch lift because of the length of their feet (protrusion) from the drum. In thicker lifts, the drum will ride on the surface of the loose soil and the feet will not reach into and compact the lower portion of the lifts. Tamping foot and the sheepsfoot rollers are not effective in compacting clean sands and gravels.
- Pneumatic tired roller – This is capable of effectively compacting soils that contain fine materials with clay particles. Pneumatic rollers apply a kneading action on the material, which can increase the compactive effort.

Figure 6-203.1. Steel Wheel Vibratory Roller.

Figure 6-203.2. Sheepsfoot Roller.

Figure 6-203.3. Pneumatic Tired Roller.

Slopes are usually finished with motorized equipment. The type of equipment varies depending on slope steepness, access, type of material, and availability of equipment. Although the type of equipment used is the contractor's decision, it must produce acceptable results.

The success of constructing an embankment depends on the proper preparation of the foundation. Specifications may describe requirements, such as benching, related to constructing embankments. The inspector should monitor construction of embankment to confirm that slippage planes, areas of soft materials, and water in the form of springs or seeps are addressed. Identifying possible problems and discussing them with the contractor before work begins can reduce disruption during construction.

Blasting, which loosens solid rock outside of the planned slopes, requires strict adherence to safety measures because of the potential for flying debris and slides. Before blasting takes place, the contractor must comply with the requirements of the specifications. If a blasting plan is required, the Resident Engineer reviews and accepts the plan.

On projects that require shaping slopes or removing rock debris, review the requirements described in the specifications. Depending on the complexity of the slope scaling, a contractor may be required to submit qualifications to perform the work. In addition to providing qualifications, a contractor may be required to submit a work plan or fulfill other requirements as described in the specifications. Review ingress and egress to work areas, haul routes, and traffic control requirements with the contractor.

6-203.3 DURING CONSTRUCTION

6-203.3.1 ROADWAY EXCAVATION

During roadway excavation, periodically check for proper elevations, depth of excavations, and conformance to the typical sections shown in the plans. The inspector should compare the actual construction and the grade stakes with information contained in the plans, especially at intersecting roads, approaches, and driveways. Monitoring the amount of completed excavation provides for scheduling of surveying.

6-203.3.1.1 UNSUITABLE MATERIAL

During roadway excavation, unforeseen conditions, such as unsuitable materials, may be encountered. Unsuitable material is any material that adversely affects roadbed stability. Preliminary investigations may identify materials as being unsuitable for roadway construction. The plans and specifications identify these areas and the measures that the contractor should take. The Resident Engineer should contact the Materials Division Geotechnical Section for direction when the specifications do not address unsuitable materials. The Resident Engineer directs the contractor to remove and dispose of unsuitable material encountered, even though not originally planned or anticipated. After consulting with the Materials Division, the Resident Engineer directs the contractor on the limits of removal.

Material that is unsuitable because of high moisture content may be satisfactory for use in embankments after it has dried. When backfilling areas that contained saturated material, the contractor may be required to install a seepage outlet or to place perforated drains.

Before removing unsuitable material that is not shown on the plans or described in the specifications, determine the payment method for excavation and disposal.

6-203.3.2 DRAINAGE AND CHANNELS

When a drainage channel is modified, maintaining alignments of existing channels inside and outside of the NDOT right-of-way is important. New or modified channels may increase the potential for erosion, either by changes in flow direction or by increasing flow velocities because of increased grades. After ditch construction, assess the ditch's ability to pass runoff without causing erosion or other damage. If the Resident Engineer determines that a ditch may cause erosion, the Resident Engineer should confer with the Roadway Design Division Hydraulics Section.

6-203.3.3 BORROW

If the material excavated from a roadway is insufficient to construct an embankment, the additional material is called borrow. Borrow material can be either excavated from a location on the jobsite outside of the roadway prism or from an off-site material source. If the excavated material is unsuitable for use as embankment, the material is disposed of and borrow material is placed in the embankment. Typically, the specifications designate a borrow material source.

When the excavation is substantially complete, the need for borrow material is confirmed. If additional borrow material is needed, the location where the borrow is to be obtained is cleared and grubbed, and then cross sectioned. Borrow measured in this manner is called borrow excavation. In urban areas, borrow may be obtained from a variety of locations and is measured in-place. Borrow measured in this manner is called borrow embankment.

If final measurements are necessary, the site is cross sectioned again to determine the volume of material excavated. Although quantities shown in the plans may be used for payment, the Resident Engineer may use or the contractor may request payment based on quantities calculated from initial and final cross sections.

6-203.3.4 SURPLUS MATERIAL

If a project requires excavation of more material than can be used in the embankment, the excess is called surplus material. As soon as possible, the Resident Engineer should reconcile preliminary quantity calculations, including shrinkage and swell factors, with actual quantities and factors. Deviations may require wasting of material, adjustments in haul, or adjustments in grade or alignment. When wasting surplus material, the Resident Engineer should consider flattening slopes to provide additional recovery areas for vehicles.

Plans typically direct the contractor to place surplus material alongside an embankment, between embankment and right-of-way lines, or in interchange areas, if such areas are available. The contractor should dispose of surplus materials in areas that will not interfere with drainage, will benefit future improvements, or will improve the appearance or stability of the roadway. Surplus material placed adjacent to an embankment should be compacted. If the plans and specifications do not address the disposal of surplus material, the contractor must dispose of the surplus material at no cost to NDOT.

6-203.3.5 SELECTED MATERIAL

Selected material is typically used for structure backfill, topsoil, or for other purposes shown on the plans. Selected material must meet requirements of the specifications. The contractor must not use selected material for any purpose other than that designated in the plans and specifications unless approved by the Resident Engineer.

6-203.3.6 SLIDES AND SLIPOUTS

Slides and slipouts are unplanned earth movements. When these movements occur, the Resident Engineer may require the contractor to excavate and remove material. Potential slides may be stabilized by installing horizontal drains or underdrains, or, in the case of small slides, by constructing bulkheads or retaining walls. Benches may be constructed in the slide area to reduce the potential of falling material.

When a slide or slipout has occurred, corrective action or resloping a slide area may be required. To determine corrective actions, the Resident Engineer should confer with the Materials Division Geotechnical Section for guidance. Resloping normally occurs incrementally during slide removal. During resloping, the Resident Engineer should determine if minor slippages appear probable. If slippages appear probable, then resloping should be discontinued until the slope is stabilized.

6-203.3.7 FOUNDATION FOR EMBANKMENT

The inspector should monitor construction of the embankment foundation to verify proper preparation. Following are conditions that may require corrective measures for a proper foundation:

- Proper compaction of the original ground
- Drainage seepage
- Springs
- Lush growth of vegetation in local areas, indicating ground water
- Trees and brush leaning downhill, indicating slippage of the surface mantle
- Rolling terrain
- Twisted trees or lack of vegetation in otherwise timbered areas, indicating a large slide

Following are common causes of embankment failure and possible corrective measures:

- The weight of the embankment displaces or consolidates material in the foundation. Possible solutions are as follows:
    - If economically feasible, remove plastic material in the foundation.
    - Construct fills adjacent to the embankment as a counterweight that would resist upward movement of foundation material next to the embankment.
    - Construct embankment at a controlled rate so that settlement occurs over an extended period, allowing hydrostatic pressures to dissipate.
    - Construct a surcharge, such as additional embankment, on the completed embankment to accelerate settlement.
    - Construct vertical sand drains to facilitate drainage of water from the foundation.

- The embankment traps water in the foundation which forces the water to escape at the edges of the embankment, causing sloughing of the embankment. Possible solutions are as follows:
  - Install a filter material over the embankment area to allow drainage.
  - Construct a ditch or underdrain on the high side (up-gradient) of the embankment to intercept water.
- The embankment moves on a slippage plane in the underlying foundation. Possible solutions are as follows:
  - Construct a stabilization trench through the slippage plane.
  - Install horizontal drains to drain water from the slippage plane.
  - Construct buttress fills to support the embankment.

The Resident Engineer should confer with the Materials Division Geotechnical Section for guidance on embankment failures.

When embankment material contains scattered boulders, the contractor should distribute the boulders throughout the fill. Rock fills are constructed with a bulldozer to manipulate the rock into a compact mass. The contractor should water boulders and rock fills to wash fine material into the voids. In swampy or marshy areas, uncompacted thick layers of rock are placed across the area to act as a bridge over the marshy area. Typically, the contractor installs settlement-measuring devices in large embankments or surcharge areas and the Resident Engineer's survey crew monitors the settlement. The Materials Division usually directs the placement of settlement measuring devices.

If embankment settlement is anticipated, the survey crew should offset slope stakes to allow for the anticipated settlement. After settlement occurs, the offset slope stakes remain valid for the settled embankment. .

6-203.3.8 COMPACTION

Compaction directly affects the ability of soil to support vertical forces such as soil, water-bearing soil, and traffic loadings. Insufficient compaction reduces the supporting strength needed for subsequent layers. The contractor can use a variety of methods to achieve the required compaction. The inspector should not direct the contractor's compaction operation. However, the inspector should monitor the thickness of the material layer placed by the contractor to verify that the contractor does not exceed thicknesses allowed by the specifications. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for testing requirements.

Successful compaction depends on uniform moisture content in the material. The contractor may do the following when working with soil and moisture:

- Some soil materials do not mix with moisture as easily as others do. The contractor may mix or manipulate the soil and water with a bulldozer, disk, or motor grader.
- The contractor may use chemical wetting agents. Because wetting agents are expensive, contractors do not use them extensively.
- Contractors may apply water during excavation to improve the mixing of water and soil. Applying water during excavation provides additional mixing time during excavating, loading, unloading, and placing of the material.
- When experiencing soil moisture difficulties, the contractor mixes soil and moisture and then compacts the mixed material in thinner layers.

In confined areas, the contractor obtains compaction by watering and using small manual or motorized compaction equipment such as hand tampers, vibrating hand compactors, small hand-operated motorized rollers, or impact-type compactors. For rock fills, the contractor may use the proof rolling method for compaction. Proof rolling is repeatedly driving over the fill with a loaded truck, heavy equipment, or roller until no deflection is observed in the surface of the material being compacted. The specifications describe acceptable methods of proof rolling. The Resident Engineer should not allow proof rolling unless the material has a significant quantity of rock greater than four inches.

When haul vehicles travel over the embankment material, the contractor should stagger the vehicle paths so that as much of the fill area as possible is compacted. .

6-203.3.9 SLOPE SCALING

Slope scaling is the process of removing loose rock debris from a slope. Slope scaling can be the first step in stabilizing a slope from further rock debris accumulation. Rock debris can create an unsafe condition for traveling motorists due to the potential for falling rocks. Scaling is performed with hand tools or power tools such as jackhammers, hydraulic splitters, drills, crowbars, pry bars, jacks, and shovels. Heavy equipment is used when hand tools are inadequate. Blasting removes larger wedges of fractured material and overhanging cemented soils, but may be used only with prior approval. Caution is taken to prevent over steepening of the slope face, which may make the slope unstable.

The specifications require the contractor to provide the Resident Engineer qualifications and submittals at least 30 days before slope scaling operations begin. Review the specifications for qualification and submittal requirements. The Resident Engineer should consult with the Materials Division Geotechnical Section to understand the intent of the slope scaling project. Additionally, the Resident Engineer invites a representative from the Materials Division Geotechnical Section to the preconstruction meeting.

Slope scaling begins at the top of the slope and proceeds down slope, removing rock. The contractor removes or stabilizes material on the slope face that is loose, hanging, or creating a dangerous situation. Qualified scalers perform slope scaling. Scalers are workers that traverse the face of a slope while attached to ropes.

If the potential exists for damage to the roadway during scaling operations, the contractor must use protective mats or a soil cover on the roadway for protection. Before work begins, the contractor must obtain approval to place a temporary protective barrier at the near edge or center of the roadway. This barrier prevents the slope material from reaching the travel lane that is open to traffic. The contractor must maintain this barrier during slope scaling operations. The contractor bears the costs for repairing any damage to the roadway. The contractor reshapes ditches after work is complete so all water drains freely. The contractor must clean debris from the roadway before traffic is returned to the roadway.

6-203.3.10 GEOTEXTILE

When geotextiles are specified to address unsuitable soil conditions, the inspector must verify that the material delivered to the project conforms to the requirements of the specifications. Verify that the certificate of compliance that accompanies the geotextile delivered to the site complies with the specifications requirements. The contractor must stockpile geotextile fabric in a manner that protects it from moisture and sun exposure. If the fabric is stored outdoors, the geotextile rolls must be stored off the ground.

Prior to placing geotextiles, the inspector should confirm that the surface that receives the geotextile has been properly prepared. The surface should be smooth and free from cavities, large stones, or other irregularities that could puncture or damage the geotextile.

Geotextiles are placed by unrolling the fabric onto the surface. Adjacent pieces of geotextile may be joined by sewing or by overlapping. Contractors typically overlap geotextiles. The inspector should review the specifications to identify seam or overlap requirements. Prior to placing material over the geotextile, confirm that the geotextile is smooth and without gaps, tears, folds, wrinkles, or stretching. Do not operate equipment on the exposed geotextile.

Overlying material is placed on the geotextile by dumping from the edge of the geotextile or from previously placed lifts. The contractor must exercise care during placement of overlying material to ensure that the geotextile is not damaged. To protect the geotextile from damage, the contractor may reduce the size of the equipment used to place the overlying material or reduce the size of the loads being placed on the geotextile. Damaged geotextile must be repaired or replaced before material is placed on it.

6-203.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. Following is additional measurement and payment guidance:

- Removal of unsuitable material – For unsuitable material that is not shown in the plans or specifications, determine the method of payment for excavation and disposal:
  - If payment will be at contract prices, record measurements for calculating quantities.
  - If the contractor requests payment to be made as extra work, obtain the request in writing. Prepare and process a contract change order or a Letter of Authorization (LOA), and keep the necessary records relating to extra work.
- Extra work – Section 104.03 of the specifications provides guidance for payment as extra work for such operations as disposal of unsuitable materials or widening cuts by special equipment or other unusual operations.
- Drainage and channels – Channels are ditches with a width of 12 feet or more and are located outside the roadway prism. Excavation of channels is measured as channel excavation because they can be excavated with common earth-moving equipment. Excavation of ditches with bottom widths of less than 12 feet is measured as drainage excavation.
- Slides and slipouts – Payment as force account for slide removal may be the equitable solution and may help to avoid controversy with respect to excavation, pioneering, and resloping. Payment for resloping is made when the slide occurs in a cut that was previously sloped. The removal process is similar to other roadway excavation procedures. Payment for slipout removal is the same as payment for slide removal, typically either by load counts or by volume balance amounts.
- Borrow embankment – The quantity for payment is the quantity shown in the plans plus or minus any authorized changes. If the contractor disputes the quantity and requests final measurement, cross sections are taken to determine the actual borrow embankment quantity. If the final quantity is less than the quantity shown in the plans, the contractor reimburses NDOT for the cost of the final measurement.
- Borrow excavation – The quantity for payment is measured at the source of the excavation. Cross sections are taken before and after the excavation to determine the quantity.
- Slope scaling – Slope scaling is measured and paid by the cubic yard of material removed. To establish a method of measurement for the quantity of material removed by slope scaling, the inspector determines the capacity of the hauling vehicles. The inspector should coordinate with the contractor to reach an agreement on the hauling vehicles capacities. The inspector monitors the loading of the hauling vehicles to confirm that the vehicles are filled to the same level for each load. Any safety measures, protective barriers, blasting, drilling, material haul, and disposal costs are considered incidental to the payment for material removed and are not paid for separately.
- Geotextile – Geotextile fabric can be either measured and paid by the square yard of placed geotextile fabric or may be considered incidental to other items of work. When measured by the square yard, only the coverage area is measured. Material that overlaps is not measured for payment. When considered incidental to other items of work, there is no additional payment for geotextile fabric.

6-206 STRUCTURE EXCAVATION

6-206.1 GENERAL

Structure excavation is the removal of materials to accommodate the construction of structures such as culverts, drainage structures, abutments, and footings.

6-206.2 BEFORE CONSTRUCTION

Before excavation begins, the contractor must submit a safety plan to the Resident Engineer that includes detailed shop drawings of any shoring, cribbing, sloping, or other protective systems that conform to the Occupational Safety and Health Administration (OSHA) regulations.

At least two weeks before excavation begins, coordinate with the contractor to reduce possible problems regarding measurements for payment. The contractor may excavate outside of the excavation limits shown in the plans, at no cost to NDOT, but the contractor cannot excavate to less than the prescribed limits because of possible interference with backfill or testing operations.

6-206.3 DURING CONSTRUCTION

Observe excavation operations as they progress so alterations or changes can be made without causing delays. Observe safety procedures during excavation and throughout the installation process. Payment for additional excavation is allowed only with prior approval of the Resident Engineer.

Inspect excavation depth and verify that the compaction of the excavation floor meets the requirements of the specifications before the contractor constructs or installs the structures.

6-206.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manua*l.

6-207 BACKFILL

6-207.1 GENERAL

Backfill includes placing and compacting material in excavations for bridges, retaining walls, headwalls, culverts, and other structures. Requirements for backfill materials are listed in the specifications. Improper backfilling can cause future failures of culverts or structures. .

6-207.2 BEFORE CONSTRUCTION

Before backfill activities begin, the inspector should review the locations where culverts and other structures require backfill. The inspector should be aware of the different types of backfill, such as backfill from the excavation, granular backfill, or slurry cement backfill, and review the specifications to determine which one the contractor is to use. The use of “pea gravel” is prohibited. The contractor may stockpile approved backfill material near the structure site where the backfill material is to be used.

The inspector should coordinate with the contractor for efficient inspection and testing activities. The inspector should confer with the testers to verify that the backfill material meets specifications before it is used. The inspector should confirm the source for backfill material has received source acceptance from the Materials Division.

6-207.3 DURING CONSTRUCTION

Place backfill uniformly on all sides of the structure. Unequal backfilling may push the structure out of line or subject it to stresses. The inspector should be aware of the maximum allowable placement depth of each layer, typically eight inches, and observe that the contractor adheres to the specification requirement. The inspector should closely monitor the compaction operations. Although it is difficult for the contractor to compact backfill under the pipe haunches, compacted material under the haunches is necessary to support the pipe. Additionally, the contractor should not over-compact the backfill, which can lift the pipe out of position. Compaction testing is performed consistent with requirements of Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*.

6-207.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-208 FOUNDATION FILL

6-208.1 GENERAL

Foundation fill is placed in excavated areas to establish a stable foundation for culverts, bridges, and other structures. Foundation fill replaces material that is unsuitable as foundation material. The specifications contain requirements for foundation fill material.

6-208.2 BEFORE CONSTRUCTION

Review the plans and specifications to determine requirements and locations for foundation fill. Coordinate with the contractor to establish a clear understanding of the foundation fill requirements. Coordination with the contractor can make inspection and testing duties more efficient.

6-208.3 DURING CONSTRUCTION

If the plans do not provide for the use of foundation fill and the Resident Engineer determines that foundation fill is required, the Resident Engineer should consult with the Materials Division. The inspector monitors excavation activities for necessary corrective actions. Occasionally, the floor of an excavated area that is to receive foundation fill is soft or spongy. The contractor should remove the unsuitable soil and place foundation fill in the excavated area. The contractor then compacts the foundation fill to the density stated in the specifications.

6-208.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-209 DRAIN BACKFILL

6-209.1 GENERAL

When water is encountered below grade, trenches are constructed to intercept and remove water from the embankments or excavated areas. Typically, these trenches contain perforated pipes that allow groundwater to enter the pipe and flow from the area. The gradation of drain backfill allows water to pass through the backfill and enter the pipe. These trenches often involve considerable quantities of excavation, drain backfill, geotextile, and perforated underdrain pipe.

6-209.2 BEFORE CONSTRUCTION

Review the plans and specifications to determine locations and requirements for drain backfill. A thorough understanding of the trenching and backfill requirements helps to reduce problems during construction. Refer to Section 6-607, Underdrains, for additional information regarding trench construction and materials placement.

6-209.3 DURING CONSTRUCTION

Drain backfill allows water to drain from the surrounding soil and enter the underdrain pipe. Therefore, to ensure a fully functioning underdrain, the backfill requires a specified gradation, adequate compaction, and proper trench bedding. The contractor may need to remove water from the trench during construction to allow equipment and laborers to construct the drainage system properly.

6-209.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-210 WATERING

6-210.1 GENERAL

Watering consists of furnishing and applying water for all of the project needs. Developing a water supply can include arranging for obtaining water from a fire hydrant, digging a well, or constructing a reservoir. Developing a water supply can also include constructing a pumping station, installing pipelines throughout the project, and installing or constructing storage facilities, such as tanks or ponds. The water supply must be capable of supplying sufficient water during high demand periods and remain functional for the duration of the project.

6-210.2 BEFORE CONSTRUCTION

For the supply of water, the contractor must negotiate with the owner of the supply and provide the Resident Engineer with a copy of the agreement. When the contractor drills a well or uses an existing well for roadway construction purposes, the contractor must complete a request for waiver as described in the specifications. The waiver request is submitted to the Nevada Division of Water Resources using forms found at the Division's website, http://water.nv.gov. The Resident Engineer confirms that an approved request for a water well waiver is on-site during drilling operations. If the water source is surface water, such as a lake, pond, or river, and has a current permit from the Nevada Division of Water Resources, the contractor must submit an application to change the place of diversion, manner of use, or place of use with the Nevada Division of Water Resources. If the surface water has not been permitted, the contractor must make application to appropriate the water through the Nevada Division of Water Resources.

Regardless of the water source, water samples are necessary to confirm that the water quality meets requirements for its intended use as described in Section 722 of the specifications.

6-210.3 DURING CONSTRUCTION

Water supplied by the contractor is used for compacting or processing material, and controlling dust. Based on how the water is used, the specifications will describe requirements.

When a waiver is issued by the Nevada Division of Water Resources, the contractor must comply with the conditions contained in the approved waiver, such as monitoring water usage, limitations on water pumping, and plugging and abandoning the well upon completion of the use of the well. The Resident Engineer must monitor the contractor's compliance with the specifications and the conditions of the approved waiver.

6-210.4 MEASUREMENT AND PAYMENT

The cost of developing a water source and supplying water is included in payment for other items of work. No separate payment is made.

6-211 EROSION CONTROL

6-211.1 GENERAL

Erosion control consists of construction or installation of permanent pollution and erosion control measures. These measures reduce air pollution, erosion, sedimentation, and pollution of water and wetlands that a completed roadway project can cause. Pollution control measures related to construction activities are contained in Section 6-637, Pollution Control.

Erosion control measures properly applied are key elements in preventing water and air pollution. Erosion control measures can also reduce sedimentation. The success of erosion control measures often depends on the time of year that they are applied.

6-211.2 BEFORE CONSTRUCTION

The contractor obtains topsoil from sources listed in the specifications. If the specifications do not designate a source, the topsoil must conform to the requirements in the specifications. If required, top soil is sampled by the Resident Engineer's tester and submitted to the Department of Agriculture for testing. The Resident Engineer reviews the test results to confirm that the top soil conforms to the requirements of the specifications. The contractor must use seeds and fertilizers that are packaged and show content analysis. The contents on the packaging, or certification of the seed or fertilizer, must conform to the requirements in the specifications.

6-211.3 DURING CONSTRUCTION

The specifications explain how to prepare for and apply products. Uniformly spread topsoil or compost at the specified rate or depth.

During seeding, the contractor must follow the manufacturer's recommendations.

Refer to Section 6-212, Landscaping, for additional information about planting and fertilizing.

6-211.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-212 LANDSCAPING

6-212.1 GENERAL

Landscaping consists of preparing areas for planting; applying pesticides and fertilizers; and furnishing, planting, and maintaining plants. The Resident Engineer should adjust the locations of shrubs and trees to avoid obstacles whenever possible. Generally, mature trees are placed more than 30 feet from the traveled way if they will grow to or have a diameter of four inches or more. Landscaping is placed to meet the intended look and purpose, as planned by the landscape designer. The inspector should be aware of the appearance and purpose of the landscape design. The landscape designer should be contacted to determine what changes may be acceptable, if changes are needed.

6-212.2 BEFORE CONSTRUCTION

The Resident Engineer must determine if container grown plants furnished by the contractor are acceptable and meet the requirements of the plans and specifications. They can make this determination by visual inspection after removing the plants from the containers. The inspector should consider the following information when evaluating container grown plants:

- Accept small plants if they have developed roots sufficient to hold a ball of earth together when removed from the container.
- Reject plants that are damaged or pot-bound.
- Reject plants that have not been properly cared for.
- Confirm that the contractor stores containerized plants in a protected and shaded area.
- Monitor plants to confirm the contractor keeps plants moist at all times. The ball of earth around the plant roots must be wet at all times. Plants in containers are more exposed to wind and heat and dry out more readily.
- The contractor should only remove plants from the container when planting.
- The contractor should cut back container grown plants as necessary to encourage plant growth while being stored in the storage area.

Refer to the specifications and the planting details in the plans for additional information on how to protect potted plants. Contact the landscape designer regarding questions related to planting.

6-212.3 DURING CONSTRUCTION

6-212.3.1 PREPARATION

Planting success depends largely on the preparation of the planting areas. Planting is easier if the contractor eliminates weeds and noxious grasses while the planting areas are easily accessible and before any planting begins. After planting, the contractor should control weed growth during the plant establishment period.

Except on slopes, follow this common planting process:

- Dig the planting holes for container grown plants. Dig to the required depth below the bottom of the completed basin.
- Mix the fertilizer with the backfill material in the planting hole. Thoroughly mix the fertilizer with the backfill material to the full depth of the planting hole.
- Saturate the mixture before constructing the basin and basin walls to the specified size. Thoroughly saturate the backfill mixture to the depth of the drilled hole. Occasionally, when planting slope areas, the basin is formed first.

The Resident Engineer determines which rocks to remove. Typically, only large rocks that will interfere with planting operations are removed from the planting area.

6-212.3.2 PLANTING

Construct basins and basin walls to the planned dimensions before planting. After the backfill material is saturated in the planting holes, the inspector should observes that the material has settled and that it retains sufficient moisture before the contractor places the plant in the basin.

Do not allow clods, rocks, or lumpy materials in the backfill. The contractor should not tamp or compact the backfill around the plant roots. Tamping or compacting around the plant root inhibits the natural penetration of water around the plant.

The contractor must plant trees and shrubs before ground cover plants and turf. To prevent unnecessary compaction of the soil, the contractor must keep foot traffic to a minimum after planting ground cover plants.

The contractor should follow these guidelines when planting trees:

- Securely stake and tie trees as soon as possible after planting. If trees are not staked immediately after planting, the wind tends to shift and move the trees and damage them.
- Place ties sufficiently high on the tree to contain the major portion of the top growth.
- Do not damage the plant ball when driving stakes.
- Place the mulch, if required, as soon as possible after planting to retain moisture and discourage weed growth. An exception is during extremely wet weather when trampling the areas while placing the mulch would compact the soil and the mulch would hold excessive moisture around the plant.

6-212.3.3 WATERING

With the initial watering, the inspector should closely monitor the amount of water applied, and the manner in which it is applied. The contractor waters most plants immediately after planting them. Following the initial watering, the contractor must water all plants and planted areas as often as conditions require. Ultimately, the contractor should keep the plants in good growing condition through the time of final acceptance. This time is referred to as the “plant establishment” period, which is a one year period. During the plant establishment period, the inspector completes NDOT form 040-046, “Monthly Summary of Plant Establishment”. Refer to the specifications for additional requirements related to the plant establishment period. The Resident Engineer should not direct the contractor on watering activities. However, the Resident Engineer should advise the contractor if the plant conditions deteriorate and watering might correct the condition.

6-212.3.4 INSPECTION

The inspector should inspect planted and stored plants weekly. Mark unhealthy plants for removal, and inspect replacement plants before planting. Coordinate final inspection with the contractor. The Resident Engineer should coordinate attendance of the landscape designer and the District landscape maintenance supervisor.

The inspector should be aware of any requirements for plant establishment and document timeframes to verify specification conformance.

6-212.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. for landscaping.

6-213 IRRIGATION SYSTEMS

6-213.1 GENERAL

Irrigation systems are installed to apply water to roadway landscaping. The specifications provide detailed requirements for irrigation systems. After installation and acceptance by NDOT, the Resident Engineer should provide NDOT maintenance personnel or the entity responsible for operations of the system with operating manuals, brochures, and “as-built” drawings from the contractor.

6-213.2 BEFORE CONSTRUCTION

The inspector and the contractor should review the irrigation system details. This review provides the inspector with the ability to schedule inspection and testing, and to collect samples or material certificates. The inspector obtains representative samples of pipes and fittings proposed for use in the watering system. In most cases, sprinklers and valves are clearly marked with the manufacturer’s name and model number and are not tested for compliance with specifications. The specifications describe water pipe installation. The plans provide a diagram layout of the watering system. The inspector can adjust the installation as needed to avoid conflicts.

The Resident Engineer coordinates with the District utility inspector who works with the utility companies to obtain power and water for the irrigation system. If water and electrical services have not been completed, coordinate service points and meter locations with the District utility representative. Verify the availability of water in the quantities and the pressure required for the irrigation system.

6-213.3 DURING CONSTRUCTION

The contractor may make adjustments to the irrigation to obtain complete and uniform coverage. These adjustments are made because of variations in water pressure, slope, or size of the coverage area. The inspector should do the following:

- Inspect the installation and location of backflow preventers to verify conformance to the requirements of local codes and to the specifications.
- Inspect the installation of gate valves and unions on each side of the backflow preventer.
- Observe trenching and the placement of conduit and pipe.
- Measure the depths and setbacks of irrigation lines to verify conformance with the plans and specifications.
- Do not allow backfilling until all piping has been inspected, pressure tested, and accepted.

The contractor must locate and repair leaks and repeat the test as many times as necessary to obtain satisfactory test results. The contractor must also refill trenches that have settled below the level of the surrounding area.

6-213.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. ..

6-214 MAILBOX SYSTEMS

6-214.1 GENERAL

This section includes removal of existing mailboxes, relocation of mailboxes, and installation of new mailboxes. Close coordination with the United States Postal Service and the mailbox owner is important to ensure no disruption of mail delivery service occurs, and to reduce owner complaints.

6-214.2 BEFORE CONSTRUCTION

Before the contractor begins construction activities, the inspector must document the condition of existing mailboxes, including taking photographs. Mailboxes may need to be moved several times during construction. If possible, mailboxes should be set once, at their final location. The contractor, the Resident Engineer, the United States Postal Service, and the owner should coordinate and plan mailbox placement before construction begins.

6-214.3 DURING CONSTRUCTION

Any mailbox relocation for contractor convenience is the contractor's responsibility. The contractor must maintain proper position and access to mailboxes for postal deliveries and owner pick-up. The contractor must coordinate with the United States Postal Service five working days before any mailbox installation or relocation. The contractor should also inform the owner of scheduled removal or installation.

6-214.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-300 BASE COURSES

6-300.1 GENERAL

Roadway composition consists of several layers, each serving a different purpose. These layers, called courses, are placed on the original ground to provide strength. When a roadway section must be raised to achieve the required grade, embankment is placed on the original ground (refer to Section 6-203, Excavation and Embankment). Following is an overview of each layer, which is collectively known as the roadway "structural section":

- Original ground – The ground on which the roadway will be built.
- Borrow/Embankment – Soil that is placed on original ground to bring the roadway to the desired elevation.
- Type 1 Class B aggregate base – Aggregate base is granular soil with a variety of particle sizes, which is designed to provide strength for the roadway.
- Plantmix bituminous surface (Type 2 coarse) – A mixture of aggregate and asphalt that provides strength to support vehicle traffic loads.
- Plantmix bituminous open-graded surface – A mixture of aggregate and asphalt that provides a smooth riding surface for traffic.

Figure 6-300.1 shows a typical cross section of a roadway structural section.

Figure 6-300.1. Typical Roadway Structural Section.

Each layer of the structural section has unique costs and physical characteristics. The structural section used on a project is determined by considering variables such as cost, climate, and material availability.

Overall pavement quality, structural longevity, and riding smoothness depend on the quality and uniformity of the base course layers. Poor base course construction can affect the long term performance of the roadway.

Base courses may consist of aggregate, aggregate mixed with asphalt, or aggregate mixed with cement. Base courses are used to provide strength in the roadway and to distribute vehicle loads to a larger area on the original ground.

6-302 AGGREGATE BASE COURSES

6-302.1 GENERAL

The plans include roadway cross sections that detail where to place aggregate base. The cross sections also show the aggregate base thickness.

NDOT distinguishes aggregate bases by gradation (Type 1, 2, or 3) and by the manner in which the material is processed and placed on the roadway (Class A or B). Following are descriptions of each of these elements:

- Type 1 aggregate has a maximum size of one inch.
- Type 2 aggregate has a maximum size of ¾ inch.
- Type 3 aggregate gradation is unique to specific projects; see the project specification for details.
- Class A aggregate is mixed with water before delivery to the roadway, where it is placed and spread in a single operation.
- Class B aggregate is typically stockpiled material that is delivered to the roadway, mixed with water, and processed on the roadway before being spread and compacted.

Because Class A aggregate requires greater control in processing, placing, and spreading than Class B aggregate, Class A aggregate is typically more costly than Class B. Although the contractor is not required to mix Class B aggregate in a mixer, if the contractor elects to do so, payment is made only at the Class B aggregate price. Refer to the specifications regarding requirements for the aggregate base.

6-302.2 CLASS A AGGREGATE BASE

Figure 6-302.1. Class A Aggregate Base Spreader.

Class A aggregate is mechanically mixed to create a homogenous material with uniform moisture. This processing takes place at a central mixing plant before delivery to the roadway. After transport to the roadway, the contractor places and spreads the processed aggregate in a single operation using a self-propelled spreader with a screed. Figure 6-302.1 shows a Class A aggregate base spreader. If approved by the Resident Engineer, the contractor may use a motor grader if the blade is equipped with wings, the blade is locked into position, and the blade has an electronic grade-sensing device. Once placed, the contractor compacts the aggregate to the specified density and trims the aggregate to the required elevation.

6-302.2.1 BEFORE CONSTRUCTION

Successful aggregate processing and placement depends on a thorough understanding of the plans and specifications relating to aggregate base. In reviewing the plans and specifications, pay attention to the following areas:

- Material gradation
- Moisture content
- Mechanical mixing requirements
- Placement and spreading method
- Typical sections and profile sheets
- Compaction requirement
- Surface tolerance
- Weather limitations
- Measurement and payment

Additionally, the Resident Engineer coordinates with the contractor about the planned sequence of operations so the Resident Engineer's crew can inspect and test effectively and efficiently. Before the contractor delivers aggregate for placement, the inspector coordinates and schedules required testing with the field tester.

Before placing aggregate, the contractor finishes the subgrade. The subgrade is acceptable when compaction tests have been taken and have passed minimum requirements. To determine if the grade and surface tolerances are acceptable, the inspector confirms that the subgrade has been graded to the elevation of the Red Heads. Finally, the inspector checks the subgrade surface for defects.

Before placement, determine which equipment the contractor plans to use for aggregate and water mixing, and for spreading and placement. Confirm that the equipment conforms to specifications. Discuss the thickness of each placement layer with the contractor, making sure the layer thicknesses do not to exceed the maximum stated in the specifications. Additionally, confer with the contractor and the survey crew chief to confirm that sufficient grade controls are in place. The contractor can then use the established grade controls for the automated grade control operation, such as a wire line. A wire line is a common technique in which a wire is set along the roadway shoulder. Placement equipment electronically senses the wire elevation and adjusts the grade of the aggregate base.

6-302.2.2 DURING CONSTRUCTION

After the contractor adequately prepares the subgrade and the inspector has reviewed the material processing operation, the inspector monitors the placement and spreading of the Class A aggregate. As the material arrives at the roadway, the inspector monitors the placement and spreading operation. Observe that the aggregate remains homogenous and is moist. A homogenous mix reduces the potential for defects. With the proper moisture content the contractor can efficiently achieve compaction.

As the material spreading progresses, the survey crew should periodically check that the contractor is constructing the proper grade. The inspector should continuously monitor the finished surface to verify conformance with specifications. Early monitoring of grade and surface tolerances allows time for adjustments before a substantial amount of material is placed. During the placement operation, tests and frequencies must be consistent with Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. Immediately following acceptance of the compacted aggregate base, the contractor is typically required to apply a prime coat to reduce moisture loss and retain compaction. See Section 6-406, Prime Coat.

The inspector must keep complete and accurate records of material quantities. Inspector reports should include information and observations relating to the equipment, operations, and materials incorporated into the work, especially anything considered uncommon. Records relating to measurement and payment must conform to the requirements of the *Documentation Manual*. When the payment method is by weight, collect and record load tickets for each truck as the load is delivered to the project.

6-302.2.3 MEASUREMENT AND PAYMENT

The specifications state the measurement and payment methods for aggregate base. Class A aggregate base is commonly measured by cubic yard or by ton. When measured by cubic yards, the cubic yards are calculated based on the cross section in the plans. When measured by tons, the aggregate is weighed after mixing but before placement. Only material that is incorporated into the work is included for payment.

Because Class A aggregate base is comparatively expensive, monitor measurements closely. When the measurement and payment method is by weight, remember to adjust the measured weight for moisture. Excessive water in the aggregate creates an artificially high weight for payment. The maximum weight for payment includes only the optimum moisture content plus one percent. Refer to the *Documentation Manual* for additional requirements.

6-302.3 CLASS B AGGREGATE BASE

Class B aggregate does not require mixing before delivery to the roadway. Class B aggregate is typically transported from the stockpile and placed directly on the roadway. To achieve the required moisture content, the contractor applies water before and during processing and spreading. A motor grader processes the aggregate on the roadway, then spreads or distributes the material. Once the material is spread, it is then compacted.

6-302.3.1 BEFORE CONSTRUCTION

Successful inspection of aggregate processing and placement depends on a thorough understanding of the plans and specifications relating to aggregate base. Class B aggregate is typically mixed on the roadway, which creates a homogenous mixture of aggregate sizes and evenly distributes moisture.

In reviewing the plans and specifications, pay attention to the following areas:

- Material gradation
- Moisture content
- Mixing requirements
- Placement and spreading method
- Typical sections and profile sheets
- Compaction requirement
- Surface tolerance
- Weather limitations
- Measurement and payment

Additionally, review the sequence of operations with the contractor so testers and inspectors can perform their tasks effectively and efficiently. Discuss the thickness of each placement layer with the contractor, making sure not to exceed the maximum stated in the specifications. Before the contractor transports the aggregate for placement, the inspector confirms that the tester is scheduled to perform the required tests.

Before placing aggregate, the contractor finishes the subgrade. The subgrade is acceptable when compaction tests have been taken and have passed minimum requirements. Finally, the inspector checks the subgrade surface to confirm that there are no defects.

Before placement, discuss equipment, methods, and sequence of operations with the contractor. An understanding of the contractor's plans allows the inspector to coordinate testing.

6-302.3.2 DURING CONSTRUCTION

After the contractor has prepared the subgrade, the inspector monitors the placement and processing of the Class B aggregate. The inspector should observe that the hauling operation does not disturb the prepared subgrade.

As the material arrives at the roadway, the inspector monitors the placement and spreading operation. The inspector periodically calculates the yield, which is the amount of material placed per station for the spread width. The inspector should make sure that the aggregate remains homogenous with a consistent moisture content. A homogenous mix reduces the potential for defects.

The contractor takes the following steps to achieve a homogenous mix:

- Spread the material in a uniform windrow on the roadway.
- Thoroughly mix the material by blading the mix from one shoulder to the center of the roadway, and back to the shoulder.
- Uniformly distribute the water to efficiently achieve compaction.

After processing, spreading, and compacting the material, the contractor finishes the aggregate base to the grade stakes placed by the survey crew. Grade stakes, typically called Red Heads, are placed to indicate the elevation of the finished aggregate base. For more information, see Section 4-304.2, Grade Stakes, of this *Construction Manual*.

Because Red Heads are placed after processing, spreading, and compaction, the inspector coordinates with the survey crew to reduce contractor delays. Early monitoring of grade and surface tolerances allows time for adjustments before placing a substantial amount of material. During the placement operation, tests and frequencies must be consistent with Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. Immediately following acceptance of the compacted aggregate base, the contractor is typically required to apply a prime coat to reduce moisture loss and retain compaction. See Section 6-406, Prime Coat.

The inspector must keep complete and accurate records of material quantities and qualities. Daily inspector reports should include information and observations relating to the equipment, operations, and materials incorporated into the work, especially anything considered uncommon. Records relating to measurement and payment must conform to the requirements of the *Documentation Manual*. When the method of payment is by weight, collect and record load tickets for each truck as the load is delivered to the project.

6-302.3.3 MEASUREMENT AND PAYMENT

The basis of measurement and payment of aggregate base is stated in the specifications. Coordination with the contractor regarding the details of measuring the material makes the measuring process efficient. Class B aggregate base is commonly measured by volume or by weight . When measured by volume, the volume is calculated based on the cross section in the plans. When measured by weight, the aggregate is weighed before transporting to the roadway.

When the measurement and payment method is by weight, remember to adjust the measured weight for moisture. Excessive water in the aggregate creates an artificially high weight for payment. The maximum weight for payment includes only the optimum moisture content plus one percent. Only material that is incorporated into the work is included for payment.

On projects that require small quantities of aggregate base at several locations, such as wheelchair ramps or sidewalks, measurement of aggregate quantities is modified. Weighing several small loads of aggregate is not practical. Typically, a contractor may stockpile the material on the project. Smaller amounts of the stockpiled aggregate are then transported using a loader or other small equipment. To determine the amount of material for payment, the inspector first determines the volume of aggregate placed by the contractor. The volume is then converted to weight, using the unit weight of the material obtained by the tester.

6-303 ASPHALT TREATED PERMEABLE BASE

6-303.1 GENERAL

Water that enters a pavement's structural section can impair the strength and durability of the pavement. To allow water to drain from the structural section, base courses can be designed to provide drainage. Asphalt treated permeable base is one means of providing drainage. Asphalt treated permeable bases are often used under portland cement concrete pavements. In addition to providing strength, asphalt treated permeable bases allow water to drain away from the pavement. Removing the water reduces hydraulic erosion that may wash away fine aggregate. Asphalt treated permeable base requires an edge drainage system to collect and remove water from the structural section.

6-303.2 BEFORE CONSTRUCTION

Successful inspection of material processing and placement requires a thorough understanding of the plans and specifications relating to asphalt treated permeable base. In reviewing the plans and specifications, pay attention to the following areas:

- Material gradation
- Moisture content
- Mixing requirements
- Placement and spreading method
- Typical sections and profile sheets
- Compaction requirement
- Surface tolerance
- Weather limitations
- Measurement and payment

Asphalt treated permeable base is prepared at a batch plant that combines the aggregate, asphalt, and mineral filler. The material is then transported to the roadway, where it is placed and compacted. Typically, one inspector monitors the batch plant and another inspector oversees the placement and compaction. For guidance on batch plant inspection, refer to Section 6-400, Surface Treatments and Pavements.

Before the contractor places material on the roadway, the contractor finishes the aggregate base. The aggregate base is acceptable when compaction tests have been taken and have passed minimum requirements. To determine if the grade and surface tolerances are acceptable, the inspector confers with the survey crew. The inspector visually checks the surface for defects. Before placing the asphalt treated permeable base, the contractor is typically required to apply a prime coat to reduce moisture loss, retain compaction, and create a moisture barrier. For more information, refer to Section 6-406, Prime Coat.

An approved mix design is required. The approved mix design provides the basis for the contractor to submit a proposed job mix formula to the Resident Engineer. The Resident Engineer then establishes a job mix formula for production and delivery to the project. The job mix formula provides a range of values and is used to monitor the materials being produced for incorporation into the work, such as gradation, temperature, and bitumen ratio. The contractor must request and the Resident Engineer must approve any modifications to the job mix formula. If approved, a new job mix formula would be established by the Resident Engineer. Refer to Section 6-401.2.2, Job Mix Formula.

Coordinate with the contractor to confirm that sufficient equipment and labor are available for spreading, compacting, and trimming before starting batch plant operations. Before the contractor begins paving, confirm the placement width of each spread. The contractor should minimize construction joints both longitudinally and transversely to build a stronger base.

Requirements for placing the asphalt treated permeable base are the same as other plantmix bituminous pavements. Refer to Section 6-400, Surface Treatments and Pavements.

6-303.3 DURING CONSTRUCTION

Before placing asphalt treated permeable base, the contractor constructs a test section. The test section will use the same equipment and procedures that will be used for the roadway. Observe and document rolling patterns for each roller. After a rolling pattern produces the required results, the contractor uses the same rolling pattern for subsequent placement of asphalt treated permeable base.

The thickness of the compacted base is important to the strength of the completed section. During placement, allow for consolidation of the base caused by rolling. If the grade of the material placed exceeds the planned grade by more than 5/8-inch, the contactor must take corrective action. If the grade of the material placed is below the planned grade by more than 5/8-inch, the contractor may be required to remove and replace the material. The contractor may be required to modify the spreading operation if it produces a grade that requires an excessive amount of trimming.

The specifications require the contractor to place asphalt treated permeable base in one lift, and, although it has no density specification, it is compacted in accordance with the rolling pattern established by the test section, and to the Resident Engineer's satisfaction. The inspector should pay attention to construction joints at the end of each day, making sure they are smooth and thoroughly compacted. Be aware that bumps or depressions at these joints invariably show up in the finished surface.

Because surface irregularities transfer to the finished surface, an inspector uses a 12-foot straightedge to identify variations in the surface of the asphalt treated permeable base. The contractor must use methods approved by the Resident Engineer to correct areas that are not smooth or are otherwise defective. Construction traffic entering or exiting the placement operation may contaminate the material being placed, not allowing the permeable base to drain as designed. Construction traffic may also cause surface irregularities. The inspector should monitor and confirm that the contractor minimizes construction traffic and takes corrective action to address contamination or surface irregularities.

Improper spreading, poor grade control, changes in rolling patterns, or types and weights of rollers may affect the finished surface of asphalt treated permeable base. Whenever equipment or procedures differ from those used for the test section, the contractor may need to construct a new test section at the Resident Engineer's request.

The inspector must keep complete and accurate records of material quantities. Daily inspector reports should include information and observations relating to the equipment, operations, and materials incorporated into the work, especially anything considered uncommon. Records relating to measurement and payment must conform to the requirements of the *Documentation Manual*. When the payment method is by weight, collect and record load tickets for each truck as the load is delivered to the project.

6-303.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. Measurement and payment are usually by the ton, so accurate weighing of the material is required. Do not use material on the roadway that has not been properly weighed. Also, be sure to record the quantity on the proper forms.

6-304 PORTLAND CEMENT TREATED BASE

6-304.1 GENERAL

Cement treated bases are used under both plantmix bituminous pavements and portland cement concrete pavements. With cement treated bases, the structural section thickness is less than that required for untreated aggregate bases. The addition of cement to the aggregate increases the structural strength.

6-304.2 BEFORE CONSTRUCTION

Successful inspection of cement treated base processing and placement requires a thorough understanding of the plans and specifications. In reviewing the plans and specifications, pay attention to the following:

- Material gradation
- Moisture content
- Mechanical mixing requirements
- Placement and spreading method
- Typical sections and profile sheets
- Compaction requirement
- Surface tolerance
- Weather limitations
- Measurement and payment

Additionally, the inspector should coordinate the sequence of operations with the contractor so testers and inspectors can perform their tasks effectively and efficiently.

Before placing cement treated base, the aggregate base is finished. The aggregate base is acceptable when compaction tests have been taken and have passed minimum requirements. To determine if the grade and surface tolerances are acceptable, confer with the survey crew. Finally, visually inspect the subgrade surface for defects.

Two methods of mixing cement treated base are plantmix or roadmix. NDOT only specifies mixing cement treated base using the plantmix method.

The plantmix method of mixing utilizes a central mixing plant to combine the aggregate, portland cement, and water. The material is then transported to the roadway, where it is placed and spread. Once in place, the cement treated base is compacted, sealed, and cured. Typically, one inspector monitors the mixing of the material at the plant, and another inspector oversees the placement operation.

The specifications allow using various types of mixing equipment. Any type is acceptable if it produces a satisfactory product. The most common type of mixer is the pugmill, which consists of revolving blades or paddles on a shaft. Depending on the capacity, the pugmill may have more than one shaft. The mixer is loaded, or charged, at one end and discharged at the other. Batch weights or volumes control the quantity of material in the mixer when material is prepared a batch at a time. For continuous mixing, adjustable vertical gates control the material proportions. Introducing water into the mixture and maintaining uniform moisture in the mixture is critical. Use positive controls to maintain uniformity.

Mixing equipment has paddles, studs, or flights located inside the revolving drum. As the drum rotates, the paddles or flights create a mixing action. The specifications do not state the number or arrangement of the paddles. However, the specifications require complete mixing and prohibit collection of unmixed materials in the mixer. Areas in the mixer that collect unmixed materials are called “dead areas” in the specifications.

Adding water in the mixing operation is important to the quality of the cement treated base. The best time to add water is several seconds after mixing the dry materials; this creates a more homogenous mix of aggregate and cement.

The specifications tightly control the contractor’s preparation of cement treated base material, and the inspector must thoroughly understand these specifications. Review Section 304 of the specifications before inspecting mixing operations.

6-304.3 DURING CONSTRUCTION

Before placing material on the roadway, the contractor finishes the aggregate base. The aggregate base is acceptable when compaction tests have been taken and have passed minimum requirements. To determine if the grade and surface tolerances are acceptable, confer with the survey crew. Finally, visually inspect the surface for defects.

Coordinate with the contractor to confirm that sufficient equipment and labor are available for spreading, compacting, and trimming before the contractor spreads the material. The contractor determines the method and amount of spread, but closely cooperating and checking the spread will lead to a more efficient operation. Additionally, confirm the placement width of each spread before starting operations. For improved quality in the base, the contractor minimizes construction joints both longitudinally and transversely.

Because time is an important factor in cement treated base construction, discuss the timing of the various activities with the contractor. Three hours is the maximum time allowed between adding water to the mixture and final compaction and trimming. After three hours, the mixture begins to harden and can be damaged. The specifications may include additional time limitations.

Because the contractor must maintain the appropriate water content throughout the mixing and placement process, the contractor typically does the following:

- Keeps the exposed subgrade moist
- Covers the material during transport
- Maintains the moisture of the compacted mixture until application of the curing seal or a subsequent layer of material

The specifications require a certain amount of cement be added to aggregate. To determine the actual cement content, take a sample after mixing and before compaction. If the material is mixed at a central mixing plant, test the cement content at the plant after mixing. Take sufficient samples to monitor uniform distribution of cement in the mixture.

Closely monitor the contractor's spreading operation. The specifications tightly control the spreading of cement treated base. During the spreading of the mixture on the subgrade or base, confirm that the depth of placement and the surface conform to tolerances stated in the specifications. Continuously monitor the screed settings because they determine the cross section of the completed roadway.

The thickness of the compacted cement treated base is important to the strength of the completed section. During placement, make allowances for consolidation of the base caused by rolling. If the grade of the material placed exceeds the planned grade by more than 5/8-inch, the contractor must take corrective action. The contractor's spreading operation may need to be modified if it needs an unusual amount of trimming. Excessive trimming is costly to the contractor and results in wasted material.

If the thickness of the cement treated base is greater than six inches, the specifications require the contractor to place it in more than one lift, each lift being approximately equal thickness. If placed in multiple lifts, each layer must be kept moist after meeting compaction requirements. Pay attention to construction joints, making sure they are smooth and thoroughly compacted. Be aware that bumps or depressions at these joints invariably show up in the finished surface.

Because surface irregularities transfer to the finished surface, the inspector uses a 12-foot straightedge to identify variations in the surface of the cement treated base. The contractor must use methods approved by the Resident Engineer to correct areas that are not smooth or are otherwise defective.

Once the surface is finished and compacted, the contractor maintains the moisture content of the cement treated base until the curing seal is applied. The contractor is typically required to apply the curing seal within 24 hours of final rolling to maintain the moisture content until fully cured. A curing seal is typically an asphalt product, such as MC-250. The contractor should protect the seal from construction operations. Traffic is not allowed on the cement treated base for 72 hours after applying the curing seal.

The inspector must keep complete and accurate records of material quantities. Daily inspector reports should include information and observations relating to the equipment, operations, and materials incorporated into the work, especially anything considered uncommon. Records relating to measurement and payment must conform to the requirements of the *Documentation Manual*. When the method of payment is by weight, collect and record load tickets for each truck as the load is delivered to the project.

6-304.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. Measurement and payment are usually by the weight, so material must be accurately weighed. Do not use material on the roadway that has not been properly weighed. Also, be sure to record the quantity on the proper forms.

6-305 ROADBED MODIFICATION

6-305.1 GENERAL

Roadbed modification rehabilitates an existing bituminous roadway. To rehabilitate the roadway, the existing surface is pulverized or milled depending on the depth of the existing material. Sometimes a portion of the existing base material is pulverized along with the bituminous surface. If the depth of the existing material is greater than the depth to be pulverized, the contractor will typically use a coldmilling machine to avoid disturbing the remaining material. The pulverized or milled material is mixed with cement and water, spread, and compacted. This construction method is typically used on roadways with a weak structural section or with a non-uniform structural section.

6-305.2 BEFORE CONSTRUCTION

The plans will specify the depth and width of the existing roadway to be pulverized. Throughout a project, the depth of pulverization may change. Review the plans to identify changes in the specified depth.

Because roadbed modification projects rehabilitate existing roadways, traffic is maintained during construction. Review the plans and specifications to determine the following:

- Maximum delay times for traffic
- Compatibility with contractor operations
- Provisions for appropriate work zones
- Hours of operation
- Other limitations to construction operations
- Access to abutting properties
- Weather limitations
- Typical sections

Confirm that the contractor's equipment to be used on the project is capable of producing the specified product. For example:

- The pulverizing equipment must have the ability to pulverize to the specified depth. If the specified depth goes beyond the existing bituminous surface and into the base, the pulverizing equipment must be capable of pulverizing only to the specified depth and not disturb the underlying base. If the existing bituminous surface section is deeper than the specified depth for roadbed modification, the contractor typically uses a coldmilling machine instead of a pulverizer.
- The cement-spreading machine must be capable of regulating the amount of cement added to the pulverized material.
- The mechanical mixing machine must have sufficient capacity to produce a homogenous mixture and must be able to control the quantity of water added during mixing. The mixing machine must not have excessive water leaks.
- Compaction equipment should be the type and size described in the specifications.

Because existing traffic is typically maintained throughout a roadbed modification project, efficiency in performing all operations is important. As the roadbed modification operation progresses, the paving operation should be staged to begin as soon as the cement treated roadway is cured. Before starting the roadbed modification activities, a plantmix bituminous surface mix design should be approved. Additionally, all equipment and materials needed for the bituminous surface paving operation should be on site and staged. The specifications state the time limitations related to curing and traffic.

6-305.3 DURING CONSTRUCTION

To pulverize the existing roadway, the contractor can use a variety of equipment. The contractor is required, however, to meet specified gradation requirements. The tester checks the material gradation at specified frequencies to determine if the material is acceptable. Review the specifications for gradation requirements.

After pulverizing a portion of the roadway, the contractor grades and compacts the pulverized material to within one inch of the adjacent travel lane surface. The excess material is moved to the shoulder of the roadway. Traffic is only allowed on the pulverized and compacted untreated base for limited amounts of time.

The pulverized material is used to determine the maximum density. After the density is determined, the spread rate for portland cement is calculated. Typically, cement is added at the rate of two percent by weight to the pulverized material. Because cement is measured and paid by the ton, the contractor must weigh the cement before spreading. Use the weight of the cement in the spreader to calculate a theoretical spread rate. The cement is spread on the re-compacted material. The cement and the material are mixed while water is added in the mixer. The contractor uses a motor grader to grade the cement treated mixture to conform with the planned cross slope and existing adjacent travel lanes. During the mixing and grading, the inspector observes the operation to confirm that the material is homogenous and that there are no defective areas. The inspector also checks that the uncompacted depth will yield the required compacted depth. After grading, the contractor compacts the material to the specified compaction rate.

While checking the depth of the roadbed modified base or during a compaction test, a hole is dug in the material. When the hole is exposed, the inspector or tester can check the uniformity of cement distribution by spraying a phenolphthalein solution on the vertical face of the hole. The solution changes color when it contacts cement. The intensity of the color varies depending on the amount of cement in the base material. Because the chemical characteristics of the phenolphthalein change with time, solutions that have aged may not give accurate indications.

After the surface is finished, the contractor maintains the moisture content of the treated base until the curing seal is applied. The curing seal is applied within 24 hours of final rolling to maintain the moisture content until fully cured. Most contractors place the curing seal near the end of each production day. A curing seal is typically an asphalt product, such as MC-250. If the cured cement treated base must carry public traffic, spread sand over the curing seal. Make sure the sand blotter meets gradation specifications, as large aggregate particles can damage vehicle windshields and small particles can create excessive dust. Verify that the contractor installs dust hazard signs throughout the work zone. Do not allow traffic on the roadbed modified surface until after the curing seal and sand blotter are applied.

Specifications limit the amount of time that roadbed modification can progress before paving must start, and maximum distances that are allowed between the two operations. The inspector should review these requirements and monitor the progress of both operations.

The inspector must keep complete and accurate records of material quantities. Daily inspector reports should include information and observations relating to the equipment, operations, and materials incorporated into the work, especially anything considered uncommon. Records relating to measurement and payment must conform to the requirements of the *Documentation Manual*.

6-305.4 MEASUREMENT AND PAYMENT

Measurement and payment are in accordance with the specifications and the *Documentation Manual*.

6-307 SHOULDERING MATERIAL

6-307.1 GENERAL

Shouldering material is a graded material placed and compacted against the edge of the plantmix bituminous surface or portland cement concrete pavement. Shouldering material aids roadway drainage by diverting water away from the structural section. The material is part of the finished roadway slope, which also acts as a recovery area for vehicles..

6-307.2 BEFORE CONSTRUCTION

Review the plans and specifications to determine the type of shoulder material specified for the project. When the surface of an existing roadway is ground or milled, the specifications may allow ground or milled material as shouldering material. To ensure meeting gradation requirements, samples of the milled material are tested before placing milled material as shouldering material.

Plans and specifications state the requirements that the contractor must meet regarding the placement of shouldering material. Before placing the shouldering material, the contractor must clear and grub the shoulder a minimum of 10 feet from the edge of the existing pavement. The contractor must dispose of trash, vegetation, and non-organic material as described in Subsection 107.14 of the specifications.

6-307.3 DURING CONSTRUCTION

Placement of shouldering material must not alter existing drainage channels. Shouldering material is placed in accordance with the specifications before paving. The contractor must place the material in a windrow along the roadway shoulder. Traffic safety hazards can be reduced by making windrow heights four inches or less. Avoid placing additional shouldering material after open-graded paving because this can damage the open-graded pavement surface. However, in unique situations and to shape the shoulder properly, the contractor may place additional shouldering material after open-graded paving if necessary.

After paving is completed, the contractor moistens, spreads, and compacts the shouldering material. The roadway cross section shown in the plans typically describes the shape of the roadway shoulder. The plans also specify the location and quantity of shouldering material to be placed.

6-307.4 MEASUREMENT AND PAYMENT

Measurement and payment are in accordance with the specifications and the *Documentation Manual*.

Shouldering material that consists of millings or grindings typically come from NDOT roadways. Millings are not typically paid for. Except for millings or grindings, measurement and payment for shouldering material are by the ton. Accurate weighing of the material is required. The specifications require the contractor provide certified scales to weigh material. Occasionally, a contractor will request using an average weight per truckload instead of weighing each load. This method can lead to inaccurate estimates of material quantities. Since specified shouldering quantities can be monitored only with accurate weights, deny contractor requests to use a method of measurement other than weighing.

Water added before weighing will be deducted from the weight of shouldering material weighed for payment. Perform moisture tests on stockpiled material to adjust weights as required by the specifications.

6-400 SURFACE TREATMENTS AND PAVEMENTS

6-400.1 GENERAL

A roadway consists of layers of various materials. These layers, called courses, provide strength and are placed on the original ground. The top layers are typically asphalt concrete or portland cement concrete. These layers add to the strength of the roadway section. The uppermost layer provides the riding surface for vehicles.

Concrete consists of coarse and fine aggregates, and a cementing agent, either asphalt or portland cement. Asphalt concrete pavements are comprised of asphalt, a byproduct of the distillation of crude oil called bitumen, and coarse and fine aggregates. Because asphalt concrete is mixed at a plant, the mixture is commonly called plantmix bituminous pavement. Pavements made with portland cement and coarse and fine aggregates are commonly called portland cement concrete pavement, PCCP. The decision to use either asphalt or portland cement concrete is based on variables such as design requirements, cost, climate, and material availability.

For existing roadways, the condition of the pavement and base significantly influences the type of pavement reconstruction, rehabilitation, or maintenance treatment used to improve the condition of the roadway. Severely distressed pavements may require removal and replacement. Less distressed pavement may only require rehabilitation by grinding, or coldmilling, the existing pavement and replacing it with new plantmix bituminous pavement.

Regardless of the surface treatment or pavement material, three operations require observation – mixing of the paving material, preparation of the roadway surface, and placement of the mixed material on the roadway. The following sections provide details for monitoring surface treatment and paving operations.

6-400.2 SAFETY

Safety is imperative throughout the entire paving process. On roadway construction projects, personnel regularly handle and move materials and equipment. Therefore, everyone on the project must be alert to all movements—equipment, people, and materials. By being aware of surroundings, you reduce the chances of being struck by a moving vehicle, construction equipment, or the traveling public. Being aware also reduces the risk of placing yourself in an unsafe situation. .

Accidents involving equipment and materials on the jobsite are not the only safety concerns. Plants that mix asphalt concrete or portland cement concrete are areas where material and processing temperatures are dangerously high, hoisting operations are ongoing, and chemicals are being used. Exercise care and awareness of activities and surroundings to improve worker safety. Federal agencies play a significant role with job-site safety. The Occupational Safety and Health Administration and the Mine Safety and Health Administration have responsibilities relating to plant operations and confined space work areas, respectively. Refer to Section 5-200, Field Safety, of this *Construction Manual* for additional information on safety.

6-401 PLANTMIX BITUMINOUS PAVEMENTS

6-401.1 GENERAL

The process of constructing a plantmix bituminous pavement consists of the following three principal operations:

- Mixing of the paving material, including aggregate preparation, storage and handling, mixing plant calibration and operation
- Preparation of the roadway surface
- Placement of the mixed material on the roadway, including equipment, paving methods, and compaction

Before construction, each of the three operations requires observation and monitoring in preparation of paving activities. During construction, the field crew continues to monitor operations at the mixing plant and paving activities operations on the roadway. The following sections provide guidance during the inspection process. The specifications describe the requirements for materials and construction methods that the contractor must follow. The Asphalt Institute publication "Construction of Hot Mix Asphalt Pavements" contains helpful information relating to bituminous pavement and other asphalt-related topics.

6-401.2 BEFORE CONSTRUCTION

6-401.2.1 MIX DESIGN DEVELOPMENT

Development of a mix design for plantmix bituminous material consists of producing and preparing aggregate, testing aggregate, obtaining asphalt samples, and transmitting aggregate and asphalt samples to the Materials Division. Using the samples submitted by the Resident Engineer, the Materials Division develops a plantmix bituminous mix design that conforms to the requirements of the specifications.

Aggregate production and stockpiling significantly influence the quality of the pavement. Although aggregate production and stockpiling are the responsibilities of the contractor, NDOT observes how these operations are performed to monitor the quality of the material. To obtain acceptable quality in the pavement, aggregate production should be uniform and stockpiling should reduce segregation.

Aggregate is commonly produced by mining, crushing, and then passing the material through a series of screens to obtain the aggregate sizes required by the specifications. Any changes in this production process, such as adjustment of crusher openings, screen changes, or equipment wear, can change the aggregate gradation.

After aggregate is screened, it is stored in stockpiles. When stockpiles are constructed, aggregate particles of similar sizes may collect at the base of the stockpile, resulting in a non-homogeneous material. This collection of similar particles, or separation of particles, is called segregation. Aggregate production and stockpiling is discussed in Section 6-100.1, Aggregate Sources.

Because the contractor is responsible for the quality of the aggregate being produced and stockpiled, the contractor conducts informational tests throughout the process. Refer to Section 106 of the specifications. A benefit of frequent testing is development of a history of each material produced. The Resident Engineer also conducts informational testing to monitor the quality of the material. While the Resident Engineer cannot tell the contractor how to produce the aggregate or store the aggregate in stockpiles, the Resident Engineer may offer input to the contractor by clarifying specifications relating to storing and stockpiling aggregate.

After the contractor has produced a quantity of aggregate representative of the material to be incorporated into the work, the contractor requests development of a mix design. At the time of the request, the contractor proposes an initial proportioning, or percentage, of aggregate from each stockpile. This proportioning is typically called "bin percentages." The specifications will state the minimum quantity of aggregate that the contractor must produce before requesting development of a mix design.

The Resident Engineer's testers then obtain and test aggregate samples from each stockpile to verify that the aggregate conforms to the specifications. The Resident Engineer compares test results with the contractor's test results. The Resident Engineer's test results and the contractor's test results should correlate. If test results do not correlate, the Resident Engineer notifies the contractor. Although the contractor is not required to make modifications, the contractor may make modifications. After the Resident Engineer confirms that test results are representative of the stockpiles and that the test results comply with the specifications, the contractor then provides asphalt samples to the Resident Engineer. The Resident Engineer confirms that the type of asphalt, as stated on the sample container, conforms to the specifications. The Resident Engineer sends the aggregate samples with the aggregate test results, and asphalt sample to the Materials Division.

The Materials Division performs tests on the aggregate and asphalt samples, confirming the Resident Engineer's aggregate test results and that the asphalt conforms to the specifications. Based on the test results and bin percentages proposed by the contractor, the Materials Division develops a mix design and sends it to the Resident Engineer. The mix design establishes the amount of asphalt that will be added to the aggregate—the "bitumen ratio."

Bitumen ratio is a percentage calculated by dividing the amount of asphalt by the dry weight of the aggregate. A similar but different term, Asphalt Content, is a percentage calculated by dividing the amount of asphalt by the total weight of the mixture (aggregate and asphalt). The terms "bitumen ratio" and "asphalt content" are often confused as having the same meaning, but they are different. In determining the mix design bitumen ratio, the Materials Division prepares several batches with varying amounts of asphalt. The Materials Division sends the mix design to the Resident Engineer. The Resident Engineer transmits the mix design to the contractor. The contractor uses the mix design to develop a proposed job mix formula, which is discussed in Section 6-401.2.2, Job Mix Formula. .

Figure 6-401.1. Aggregate Marination Plant.

After aggregate is produced and stockpiled, the aggregate may require treatment to modify its characteristics. A finely ground mineral called hydrated lime is added to the aggregate to reduce plasticity and moisture sensitivity. The most common process of mixing aggregate, water, and hydrated lime is called marination. NDOT specifications call this process the Marination Method. The marinated aggregate must be stockpiled for a minimum of 48 hours before being mixed with asphalt. The equipment used in the marination process includes a lime storage silo, aggregate bins with feeder belts, a pugmill for mixing, and a conveyor system to a stockpile or hauling truck. Figure 6-401.1 shows a typical aggregate marination plant.

The contractor must calibrate the equipment used in the marination process before materials are marinated. The inspector observes the calibration of this equipment as described in Section 6-401.2.4, Marination Plant Calibration.

In the marination process, the aggregate must be wet and have water on the surface to activate the chemical reaction with the lime. If the aggregate is not wet, the contractor adds water to the aggregate before adding lime. The appropriate amount of moisture in the aggregate allows each individual piece of aggregate to be coated with lime, whereas too much moisture has a clumping effect, causing several pieces of aggregate to stick together. The Resident Engineer visually determines the appropriate amount of moisture. The appropriate moisture content is determined using the following guidelines:

- Before the addition of hydrated lime, the coarse aggregate has a wet sheen on the surface of the aggregate particle without water dripping from it.
- Before the addition of hydrated lime, the fine aggregate holds its shape after squeezing without water dripping from it.
- After the addition of hydrated lime, the aggregate is completely coated with lime, without clumping of lime or aggregate particles.

The specifications will state the amount of hydrated lime, also referred to as mineral filler, to be used in the marination process, which is typically one percent for coarse aggregate and two percent for fine aggregate. The specifications typically state different amounts of hydrated lime for fine aggregate and coarse aggregate.

The moist aggregate is transported by conveyor belt to the pugmill for mixing. If the aggregate requires additional water to reach the appropriate moisture content, water is added to the aggregate before hydrated lime is added. This ensures that sufficient moisture is available to activate the hydrated lime. The hydrated lime is added to the moist aggregate at the pugmill. The marinated aggregate is discharged from the pugmill and transported to a stockpile.

Figure 6-401.2. Aggregate Properly Coated with Lime.

To verify the amount of lime added to the aggregate, the inspector performs periodic checks during the marination process. Periodic checks are performed hourly. During the check, flow rates of aggregate and lime are measured during a 10 minute period. Using the flow rates of aggregate and of lime during the 10 minute period, the inspector can calculate the percentage of lime added to the aggregate. Coarse and fine aggregates are marinated and monitored separately. An example of a ten-minute check for fine aggregate is as follows:

EXAMPLE:

Between 5:30 pm and 5:40 pm, total fine aggregate across the weigh belt was 50.23 tons. The daily moisture content measured by the tester was 4.1%. The hydrated lime across the weigh belt was 0.817 ton. The required amount of hydrated lime for fine aggregate, as stated in the specifications, is 2% of the dry weight of aggregate.

Calculation:

Weight of aggregate: 50.23 tons

Aggregate moisture: 4.1%

Weight of hydrated lime: 0.817 ton

$$WT_{\text{dry aggregate}} = \frac{WT_{\text{aggregate}}}{1+(\%\text{moisture})} = \frac{50.23\text{ tons}}{1+0.041} = 48.25\text{ tons dry aggregate}$$

$$\text{Percent of hydrated lime} = \frac{WT_{\text{hydrated lime}}}{WT_{\text{dry aggregate}}} \times 100 = \frac{0.817\text{ ton}}{48.25\text{ tons}} \times 100 = 1.7\%$$

In this example, the inspector would inform the contractor that corrective action is necessary because the actual hydrated lime percentage is below the required amount of 2%.

The calculated percent of hydrated lime for each ten-minute check is recorded in the marination plant inspector's daily diary. Additionally, for the day's production, the percentage of lime and total dry weight of the aggregate is recorded in the plant inspector's daily diary for each aggregate size stockpiled. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a completed marination plant inspector's daily diary.

The inspector verifies that the discharged marinated aggregate is uniformly coated with hydrated lime and that the hydrated lime is uniform throughout the marinated aggregate. Uniformly coated marinated aggregate is shown in Figure 6-401.2. To verify that the hydrated lime is uniform throughout the marinated aggregate, the inspector squirts a stream of phenolphthalein across the aggregate mix. The phenolphthalein reacts with the hydrated lime and changes from clear to a pinkish purple color. By observing the coloring of the phenolphthalein strip, the inspector can determine the uniformity of the hydrated lime distribution within the marinated aggregate. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for sampling and testing requirements.

Marinated aggregate must cure for at least 48 hours before use. After the 48-hour cure time, the aggregate is approved for use up to a maximum number of days, as stated in the specifications, usually 60 days after mixing. If aggregate is cured longer than the maximum number of days specified and the contractor plans to use the aggregate in the work, the Resident Engineer should confer with the Materials Division. The Materials Division may recommend re-marinating the aggregate to ensure the effectiveness of the hydrated lime, using half the amount of lime originally specified for the marination process.

The marination inspector must document when the stockpiled material was mixed and how long each stockpile has cured. Accurate documentation reduces the contractor from introducing the wrong material into the mix. To help monitor which stockpiles are incorporated into the mix, create a diagram of the stockpiled materials, showing the location and the marination date. Provide a copy of the diagram to the NDOT plant inspector, and to the contractor's plant operator and loader operator to assist in managing the material being incorporated into the plantmix. Additionally, the marination inspector marks the stockpiled material with a lath listing the date, time, and other relevant information. Painting the date on the stockpiled aggregate is also acceptable.

On rare occasions, NDOT specifications may allow the addition of hydrated lime using a process called the Cold Feed Method. In these situations, the hydrated lime is added to modify the chemical characteristics of the mixture, not the characteristics of the aggregate. The hydrated lime is added to the aggregate prior to the addition of asphalt. A significant difference between the cold feed method and the marination method of adding hydrated lime is that the cold feed method does not have a curing period.

After an amount of marinated aggregate has been prepared, as stated in the specifications, and after an approved mix design has been received from the Materials Division, the Resident Engineer establishes a job mix formula. The purpose of the job mix formula is to produce a uniform plantmix material.

6-401.2.2 JOB MIX FORMULA

Although the Resident Engineer establishes the job mix formula, the contractor must first propose a job mix formula that is based on the mix design approved by the Materials Division. The Resident Engineer reviews the contractor's proposed job mix formula. The Resident Engineer may make minor adjustments to the contractor's proposed job mix formula. The purpose of the job mix formula is to produce a uniform plantmix material by narrowing the tolerances. The aggregate gradation specification for plantmix pavements allows a wide range of values to accommodate a variety of aggregates. The durability of the pavement is directly related to the uniformity of the mixture. If aggregate gradation or the amount of asphalt fluctuates, even though the mixture remains within specified limits, the pavement durability is reduced. The job mix formula narrows the gradation specifications to limit variability, improve uniformity, and increase durability.

In addition to the job mix formula, the contractor can do the following to improve the mixture's uniformity:

- Build stockpiles using techniques that reduce segregation
- Build two or more stockpiles of various size aggregates
- Use multiple aggregate bins at the mixing plant

Based on the job mix formula proposed by the contractor, the Resident Engineer establishes the job mix formula used on the project. The job mix formula includes the following items:

1. Mix design number, assigned by the Materials Division, on which the job mix formula is based
2. Job Mix Formula number, assigned sequentially by the Resident Engineer, commencing with JMF#1
3. Names and locations of aggregate sources
4. Percentage of each type of aggregate being used (bin percentage)
5. Percent of aggregate passing each specified sieve
6. Percent of asphalt to be added (to the 0.1%), which is the bitumen ratio
7. Asphalt type and producer
8. Actual total percent of hydrated lime, based on coarse and fine aggregate stockpiles
9. Statement of whether baghouse fines are used or not, and maximum percentage allowed
10. Temperature of mixture leaving the mixer
11. Minimum temperature of the mixture in the hopper of the paving machine

While the job mix formula sets a single value for the items listed, the specifications provide a range of tolerances within which the contractor must produce the plantmix material. Single values with tolerances provide a uniform mixture, yet allow for minor fluctuations in the production process. Throughout the life of a project, the job mix formula may be modified for various reasons. The contractor must request modifications to the job mix formula and the Resident Engineer reviews and, if reasonable, approves the request. If approved, the Resident Engineer establishes a new job mix formula. Discussions with other NDOT Resident Engineers using the same mix design may be helpful in establishing the initial job mix formula. The Resident Engineer should not revise the job mix formula in reaction to the contractor's variability, or lack of uniformity, in the aggregate. To maintain uniformity, limit changes to the job mix formula. The Resident Engineer documents the job mix formula in a letter to the contractor. . Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a job mix formula letter and explanation of the process for developing a job mix formula letter.

The Resident Engineer may modify portions of the job mix formula without contacting the Materials Division, although consultation with the Materials Division and the Construction Division Quality Assurance Section is encouraged. The Resident Engineer must contact the Materials Division before making changes to the bitumen ratio.

Bin percentages, on which the mix design is based, may only be modified within limits. The Resident Engineer may allow changes in bin percentages that do not exceed a total of six percentage points for all bins. For example, if a mix uses three bins of aggregate, the amount of Bin #1 aggregate is reduced by two percent and Bin #2 aggregate is increased by three percent. Bin #3 may be reduced by only one percent to maintain the total of 100 percent and keep the total percentage change at six percent or less. Because the bin percentages have been changed a total of six percent (2 + 3 + 1 = 6), no additional changes are allowed without Materials Division approval. Changes greater than six percent must be approved by the Materials Division. For changes greater than 10 percent total, the Materials Division may require a new mix design.

6-401.2.3 MIXING PLANT

The mixing plant combines the prepared aggregate and asphalt under conditions required by the specifications. The mixture produced at the plant is loaded into hauling trucks and transported to the paver on the roadway, where it is spread and compacted. The controlled conditions and operations at the mixing plant significantly influence the quality and durability of the plantmix placed on the roadway. The Resident Engineer's plant inspector must be knowledgeable of the specification requirements, the job mix formula, the mixing plant operations, and the materials processing and storage. The Construction Division Quality Assurance Section is available for support and guidance.

In general, two types of plants are used to mix materials for plantmix bituminous pavements: batch plant and continuous mixing plant. A batch plant produces plantmix material a single batch at a time. A continuous mixing plant produces plantmix material continuously. Another significant difference is that, in a batch plant, aggregate is proportioned after it is dried and heated. With a continuous mixing plant, the aggregate is proportioned and then dried and heated. While the plants have distinct differences, many elements of the plant components and operations are similar. Following are common elements that require a plant inspector's attention:

- Aggregate Bins – Bins store aggregate that has been processed and screened into various sizes, ready for proportioning. The partitions separating one bin from another must be solid, free of holes, and high enough to prevent the aggregate from spilling over into an adjacent bin. Fine dust may collect in the corners of the bins. Material can also stick together, forming clumps that result in aggregate segregation. An accumulation of fine dust or clumps of material may be detrimental to the mix. The inspector should observe the bins to monitor the uniformity of the aggregate. The contractor should take measures to minimize accumulation of fines in the bins.

- Aggregate Cold Feed – The aggregate cold feed belt is a conveyor belt that delivers the aggregate from the aggregate bins to the mixer. Each aggregate bin is equipped with a feed belt that delivers aggregate from the bin to the cold feed belt. The speed of each aggregate bin feed belt, as well as the aggregate bin gate setting, determines the proportion of the particular aggregate. After calibration of the aggregate cold feed, no changes in the bin gate settings are allowed. Loading of the belts can affect the uniformity of the aggregate gradation. Malfunctioning belt feeders or gates, overloading the bins, and inconsistent aggregate moisture can adversely affect the operation of the aggregate cold feed. .

- Aggregate Screens – Screens located between the aggregate bins and the mixer are commonly called scalping screens. A scalping screen vibrates and separates oversized or clumped aggregate for removal before the aggregate enters the mixer. Inspect the screen to verify that the screen size opening is correct. The correct size screen opening is slightly larger than the largest aggregate size of the mix. Production rates that exceed the capacity of any screen may alter gradation. During the screening process, the following factors can affect aggregate gradation:

  - Types and sizes of screen openings
  - Tendency for screens to plug
  - Foreign matter in the aggregate
  - Wear, holes, or breaks in screen

- Plant Scales – Plant scales weigh each component of the mixture. The completed mixture is weighed at the plant with a scale at the storage silo or with a platform scale that weighs the loaded truck. The scale that weighs the completed mixture is typically the scale used to determine payment quantities. Nevada Bureau of Weights and Measures must certify the payment scale. The Resident Engineer coordinates the certification of the scales with the contractor and the Nevada Bureau of Weights and Measures. Refer to Section 109 of the specifications. The Nevada Bureau of Weights and Measures certifies the plant scales and places a sticker on the scale indicating the certification. Allow sufficient time to schedule certification by the Nevada Bureau of Weights and Measures. The inspector must verify that the payment scale is certified.

- Storage Tanks – Inspect storage tanks to verify that no material is in the tank, other than the material designated for the mix. The bituminous storage tank must be capable of uniformly heating and maintaining the asphalt at the temperature stated in the specifications. Specifications may require certain bituminous materials be continuously circulated during storage. To reduce cooling, the contractor insulates the pipe that conveys asphalt from the storage tank to the mixer. The type of burner fuel the contractor uses must be in accordance with the specifications and have required certifications. The asphalt and the burner fuel may be stored in a multi-compartment storage tank, as long as the asphalt and the burner fuel do not share a common wall.

- Bituminous Metering Device – The specifications state the tolerance allowed for the bitumen content used in the mix. One of the most common causes for bituminous paving mixture failures is incorrect amounts of asphalt. The plant inspector should frequently check and monitor the amount of asphalt used in the mixture, and communicate with the testers and the street inspector to confirm the correct amount of asphalt in the mix.

- Mixer – The mixer is a revolving drum or cylinder in which aggregate is dried and heated by burning fuel oil or gas. The cylinder walls are lined with longitudinal cups or channels called “lifters” or “lifting flights” that drop the aggregate as a veil or curtain through hot gases. The mixer slope, diameter, length, arrangement of lifters, number of lifters, and RPM control the time the aggregate is in the mixer.

Air is used to atomize the fuel oil as it is ejected from the burner nozzle to provide for complete combustion, and to provide draft or suction necessary to carry combustion gases through the mixer. If complete combustion does not occur, the fuel oil tends to deposit a black, oily residue on the hot aggregate material, making it difficult to coat the aggregate with asphalt. Black smoke coming from the mixer exhaust indicates incomplete fuel oil combustion in the mixer. Intermittent puffs of smoke at the exhaust end of the mixer, or a flame that enters the mixer at a short distance, indicate insufficient draft through the mixer. With complete combustion, the flame penetrates about one-third to one-half the length of the mixer. Overloading the mixer may prohibit sufficient heating and drying of the aggregate. In a continuous mixing plant, the drum serves as the mixer and mixes asphalt with the dry aggregate, producing the final mix.

- Dust Collector – Dust and fine aggregate particles are emitted during the mixing process. A dust collection system captures the dust that is exhausted during the heating process. Typically, mixing plants have two components to the dust collection system: Primary dust collector and secondary dust collector.

    - Primary Dust Collector - The primary dust collector is the first point of extracting dust and fine aggregate particles from the mixer exhaust system. Primary dust collectors are either a knockout box or a cyclone dust collector. Collected dust particles are returned to the mixer to be re-mixed with the aggregate and asphalt. Collected dust particles are returned to the mixture to reduce the loss of fine aggregate particles, which are integral to an acceptable mix.

- Secondary Dust Collector - Because of stringent air quality standards, secondary collectors may be required. A secondary dust collector is either a wet scrubber or a baghouse. The dust collector system serves two purposes: (1) to provide an adequate draft through the mixer, and (2) to collect and return a uniform amount of the fine material. If a baghouse is used for dust collection, and the contractor wants to reintroduce the fines back into the mix, the contractor must be able to measure and control the amount of fines being reintroduced into the mix. The inspector observes the contractor's calibration of the system that reintroduces fines to verify that the amount of fines reintroduced into the mixture is uniform and does not exceed limits stated in the specifications. If the system is not calibrated, then the contractor cannot reintroduce baghouse fines into the mixture and the job mix formula will reflect the exclusion of baghouse fines.

Thermometers determine temperatures at various locations in the mixing plant. Specifications describe temperature requirements. Specifications typically state temperature requirements of the asphalt entering the mixer and temperature requirements of the mixture exiting the mixer. An armored thermometer, capable of detecting temperature ranges expected in the asphalt entering the mix, are fixed in the asphalt feed line as the asphalt enters the mixer. The thermometer is located so that the inspector can observe the readings conveniently and safely. Plants may also be equipped with a dial scale thermometer, a mercury-actuated thermometer, an electric pyrometer, or other thermometric instrument placed at a discharge chute of the mixer to register or indicate the temperature of the heated aggregates automatically. Such a device is in full view of the plant operator and convenient to the inspector to make observations.

Any thermometers used by the inspector should be correlated with the contractor's thermometers. By correlating thermometers, disputes involving temperature readings are reduced. If unresolved questions remain, contact the Resident Engineer, who may request replacement or verification of the temperature readings.

In a mixing plant, the mixture components—aggregate, asphalt, and baghouse fines—are combined in a mixer. First, the aggregate is introduced into the mixer where it passes over a series of flights, creating a sheet of aggregate that passes in front of the hot gases from the burner. This heats the aggregate and drives off the moisture before the asphalt introduction. Then, the asphalt is introduced into the mixer. The asphalt introduction point varies, depending on the individual plant characteristics. Aggregate coating occurs through a foaming action caused by the steam driven from the aggregate. Mixer slopes affect the amount of time that mixing action occurs. Mixers typically slope between five percent and 2 1/2 percent.

Plantmix can be produced at a contractor's portable job-site plant or at a commercial plant that serves multiple customers. For job-site plants, the contractor must provide a copy of the Nevada Department of Environmental Protection permit, which addresses the plant production limitations, to the Resident Engineer at least 48 hours before beginning operations.

6-401.2.3.1 MIXING PLANT CALIBRATION

After the contractor processes and stockpiles the aggregate and assembles the mixing plant, and the Resident Engineer receives the mix design, the contractor calibrates the mixing plant. Even though the contractor calibrates the mixing plant, the NDOT inspector observes and verifies the calibration process.

Mixing plant calibration is the process of determining the accuracy of plant instruments that produce the mixture in accordance with the job mix formula. Feed rates of the component materials that make up the mixture are identified and recorded. After the contractor calibrates the plant and the inspector has observed and verified the calibration, the plant inspector uses these calibration results to monitor plant operations during plantmix production.

Calibration is a step-by-step process that is done without operating the burner or introducing asphalt to the aggregate. Components of the mixture that require calibration are aggregate, asphalt, baghouse fines. For aggregate, the contractor adjusts the aggregate bin gate opening and the aggregate feed belt speed from each aggregate bin to produce an aggregate mixture that is consistent with the job mix formula. Asphalt feed rates are measured by a flow meter, which requires calibration. Contractors use a variety of methods to introduce baghouse fines into the mix, which requires calibration methods specific to the equipment used. The calibration process includes operating the mixing plant at several speeds (tons per hour) to establish a range of production rates. The composition of the mixture depends on the proportioning of each component material, and is based on the feed rate of aggregate. The feed rates of asphalt and baghouse fines are interlocked with the aggregate feed rate to maintain consistent proportioning.

Mixing plants are calibrated and documented at least every 12 months. Recalibration is required, however, if the plant was moved or components of the plant were altered or rearranged. If a plant is shut down for an extended period, such as during the winter months, the Resident Engineer should check the plant calibration before full production begins. The Resident Engineer may require recalibration of the plant at any time if the accuracy is questioned. Even though the Resident Engineer is responsible for checking the accuracy of the plant control settings, the Resident Engineer must notify the Construction Division Quality Assurance staff before calibrating a plant. The specifications require the contractor to notify the Resident Engineer, typically 48 hours in advance, when the plant is ready to be calibrated. The Construction Division can provide technical assistance and support to the Resident Engineer during the calibration process. The plant should be operating in a consistent manner before the plant calibration is scheduled.

The following sections provide information on calibrating component parts of the mixing plant. The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains NDOT form 040-038, "Hotplant Calibration Sheet." A hot plant calibration guide is available from the Construction Division Quality Assurance Section.

6-401.2.3.1.1 Aggregate Feed Calibration

Aggregate feed calibration consists of first calibrating the individual feed belts from each aggregate bin. Second, the weigh belt that delivers aggregate from the individual aggregate feed belts into the mixer is calibrated. A configuration of a weigh belt and aggregate feed belts is shown in Figure 6-401.3.

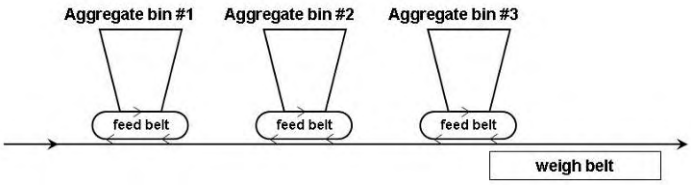

Figure 6-401.3. Configuration of Weigh Belt and Aggregate Feed Belts.

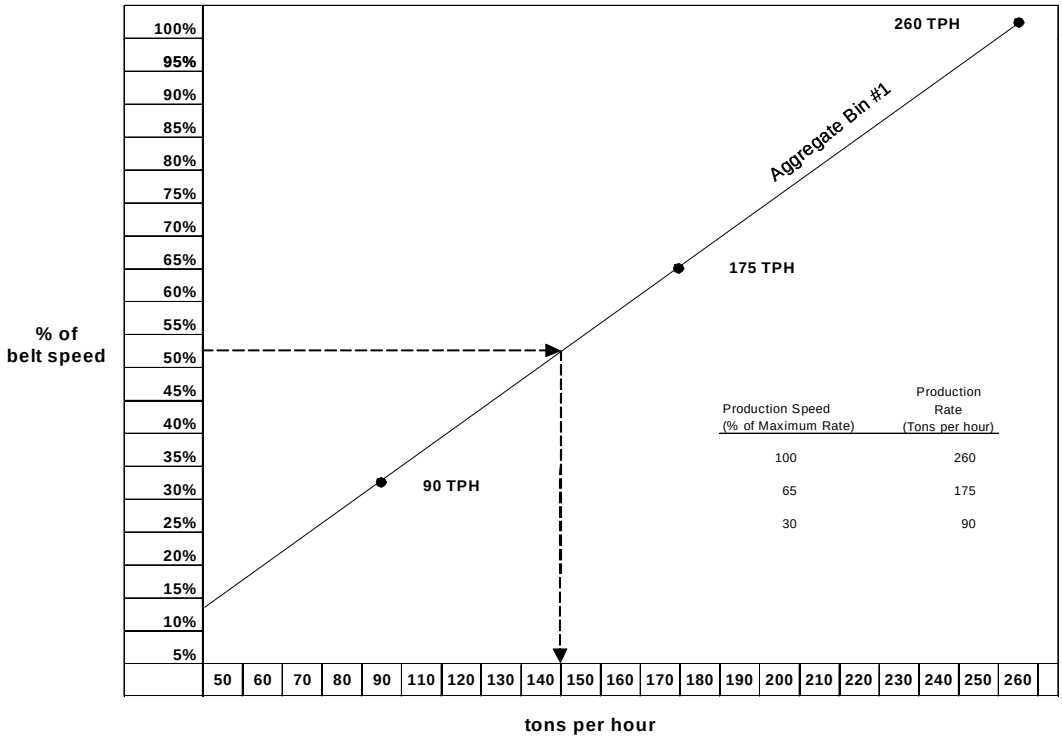

Figure 6-401.4. Example Bin Graph.

The contractor develops bin graphs for each of the aggregate feed belts. A bin graph is a plot of the relationship between aggregate feed, measured in tons per hour, and percentage of belt speed. The plant is operated at low, medium, and high production rates. For each plant production rate, the belt speed (measured as a percentage of the maximum belt speed) and aggregate feed rate (measured in tons per hour) for each bin is noted. A graph is produced for each bin. Figure 6-401.4 is an example of a bin graph developed by the contractor.

After the contractor develops the bin graphs, the weigh belt is calibrated. The weigh belt calibration determines the actual weight of aggregate introduced into the mix. A scale weighs the aggregate on the conveyor belt as it passes over the scale, commonly called a belt scale. The belt scale system sends a reading to the mixing plant control house. The reading is used to determine the weight of aggregate introduced into the mixer. When using a belt scale system, the contractor conducts a weight calibration according to the manufacturer's recommendations. The purpose of the weight calibration is to show the relationship between the actual weight of aggregate and the weight of aggregate indicated by the control house instruments. This relationship is then used to determine the actual weight of aggregate introduced into the mix.

After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. Each aggregate weigh check should be at least 10 tons. For a given production rate, the plant scale readings are compared to the certified platform scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight calibration should be conducted each time the belt scale is set up, and whenever the Resident Engineer questions the accuracy of the weigh system, but not less than once a year. After the weigh belt has been calibrated, the inspector notes and, if possible, marks the location of the settings of the bin gates. After the weigh belt is calibrated, verify the accuracy of one of the aggregate bin feed belts to confirm a correlation with the bin graph.

6-401.2.3.1.2 Asphalt Feed Calibration

The asphalt feed calibration determines the actual weight of asphalt introduced into the mix. Because the amount of asphalt in the mixture is directly related to the amount of dry aggregate in the mix, the asphalt feed rate is interlocked with the aggregate feed rate to maintain consistent proportioning.

A measuring device, such as an in-line flow meter or an asphalt pump revolution counter, measures the amount of asphalt introduced into the mixture from the storage tank. The measuring device should compensate for the temperature of the asphalt. The asphalt measuring device sends a reading to the mixing plant control house. The reading is used to determine the weight of asphalt introduced into the mixer.

The measuring device is calibrated to show the relationship between the actual weight of asphalt and the weight of asphalt indicated by the control house instruments. The inspector should be aware that plant control consoles may indicate a percent of asphalt that differs from the percent of asphalt required by the job mix formula because plants may utilize total weight of aggregate instead of dry weight of aggregate. The relationship between the weighed asphalt and indicated asphalt weight is then used to determine the actual weight of asphalt introduced into the mix. The metered quantity of asphalt, measured in gallons (minimum of 1,000 gallons) and converted to weight, should correlate within one-half percent of the actual weight as measured on the certified scales. Instead of gallons, the meter may read the quantity of asphalt by weight, measured in pounds or tons. Regardless of the units of measurement, a minimum of 1,000 gallons of asphalt is required for calibration. After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. The Resident Engineer can request recalibration of the asphalt meter whenever the meter's accuracy is in question.

6-401.2.3.1.3 Baghouse Fines Calibration

The contractor may introduce baghouse fines into the mix, provided the fines do not exceed two percent by dry weight of aggregate. If the contractor decides to introduce baghouse fines into the mix, the contractor must provide a positive weighing device that is interlocked with the aggregate feed system. Baghouses collect fines at varying rates. However, the fines must be introduced into the mixture at a uniform rate to produce a consistent mix. The contractor must have a system that eliminates the sporadic delivery of baghouse fines returned to the mix. The system must provide continuous uniform flow within tolerances stated within the specifications. The types of systems that measure reintroduced baghouse fines can vary. The contractor is not required to introduce fines. The contractor may dispose of the fines.

If the contractor chooses to introduce baghouse fines, the measuring system must be calibrated. Baghouse fines calibration compares plant weight readings to actual weights as determined by accurate scales. The weight readings of baghouse fines should correlate within 5 percent of the actual weight as measured on accurate scales. Because the quantity of baghouse fines is small, commonly no more than 2% of the aggregate dry weight or as stated in the specifications, baghouse fines may be weighed on a scale smaller than a platform scale used to weigh trucks.

Because baghouse fines are available only after a plant has operated for a period time, calibration procedures for commercial and jobsite plants are different. When using baghouse fines from a commercial plant, the baghouse fines must be calibrated before any plantmix is produced, including mixture for field trial mixtures or the first half day of paving. When using baghouse fines at a jobsite plant, baghouse fines are calibrated after producing field trial mixture or the first half day of paving. Calibration must be completed before any additional plantmix is produced.

6-401.2.3.1.4 Hydrated Lime (Mineral Filler) Calibration

The specifications direct the contractor to add hydrated lime by using the Marination Method or, in rare cases, by the Cold Feed Method. Regardless of which method is used, calibration of the measuring system used is the same as calibrating baghouse fines. The weight readings of hydrated lime should correlate within 5 percent of the actual weight as measured on accurate scales. Because the quantity of hydrated lime is small, commonly between 1% and 2% of the aggregate dry weight or as stated in the specifications, the hydrated lime may be weighed on a scale smaller than a platform scale used to weigh trucks.

6-401.2.4 MARINATION PLANT CALIBRATION

Marination plant calibration is the process of determining the accuracy of plant instruments that produce the marinated aggregate. Feed rates of the aggregate and hydrated lime are identified and recorded. After the contractor calibrates the marination plant and the inspector has observed and verified the calibration, the plant inspector uses these calibration results to monitor plant operations during the marination process.

The contractor adjusts the aggregate feed belt and hydrated lime feed belt speed to produce a marinated aggregate mixture that is consistent with the specifications. The calibration process includes operating the mixing plant at several speeds (tons per hour) to establish a range of production rates. The composition of the mixture depends on the proportioning of each component material, and is based on the feed rate of aggregate and hydrated lime. The feed rates of hydrated lime and water are interlocked with the aggregate feed rate to maintain consistent proportioning.

Aggregate feed calibration consists of first calibrating the aggregate weigh belt that delivers aggregate from the aggregate bin into the mixer. The weigh belt calibration determines the actual weight of aggregate introduced into the mix. A scale weighs the aggregate on the conveyor belt as it passes over the scale, commonly called a belt scale. The belt scale system sends a reading to the marination plant instruments. The reading is used to determine the weight of aggregate introduced into the mixer. When using a belt scale system, the contractor conducts a weight calibration according to the manufacturer's recommendations. The purpose of the weight calibration is to show the relationship between the actual weight of aggregate and the weight of aggregate indicated by the instruments. This relationship is then used to determine the actual weight of aggregate.

After the contractor completes the initial weight calibration, checks are made at low, medium, and high production rates within the rated operating range of the plant. Each weigh check should be at least 10 tons. For a given production rate, the plant scale readings are compared to the certified platform scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight calibration should be conducted each time the belt scale is set up, and whenever the Resident Engineer questions the accuracy of the weigh system.

After calibration of the aggregate weigh belt, the weigh system for the hydrated lime is calibrated. Hydrated lime calibration compares plant weight readings to actual weights as determined by accurate scales. Because the quantity of hydrated lime is small, commonly no more than 2% of the aggregate dry, hydrated lime may be weighed on a scale smaller than a platform scale used to weigh trucks. The contractor determines the amount of hydrated lime for each weigh check, typically several hundred pounds. For a given production rate, the plant readings are compared to the accurate scale readings. The percentage of error between the readings must be one percent or less. The percentage of error is then calculated for each of the other two production rates. Each production rate percentage of error must be one percent or less. Additionally, the range of the percentages of error between the low, medium, and high production rates must be within one percent of each other. The weight readings of hydrated lime should correlate within 5 percent of the actual weight as measured on accurate scales.

The water metering system does not require calibration because accurate measurement of the amount of water is not needed. The appropriate amount of water is visually determined as described in Section 6-401.2.1, Mix Design Development. Water must be added to the aggregate prior to the addition of hydrated lime. Adding water after the hydrated lime would tend to wash the hydrated lime from the aggregate.

6-401.2.5 ROADWAY

The roadway surface must be prepared prior to placing plantmix material. Preparing the roadway for paving includes the following:

- Constructing the base course
- Preparing the surface
- Conducting required tests
- Applying liquid or emulsified asphalt

The plans and specifications describe how the contractor is to prepare the roadway surface for paving. Plantmix paving can be placed on roadway surfaces such as aggregate base, coldmilled surfaces, concrete, or asphalt permeable base. After the contractor prepares the surface, the inspector determines the acceptability of the prepared surface. The surface to receive plantmix paving is acceptable when it conforms to grade, profile, and other requirements described in the plans and specifications. If testing requirements are specified, refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. Visually inspect the surface to confirm that no surface defects exist.

When liquid asphalt materials are applied, such as a prime coat, tack coat, or seal coat, the sealed surface must be protected from damage. Refer to Section 6-406, Prime Coat, and Section 6-407, Seal Coat, for additional information. Prime coats protect the compacted base courses from the destructive action of traffic, minimizes moisture evaporation from base material, and reduces weather damage. A tack coat is applied to serve as an adhesive between pavement surfaces. Seal coats are applied to a finished pavement surface to serve as a moisture barrier. Theoretical application rates and types of liquid asphalts to be applied are determined by the Materials Division and are included in the plans.

Before applying a prime coat, the inspector and contractor should confer regarding the planned application rate, traffic conditions, and paving schedule. Applying too much liquid asphalt is wasteful and may cause slippage, instability, and migration of asphalt to the roadway surface, called bleeding of the pavement. Applying too little liquid asphalt may require repairs before paving operations begin.

When prime coats are not used, the placement of hot paving material may cause rapid drying of the top of the base, leaving a loose dust film that may cause slippage. If a bituminous dust palliative has been used on the base material, it may be possible and desirable to eliminate the prime coat. Tack coats are used to bind one asphalt surface to another. Refer to Sections 6-405, Tack Coat, and 6-406, Prime Coat.

In addition to the materials and condition of the roadway surface, the inspector should confer with the contractor regarding the operational aspects of the paving operation. Operational aspects are addressed during a meeting, called a pre-pave meeting. . The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains a pre-pave meeting checklist. In general, operational aspects to consider are as follows:

- Equipment and labor for spreading and compacting plantmix material. By knowing the types of equipment that the contractor plans to use, the inspector can confirm that the equipment meets specifications. Knowledge of the contractor's use of equipment and personnel allows the Resident Engineer to schedule testing and inspection personnel.
- Plantmix material placement width and depth, and longitudinal and transverse joints placement. Specifications limit the depth of material that can be placed in a single pass of the paver. Specifications also restrict the location of joints. Conferring with the contractor on these issues allows the inspector to address potential problems.

After the inspector confers with the contractor on the operational aspects of paving, and after the equipment is on-site, the inspector verifies that the equipment conforms to the specifications. The inspector should also determine the adequacy of the equipment to produce the final product and report concerns of inadequacy to the Resident Engineer.

6-401.2.4.1 PAVING MACHINE

Plantmix material produced at the mixing plant is transported to the paving machine which spreads it on the roadway. Paving machines typically consist of a hopper for receiving the plantmix, augers to spread the mixture uniformly across the surface to be paved, a screed to strike off and smooth the mix, and a grade-sensing device used to raise and lower the screed to level the plantmix to the proper grade. Figure 6-401.5 shows a plantmix paving machine.

Figure 6-401.5. Plantmix Paving Machine.

Hauling trucks deliver plantmix material from the plant to the roadway. The material is unloaded from the hauling truck into a windrow in front of the paving operation or into another vehicle, called a material transfer vehicle. When the material is placed in a windrow on the roadway, a pick-up machine, attached to the front of the paver, lifts the windrowed material into the hopper. A material transfer vehicle also delivers material into the hopper. If approved by Resident Engineer, hauling trucks may deliver material directly into the hopper of the paver for areas requiring small quantities of material. The inspector must review the specifications to determine if a specific material delivery method is required. The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains an asphalt paving checklist.

Material in the hopper of the paver is conveyed to the rear of the paver where augers distribute the material across the full width of the paver. Once the material is distributed, the screed strikes off excess material leaving a level, partially compacted plantmix surface. Screeds are controlled manually or automatically. When pavers begin a pass, screeds are commonly operated manually. Manual control is transferred to automatic control after the position of the screed has been stabilized. Paving operations usually begin and end at a slow speed because the paver operator may need to revert to manual control.

An important aspect of automatic screed control is the sensitivity of the controls. An overly sensitive grade sensor, or excessive manual control adjustment, frequently produces false control signals that can produce a wavy pavement surface. An under-sensitive grade sensor does not detect deviations in the grade soon enough to adjust the pavement depth. The paver operator should adjust the sensor sensitivity so that the chatter or bounce of the grade-sensing device is not transmitted for correction. Screed adjustments are not transmitted to the actual pavement until the paver has traveled a distance after the adjustment is made, typically more than 50 feet.

The inspector should discuss with the contractor which type of grade sensing device will be used. Inspect the grade-sensing device to verify that it is in good working order and that it will produce the desired finished product and conforms to the requirements of the specifications.

Grade reference devices are of two general types: (1) transverse control, used to provide cross-slope, and (2) longitudinal control, used for grade elevation. A transverse beam mounted above the screed controls the cross-slope. An external reference device controls the longitudinal grade. External reference devices include the following:

- The floating beam is a rigid beam, approximately 30 feet long, supported every 2½ feet by spring-loaded shoes. The spring-loaded shoes provide an average grade reference, or they can be locked to provide reference control similar to the long ski. When matching an adjacent, newly paved roadway on which the beam will ride, the beam may be as short as 10 feet in length.
- An electronic grade control system uses a “non-contacting” sonic sensor. The placement of the sensors must average four sensors over 20 linear feet. The system controls grade and cross slope without skis or string lines and matches joints without requiring the sensors to touch any surfaces.
- The long ski is a semi-rigid truss or a pipe with a wire-line. This assembly is loosely attached to the paver. The paver has a grade-sensing device to detect slope changes in the wire. Use a wire-line to check or control long skis (not less than 30 feet long). When matching an adjacent, newly paved pad on which the ski will ride, the ski may be as short as 10 feet in length.
- String-line or wire-line is supported above the base course and provides grade reference with a high degree of accuracy. Keeping these lightweight lines at the proper tension is important to prevent sagging.

Regardless of the type of grade-sensing device, the inspector must verify that the paver can produce a finished product that conforms to the plans and specifications.

6-401.2.4.2 ROLLERS

After the paver places the plantmix material on the roadway, rollers compact the material to the required thickness and density. Rollers come in many configurations, sizes, and weights. The two most common types of rollers are steel wheel and rubber tired pneumatic. Rollers perform the following functions: breakdown rolling (steel wheel, with or without vibration), kneading (rubber tired pneumatic), and finish rolling (steel wheel).

- Breakdown Roller – This roller immediately follows the paver and performs breakdown rolling. The breakdown roller is a tandem axle steel wheel roller, which meets the requirements of the specifications. Typically, a breakdown roller weighs at least 10 tons and is capable of vibrating.
- Pneumatic Roller – This roller follows the breakdown roller. A pneumatic roller has rubber tired wheels, typically weighs at least 10 tons, and must have skirting surrounding the tires to retain heat in the tires. The pneumatic roller aids in compacting the mix. It also kneads the mix, which can repair cracked areas in the pavement while the plantmix is still hot. Kneading the mixture with a pneumatic roller may decrease the compaction of the pavement but will allow higher compaction to be achieved. The pneumatic roller may pick up plantmix material on the wheels if the paving mat is too hot or the roller tires are too cold. Tire pressure can also affect whether a pneumatic roller picks up material. The pneumatic roller is most effective when the pavement temperature is above 185°F. Some contractors provide roller operators with an infrared hand-held thermometer. The thermometer readings help the roller operator determine appropriate optimum times to begin compactive efforts.
- Steel Wheel Roller – This roller follows the pneumatic roller, which performs the finish rolling of the mat. A finish roller typically weighs at least eight tons. Although most steel wheel rollers are equipped with a vibrator, the finish roller operator does not use the vibrator during final pass of finish rolling on the mat. The purpose of finish rolling is to remove irregularities and provide a smooth surface.

Rollers could pick up plantmix material during rolling. If this occurs, the contractor applies a release agent to the roller wheels or drum. The release agent must comply with the requirements of Section 401.03.02 of the specifications. The contractor is prohibited from using diesel or kerosene as a release agent because of the detrimental effects on the plantmix.

The inspector should confirm the availability of an appropriate number and types of rollers and verify each roller's weight before placement of the plantmix. Steel wheel rollers should be in good condition and should be checked for minimum weight. Pneumatic rollers must also comply with specifications. The inspector should report concerns of inadequacy of the equipment to the Resident Engineer. Typical rollers are shown in Figures 6-401.6 and 6-401.7.

Figure 6-401.6. Steel Wheel Roller.

Figure 6-401.7. Rubber Tired Pneumatic Roller with Skirting.

6-401.2.4.3 MISCELLANEOUS EQUIPMENT

Figure 6-401.8. Material Transfer Vehicle.

Specifications direct the contractor on the types of miscellaneous equipment to be provided and other requirements such as the specific time when the equipment must be on the project. Typical miscellaneous equipment includes a material transfer vehicle, core-drilling machine, and a profilograph.

With a material transfer vehicle, a hauling truck conveys material directly into a transfer vehicle, which continuously feeds material into the hopper, or the material transfer vehicle transfers material from a windrow into the hopper. A material transfer vehicle has advantages over other delivery methods because it allows uninterrupted delivery of material to the paver, it provides the ability to remix the material, and reduces temperature variability and segregation of the plantmix material. Figure 6-401.8 shows a material transfer vehicle.

The contractor must furnish a pavement core-drilling machine for coring samples of compacted bituminous mixtures for density testing. The inspector must verify that the drill is capable of drilling the required cores without distorting or tearing the pavement, and is of the correct size. The inspector should confirm with the contractor that the coring machine will be available on the project and operational at the time required by the specifications.

The contractor must also furnish a profilograph for checking riding tolerances of the finished roadway. The inspector must confirm that the profilograph is on the project and in good working order, including operating instructions and calibration blocks. Refer to Section 402 of the specifications.

6-401.3 DURING CONSTRUCTION

The Resident Engineer typically assigns the NDOT field crew to monitor the contractor's paving operations as follows:

- Plant inspector
- Field testers
- Street inspector
- Ticket taker

Depending on the size and complexity of the paving operation, the Resident Engineer may increase or decrease the staffing level. Materials incorporated into the plantmix are tested to determine if the material is acceptable for incorporating into the work. The Resident Engineer's field testers perform acceptance testing. Some acceptance tests, however, are performed by the Materials Division, which has specialized testing equipment. Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* identifies acceptance tests that are performed by the Materials Division.

6-401.3.1 MIXING

The plant inspector must monitor a variety of operations that affect the production and quality of the plantmix. Material and equipment, such as storage tanks for asphalt cement, burner fuel, hydrated lime, aggregate bins, baghouse, and aggregate feed belts, require inspection to ensure a uniform quality mix. After calibration and before full production begins, the contractor operates the mixing plant to verify that it produces a mixture that conforms to the job mix formula. After verification that the plant produces the specified plantmix, the plant may begin full production of plantmix. During production, whether it is preliminary or full production, the plant inspector monitors the production to verify that the specified mixture is produced. Inspecting the plant requires attention to multiple details and activities.

Before plantmix production begins, the plant inspector should have available all records and documents prepared during material preparation and equipment operation, as well as records and forms needed during construction. The plant inspector should have the following items:

- Specifications
- Special Provisions, which modify the specifications and are project-specific
- Mix design
- Job mix formula
- Calibration record (Completed calibration sheet, NDOT form 040-038)
- Aggregate marination records and sketches detailing marinated stockpiles
- Delivery records: mineral filler field book, asphalt cement field book, asphalt cement bills of lading, and samples
- Daily plant report of asphalt mixtures (NDOT form 040-011)
- Daily diary sheet
- Sample containers and transmittal sheets (NDOT form 020-016, black marking pen, masking tape, plastic bags for transmittals)
- Daily hotplant worksheet (NDOT form 040-045, if plant is a jobsite plant, not commercial), for information only
- Calibrated thermometer that has been correlated with plant thermometer
- Additionally, reference manuals such as “Hot Mix Asphalt Materials, Mixture Design and Construction” by the Center for Asphalt Technology and “Principles of Construction of Hot-Mix Asphalt Pavements” by the Asphalt Institute may be helpful.

Delivered materials, such as asphalt cement and hydrated lime, are stored on or near the jobsite. When asphalt cement is delivered, a shipping notice—commonly called a bill of lading—and a copy of the refinery material test report must accompany each delivery. Section 703 of the specifications describes the required information contained in the bill of lading and refinery test report.

If hydrated lime is not added to the aggregate using the Marination Method, hydrated lime (mineral filler) is added to the mixture during the production process. This process is called the Cold Feed Method, and is described in Section 401.03.08 of the specifications. With the Cold Feed Method, the plant inspector confirms that the lime storage silo is filled and ready for use before plantmix production begins. When the Cold Feed Method is used, the aggregate must be wet and the flow of the hydrated lime must be uniform as it is added to the aggregate. The aggregate and lime are mixed before being added to the mixer, where it is mixed with asphalt. Whether the lime is added by the Marination Method or by the Cold Feed Method, the inspector verifies that the aggregate on the conveyor belt entering the mixer is thoroughly and uniformly coated with hydrated lime.

Before starting production, discuss plant procedures with the plant operator. The discussion should include identifying inspection points to observe mixture production and where to take samples and temperatures. Sufficient notice should be given to the field tester to allow time to calibrate plantmix testing equipment. Certain testing equipment cannot be calibrated until after the mixing plant is calibrated and may require as much as a day for the calibration process. Confirm that each haul truck will have a delivery record indicating the load weight. The inspector should confirm with the contractor that the truck beds will be clean and discuss the method used to reduce plantmix from adhering to the haul truck beds. Contractors commonly apply a releasing agent to the truck bed to reduce the plantmix from adhering. Section 401.03.02 of the specifications describes releasing agent requirements.

Before full production begins, specifications require the contractor to complete a verification process showing that the plantmix complies with the job mix formula and meets specifications. The verification process includes producing a “hot drop” and completing field trial mixtures. A “hot drop” is an amount of material produced, which is representative of the plantmix produced for placement on the roadway and conforms to the job mix formula. The contractor determines the amount of material to be produced. Typically, the larger the hot drop sample, the more representative the sample is of the final product. The Resident Engineer’s tester samples the material produced from the hot drop and tests the material to verify conformance to job mix formula. After the contractor compacts the field trial mixture material using the job mix formula bitumen ratio, the Resident Engineer’s testers calibrate the nuclear thin lift density gauge. The Resident Engineer may also request samples be taken to obtain informational test results for stability and air voids.

After the Resident Engineer determines that the hot drop material meets specifications, the contractor may begin producing plantmix for the required field trial mixtures, as described in Section 401.02.02 of the specifications. Depending on the project, the specifications will require either a single field trial mixture or three field trial mixtures. The field trial mixtures determine the bitumen ratio that best meets the requirements for Stabilometer Value (Nev. Test Method T303) and Percent Air Voids of Compacted Bituminous Material (AASHTO T269). For some projects, field trial mixtures may not be required. When field trial mixtures are not required, the specifications may limit production on the first day of paving. The limitation allows NDOT to verify that the material conforms to the job mix formula and specifications, and to limit the amount of paving if the mixture is unacceptable. The inspector should review Section 401 of the specifications for details relating to field trial mixtures or limitations on the first day of paving.

Three field trial mixtures are produced, each using a different bitumen ratio, as described in the specifications. The contractor should carefully consider the test section location. If the contractor decides to place the field trial mixture material on the travel lane, the contractor may have to remove the material if it is determined to be unacceptable.

The tester takes samples of each of the three field trial mixture test sections. The samples must be large enough to allow the Resident Engineer's field testers and the Materials Division to run tests. After the trial mixtures are produced, the Resident Engineer suspends assessing working days, and the contractor cannot continue producing mixture for the project for three days while the Materials Division tests the filed trial mixture. The Materials Division forwards the results of the field trial mixtures to the Resident Engineer. The field trial mixtures' test results will either verify the mix design bitumen ratio or determine the new bitumen ratio that will be used for full production. If the bitumen ratio determined from the field trial mixture test results differs from the initial job mix formula bitumen ratio, then the Resident Engineer establishes a new job mix formula, which is assigned the next sequential job mix formula number. If field trial mixtures do not meet specifications, additional field trial mixtures may be required.

The mixing plant is now ready to run at full production. The contractor is responsible for producing plantmix that conforms to the job mix formula and specifications. The inspector reviews, observes, and monitors operations at the plant to determine if the contractor's plantmix processes are consistent with specifications. In addition, the inspector performs calculations based on information obtained from the plant instrument readings to determine if the material meets specifications. Test results are used to determine conformance with specifications.

To determine the bitumen ratio, the inspector periodically observes and notes the aggregate and asphalt cumulative totals and the production rate for the plantmix. These periodic observations are called plant checks. Plant checks are used to determine bitumen ratio analytically and to monitor consistency of the mix. During production, the inspector typically performs hourly plant checks. Each hour during production, the inspector performs a plant check, monitoring aggregate and asphalt feed rates for a ten-minute period. During the plant check, the inspector notes the plant readings at the beginning and end of the ten-minute period for aggregate and for asphalt. Using the noted plant readings, the bitumen ratio is calculated using the following formula:

$$\frac{WT_{asphalt}}{WT_{dry\ aggregate}}$$

$WT_{asphalt}$ = weight of asphalt, tons
$WT_{dry\ aggregate}$ = weight of dry aggregate, tons

Typically, plant readings are based on total aggregate weight, which includes the weight of hydrated lime and water. To calculate the dry aggregate weight, the weight of water and the weight of hydrated lime are deducted from the total weight of the aggregate. The weight of water is calculated using the plant reading for total aggregate weight, the moisture content from test results, and the total percent of lime used in the aggregate marination process. The following example illustrates how to calculate a bitumen ratio based on an hourly plant check.

EXAMPLE:

A plant inspector makes a ten-minute plant check every hour. The inspector notes the plant readings for aggregate and for asphalt at the beginning and end of the ten-minute period. The readings are as follows:

Aggregate Feed:	beginning reading – 890 tons,	end reading – 965 tons
Asphalt meter:	beginning reading – 6.00 tons,	end reading – 9.50 tons

The lime content from the job mix formula is 1.48% of the dry weight of aggregate.

The aggregate moisture obtained from a belt sample during that day's production is 3.65%.

Calculation:

Lime:	1.48%
Aggregate moisture:	3.65%
Total lime and moisture:	5.13%

Weight of aggregate:	965 tons – 890 tons = 75 tons
Weight of asphalt:	9.50 tons – 6.00 tons = 3.50 tons

$$WT_{\text{dry aggregate}} = \frac{WT_{\text{aggregate}}}{1 + (\%\ \text{lime} + \%\text{moisture})} = \frac{75\ \text{tons}}{1 + 0.0513} = 71.34\ \text{tons dry aggregate}$$

$$\text{Bitumen ratio} = \frac{WT_{\text{asphalt}}}{WT_{\text{dry aggregate}}} \times 100 = \frac{3.50\ \text{tons}}{71.34\ \text{tons}} \times 100 = 4.91\%$$

The calculated bitumen ratio for each ten-minute check is recorded in the plant inspector's daily diary. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a completed plant inspector's daily diary.

In addition to plant checks, the daily amount of asphalt used can be checked for information purposes by observing the contractor's personnel measuring the decrease in asphalt quantity in the storage tank. Contractors typically measure the depth of asphalt in a storage tank before and after production, taking into account deliveries, the difference being the volume of asphalt removed from the tank.

The moisture content of the aggregate influences the amount of asphalt added to the mix. During full production, adjustments may be required to compensate for changes in the aggregate moisture. Because aggregate moisture affects the amount of asphalt added to the mix, aggregate moisture tests should be taken twice daily—morning and afternoon.

The plant inspector records daily observations in the following two documents:

- Daily diary
- Plant Inspectors Report (part of NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures")

In the daily diary, the plant inspector records the hourly bitumen ratio obtained from the plant checks. The inspector records the hourly bitumen ratio calculated throughout the day, and the average daily bitumen ratio, calculated from daily totals of mix, aggregate, and asphalt. The inspector records quantities of material delivered to the plant, plant settings, and moisture corrections. The daily diary also includes the plant production rate and plant operation times, noting any time the plant is not in operation and the reason why. An example of a completed daily diary entry is located on the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx.

The plant inspector's report is one part of a three-part form (NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures"). The plant inspector records information obtained while performing inspection duties at the plant, such as bitumen ratio, stored asphalt quantities, and temperatures.

The inspector should be familiar with the specifications. The following suggestions may prove helpful:

- Acceptable mixing produces coated aggregate particles, with a homogenous and uniform appearance. Unacceptable plantmix material is characterized by some or all of the aggregate particles not being coated with asphalt. Aggregate particles that are not coated with asphalt are often described as "white rock."
- If unmixed material comes out of the mixer, either the pugmill or mixer, the mixer could have dead spaces, where complete mixing does not occur. The contractor periodically inspects the mixing flights or paddles for excessive wear or other problems that result in incomplete mixing.
- If unmixed material comes out of the mixer, the mixer could be overloaded. Compare the production rate with the operating capacity.
- The inspector should view the mixture before the mixture is placed in a silo or haul truck. The contractor is required to provide a viewing port in accordance with Section 401.03.09 of the specifications. View the material to verify complete mixing and uniform coating of the aggregate. Poorly mixed material or material that is not completely coated with asphalt should be rejected and the contractor must correct any problems.
- Two important elements of producing a quality mixture are bitumen ratio and a homogenous mix. Air voids and stability are sensitive to the bitumen ratio, and a homogenous mixture significantly contributes to a durable pavement.
- Observe the contractor's loader operator to confirm that the correct aggregate is supplied to the appropriate bin. Also, check the aggregate feed gates to verify that they are set at the calibrated settings.
- Inspect the hauling truck beds to see that they are clean. The truck drivers should use only an approved release agent, listed in the current Qualified Product List, on the truck beds. Observe the application of release agent, making sure that any excess material is drained from the bed of the hauling vehicle before loading with plantmix.

- If the plantmix material does not appear satisfactory, such as not being uniformly mixed or temperatures not within specification, the inspector should not allow the material to leave the plant. The inspector should discuss any problems with the mixture immediately with the plant operator and the Resident Engineer so that corrections can be made.
- The contractor issues a haul ticket (scale ticket) to each hauling vehicle before the vehicle leaves the plant and goes to the jobsite. If the loaded truck is weighed on platform scales not at the plant, the weighmaster issues the haul ticket to the truck driver.
- Haul trucks with long beds are typically loaded with three smaller batches spaced within the bed—front, back, and center—instead of a large single batch. This reduces material segregation.

Many variables affect the consistency and uniformity of plantmix. The Construction Division Quality Assurance Section is available to provide support and technical guidance.

The plant inspector, street inspector, and tester must communicate with each other. The contractor may make adjustments at the plant and at the paver. If the plant inspector detects changes in the mixture being produced, the observation should be communicated to the street inspector and tester, documented, and appropriate action taken. If the street inspector detects any changes in the delivered plantmix, the observation should be communicated to the plant inspector and tester, documented, and appropriate action taken. During mixture production, an intermittent, stop-and-go operation by the contractor may reduce the quality and consistency of the mix. Therefore, planning and constant communication between the plant and the placement operation keeps the production of plantmix at a constant pace, leading to a uniform material.

6-401.3.2 PLACEMENT

At the roadway, the street inspector is responsible for monitoring the contractor's plantmix placement and compaction operation. Haul trucks transport plantmix material from the plant to the paving operation. The plantmix is unloaded into the paver hopper, windrowed on the ground in front of the paver, or transferred into a pickup machine or material transfer vehicle. The paver spreads the plantmix to the appropriate width and depth. The plantmix is then compacted using two or more rollers.

As the plantmix is delivered to the paving operation, the inspector records the amount of material incorporated into the work. Haul tickets are used to record and document the amount of plantmix that each truck delivers to the paving operation. The truck driver receives a haul ticket after the truck is loaded with plantmix and weighed. When the truck arrives at the paving operation, the street inspector takes the ticket and records the information in the load field book. On large paving projects, a ticket taker receives the ticket and records the information in the load field book. This confirms that the truck left the plant and arrived at the project. The street inspector records daily observations in the following three documents:

- Load field book – In the load field book, the street inspector or the ticket taker records the delivery of each truck hauling plantmix to the project. The quantity of material the inspector records is used to calculate the amount of plantmix placed per station, which is the yield. The yield is a means to compare actual placed quantities to planned quantities. While the yield serves as a guide, the inspector must confirm that the actual pavement dimensions conform to those contained in the plans. Deviations from the planned quantity can cause overruns that can be costly or underruns that fail to meet structural requirements. Notify the contractor if the required depth is not being achieved. Then, notify the Resident Engineer of the deviation.

- Street inspectors report (part of NDOT form 040-011, "Daily Plant Report of Asphalt Mixtures") – The street inspector's report is one part of the three-part form. The street inspector records information collected while performing inspection duties at the paver, such as temperatures, placement information (stationing and thickness of pavement), and weather conditions..
- Daily Construction Report, NDOT form 040-056 – The street inspector uses this form to record information and observations that are not specifically recorded in the street inspector's report. Also recorded in the Daily Construction Report are straightedge readings, which the street inspector is responsible for taking. This report also includes conversations and other events or activities that may influence the final pavement.

Temperature is important for proper placement and compaction of plantmix. Not only is the temperature of the mixture important, but specifications require minimum atmospheric and surface temperatures before paving can take place. The street inspector takes the temperature of the mixture to determine if it is within specified ranges for spreading and compaction. Although the specifications do not have a temperature requirement for the mixture in front of the paver, the temperature gives an indication of the suitability of the mixture for placement in the hopper. Specifications require minimum temperatures of the material at the hopper of the paver. Behind the paver, temperatures of the plantmix must be above specified minimums for various stages of compaction.

As paver augers spread plantmix through the screed, the paver creates an unconsolidated layer of plantmix, called a mat. The inspector observes the surface of the mat for irregularities and cross slope uniformity. Typical irregularities are lumps of cold asphalt, drag marks, pockets of rock—coarse aggregates or fines. If the inspector observes irregularities, the contractor corrects the irregularities before compacting the mat. The inspector must check the depth of the uncompacted mat frequently. The uncompacted mat thickness will be greater than the design thickness to allow for compaction. As a rule of thumb, for every inch of uncompacted plantmix placed, the mat will compact ¼ inch. For example, 2½ inches of plantmix would compact to approximately a two-inch thick compacted pavement. The compacted plantmix depth should be checked to confirm pavement thickness.

Rolling the mat for compaction is an important step in the paving process. The compactive effort, which comes from rolling, increases the density of the plantmix by reducing air voids in the material. Specifications state the acceptable range of density and air voids. The first roller performs initial breakdown rolling with a steel wheel roller to set the mixture and reduce lateral displacement. The second roller is a pneumatic-tired roller. The last roller is a steel wheel tandem roller that provides a smooth finished surface. If density test results indicate that the hot mat has not achieved the required compaction, the inspector, in coordination with the tester, should work closely with the contractor. While the contractor is responsible for achieving the required density, the tester can provide testing information so that the contractor can modify rolling patterns to achieve the required results before the mat cools.

The street inspector must monitor the delivery, spreading, and compaction procedures to ensure that samples and tests are performed at the required frequencies. Ongoing communication with the testers ensures they take samples in a timely manner. Well-coordinated sampling and testing provides timely confirmation that the placement and compactive effort yields a product that conforms to specifications.

An inspector may find the following suggestions helpful:

- If a pneumatic roller causes excessive wheel marks, the contractor can correct the wheel marks by (1) reducing tire pressure, or (2) delaying rolling until the plantmix temperature decreases, but above 185°F. Although some wheel marks occur with pneumatic rollers, excessive deformation of the surface indicates decompaction of the plantmix.
- With a pneumatic roller, the roller operator warms the tires before the roller gets onto the mat. The operator proceeds slowly with rolling while the tires gain heat; and, if pickup occurs, immediately remove it from the tires. Typically, pneumatic rollers use an approved release agent, as listed on the current Qualified Product List, to reduce asphalt pickup.
- The contractor must protect longitudinal joints between traffic lanes from damage or distortion by traffic or other causes until the adjacent lane is constructed. During construction of the abutting lane, excess material that accumulates along the joint during spreading should be wasted and not cast over the surface of the uncompacted material.
- When rolling a cold transverse joint, the roller operator cross-rolls the joint, perpendicular to the paving direction, starting with the roller on the cold mat with about six-inches of the roller extending onto the new hot mat. The operator moves the roller onto the new mat in successive increments of 12 inches until the entire roller is on the new mat.
- A continuous paving operation minimizes irregularities in the finished surface caused by stopping and starting the paving equipment.
- The contractor typically uses screed heaters to heat up the paver screed until the plantmix can maintain the screed's temperature.
- When the paving operation is halted and delayed for any appreciable amount of time, the paver operator may run material out of the paver, stopping the paver as the screed begins to run out of material. Before restarting the paver, the operator augers sufficient plantmix material to the screed, and allows the paver to stand until the cooler material in front of the screed is warmed by freshly delivered plantmix.
- If end-dump trucks are used, the truck is held against the front of the paver, avoiding bumping the machine. Bumping the paver creates bumps or dips in the mat and spills material in front of the paver. The contractor must clean up any material spillage in front of the paver to prevent bump formation. The contractor should never use trucks to pull the paver.
- The operator should avoid frequent screed adjustments.
- Monitor the cross slope produced by the screed to confirm construction of the planned cross slope.
- Changes in temperature, height, and amount of material in front of the screed; the weight of the screed; and the forward speed of the paver all affect the thickness of the mat without any change of the thickness controls.
- Paving is a continuous operation during which the contractor makes adjustments to achieve the quality required by the specifications. Therefore, providing the contractor with timely test results is essential so that the contractor can make immediate decisions that produce a plantmix pavement that meets the requirements stated in the specifications. If necessary, provide the contractor with draft test results prior to completing test report forms.

- The inspector should continually verify that the project testing frequencies are consistent with the minimum frequencies listed in Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*.
- When constructing a tapered transverse joint to match an existing pavement, the operator starts the paver using manual controls. As the paver progresses, the operator adjusts the screed manually until it reaches full thickness, about 20 feet from the joint.
- The contractor must correct areas that have a non-uniform mixture or where aggregate segregation is evident.

After final rolling, the street inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The street inspector reports the straightedge results on NDOT form 040-056, "Daily Construction Report." The street inspector should carefully inspect all paving joints to verify compliance with specifications. If the specifications have profilograph requirements, the contractor performs profile testing of the plantmix surface before allowing traffic on the surface, typically within 48 hours of placement. Traffic could adversely affect the pavement's smoothness. The profilograph is operated to take test readings in the planned vehicle wheel path and in the direction of traffic.

The Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, "Report of Profilograph Test." Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications, typically seven days after the tests are taken. If the profilograph test results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements. Excessive high points in the pavement—called "must grinds"—as described in the specifications, should be marked with paint during the profilograph testing. With timely notification, the contractor may be able to alter placement operations to reduce "must grinds" and improve the pavement smoothness.

6-401.4 MEASUREMENT AND PAYMENT

Measurement and payment for plantmix bituminous pavement is described in Section 6-402, Plantmix Bituminous Surface, Section 6-403, Plantmix Bituminous Open-Graded Surface, and Section 6-404, Cold-Recycled Bituminous Surface and Pre-Mixed Bituminous Paving Material.

6-402 PLANTMIX BITUMINOUS SURFACE

6-402.1 GENERAL

Plantmix Bituminous Surface is a layer of the roadway structural section. This layer is often called "dense-grade" because it is the densest of the bituminous pavements. In the roadway structural section, the dense-grade layer provides the greatest load-bearing capacity per inch of thickness than other elements of the structural section.

The plans designate the type of plantmix to be placed. Section 705 of the specifications describes three types of plantmix bituminous surface. The types of plantmix surface are related to the types of aggregate used in the plantmix. A description of plantmix surface types is provided below:

- Type 2 – commonly used on roadways having typical traffic loading. A Type 2 plantmix may have little or no ¾ inch aggregate.
- Type 2C – contains higher percentage of coarse aggregate than Type 2 to improve load-bearing capacity. A Type 2C plantmix has at least 5% of ¾ inch aggregate. It is typically used on roadways that carry high traffic loads, such as Interstate highways and urban arterials
- Type 3 – contains no aggregate greater than 3/8 inch and is typically used as a leveling course prior to placing a Type 2 or 2C plantmix surface

Section 6-401, Plantmix Bituminous Pavements, describes construction techniques, processes, and details that apply to plantmix bituminous surface before and during construction.

6-402.2 BEFORE CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements.

6-402.3 DURING CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements. The following sections provide additional information on compaction and surface tolerances for plantmix bituminous surface (dense-grade).

6-402.3.1 COMPACTION

Although Section 402.03.06, Compaction, of the specifications describes three methods of compaction (standard rolling pattern, test section, and control strip), the specifications will state the specific method to be used on the project. The specifications refer to the three methods of compaction as Method A, Method B, and Method C. Refer to the specifications for requirements for each compaction method. After the rollers compact the plantmix, the Resident Engineer's testers use nuclear density gauges to measure the density of the plantmix. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for compaction testing requirements. Regardless of the compaction method, proper compaction and density at pavement joints is important to the life of the pavement. Poor compaction at joints may result in pavement aging by allowing moisture and air into the pavement. The following additional information is provided on the three methods of compaction:

- Standard Rolling Pattern (Method A) – The standard rolling pattern method describes the minimum rolling requirements that must be met, including the number of roller passes. The contractor is responsible for establishing the rolling pattern. The standard rolling pattern method for achieving density is typically used only for small areas.

- Test Section (Method B) – The test section compaction method specifies an acceptable density range, based on the maximum density. This method correlates nuclear density gauge readings with pavement core sample density test results taken at the same locations. The test section method is the most common compaction method used with new plantmix surface construction.
- Control Strip (Method C) – The control strip method establishes an average density using 10 nuclear density gauge readings. Density tests are not performed on core samples with this compaction method. To establish a target density value, the pavement is rolled until nuclear density gauge readings show no increase in density. Once the pavement has reached this density, nuclear density gauge tests are taken at 10 randomly selected locations to establish the average density, which is now the contractor's target value.

6-402.3.2 SURFACE TOLERANCES

The pavement surface smoothness is a measure of the contractor's ability to place the material within the tolerances specified. A smooth ride is the most important quality to the motorist. Additionally, a smooth surface reduces vehicle impact loading caused by surface irregularities. Impact loading can reduce the life of the pavement.

The specifications describe pavement smoothness requirements. Smoothness specifications include straightedge and profilograph methods of assessing pavement smoothness. The straightedge and the profilograph measure different characteristics of surface smoothness. A 12-foot straightedge is used to measure pavement irregularities longitudinally and transversely. A profilograph is an instrument that measures pavement smoothness longitudinally. The profilograph measurements are taken in the direction of traffic in the vehicle wheel path, as described in the specifications.

The inspector may use straightedge testing at any location. However, the inspector must straightedge longitudinal and transverse pavement joints. Pavement joints are seams between adjacent mats. Because construction of pavement joints requires matching an existing surface with newly placed plantmix, surface smoothness can vary. The inspector must straightedge these areas to verify that the contractor has constructed a joint with a smooth surface. The inspector records straightedge test results on NDOT form 040-056, "Daily Construction Report."

Surface smoothness tolerances measured by a profilograph must comply with tolerances listed in the specifications. A profilograph is shown in Figure 6-402.1. The specifications list three pavement smoothness types: Type A, Type B, and Type C. The specifications will state the smoothness type that the contractor must meet for the project. To measure the pavement smoothness, the contractor must furnish, maintain, and operate a profilograph. The Resident Engineer verifies that the profilograph meets specifications. The calibration of the device is important to obtain accurate and representative readings.

Figure 6-402.1. Profilograph.

The Resident Engineer assigns an inspector to observe the calibration and operation of the profilograph. The inspector must verify that the contractor has calibrated the profilograph before using it. To measure pavement smoothness, the contractor takes profilograph readings before placing traffic on the surface. Traffic can alter the smoothness of pavement. At the end of each day, the Resident Engineer receives the profilograph readings, which are depicted as a graph showing the pavement smoothness. The Resident Engineer or crew analyzes the readings and reports the results on NDOT form 040-073, "Report of Profilograph Test." The Resident Engineer provides copies of the completed Report of Profilograph Test form to the contractor as soon as possible. The contractor may use the profilograph test results to make modifications to the paving operation to improve the plantmix surface smoothness.

If the surface smoothness is unacceptable, the contractor must take corrective action to bring the pavement into the designated smoothness tolerance. Typically, the contractor will hire a specialty grinding company to grind the pavement. The equipment used to grind pavement must be capable of grinding the surface to the surface texture requirements of the specifications. After grinding, the area is profilographed again to determine if the area complies with the specification. Results are again reported on NDOT form 040-073 using a corresponding retest number.

After the grind area meets surface tolerance specifications, the contractor cleans the grind area, allows it to dry, and then seals it with emulsified asphalt (refer to Section 6-405, Tack Coat). An exception to applying emulsified asphalt after grinding is if the pavement will receive another layer of plantmix bituminous pavement within several weeks.

6-402.4 MEASUREMENT AND PAYMENT

Measurement and payment are usually by the ton, which requires accurate weighing of the material. Prior to placing material on the roadway, the material is weighed. Do not pay for material that has not been weighed. Record the placed material quantity on the proper forms. Measurement and payment are described in the specifications and the *Documentation Manual*.

When the specifications require field trial mixtures, NDOT pays the contractor for acceptable material that is placed. For unacceptable field trial mixture material, the Resident Engineer may allow the material to remain in place with concurrence from the District Engineer and the Materials Division. The Resident Engineer may allow payment for unacceptable material that remains in place. On federal-aid projects, no federal funds are used to pay for unacceptable field trial mixture material that is allowed to remain in place. If NDOT pays for unacceptable material remaining in place, NDOT pays with non-federal funds. The cost to remove unacceptable field trial mixtures is shared equally by NDOT and the contractor.

Areas that the plans designate as “miscellaneous paving areas” typically include median areas or road and driveway approaches. For miscellaneous paving areas, the contractor is paid for the weight of the material placed and for the measured surface area paved. Regardless of the number of layers placed, the measured surface area is paid only once.

6-403 PLANTMIX BITUMINOUS SURFACE – OPEN-GRADED

6-403.1 GENERAL

Plantmix Bituminous Surface – Open-Graded is the final layer of a roadway section. The open-graded surface provides a friction surface for vehicles, helps dissipate surface water, and improves the appearance and rideability of the roadway. In contrast to plantmix bituminous surface (dense-grade), open-graded plantmix is a thin layer of plantmix with a maximum size aggregate of 1/2-inch or 3/8-inch. The plans designate the open-graded aggregate size and course thickness to be placed. Open-graded provides no structural strength to the pavement section.

The open-graded course is the final wearing surface, which establishes the public perception of the quality of the project. The appearance of the open-graded surface is a reflection of the workmanship incorporated into the roadway. Because of the impact that the open-graded surface has on the traveling public, it is important to exercise care during placement of the open-graded. The freshly placed surface must be protected from damage and defects must be corrected before the material cools. Damage typically occurs from walking or driving on the hot mat.

Because the open-graded course is a thin layer, typically 3/4-inch, the placement operation can move significantly faster than placement of dense-grade. Although the paver may move at a fast pace, the progress of the paving operation is limited to the rollers producing a compacted smooth mat. Additionally, the progress of the paving operation may be limited when pavement marking tape is inlaid in the fresh surface during final rolling of the mat. If the paver is placing material far in advance of the tape placement operation, the placed open-graded may cool below the minimum temperature required by the specifications for placement of the tape. Inlaid striping, like the finished open-graded surface, is a reflection of the workmanship incorporated into the roadway.

Section 6-401, Plantmix Bituminous Pavements, describes construction techniques, processes, and details that apply to plantmix bituminous surface – open-graded before and during construction.

6-403.2 BEFORE CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements.

6-403.3 DURING CONSTRUCTION

Refer to Section 6-401, Plantmix Bituminous Pavements. Because plantmix bituminous surface – open-graded is the final surface on which vehicles ride, surface smoothness is important. To reduce the amount of ridges and ruts, the contractor should minimize the number of transverse joints. The following sections provide additional information on compaction and surface tolerances for plantmix bituminous surface—open-graded.

6-403.3.1 COMPACTION

Although specifications do not require density testing of open-graded, it is still compacted using at least two rollers meeting the requirements of the specifications. The first roller, commonly called a breakdown roller, is a tandem axle roller, typically weighing at least 10 tons. The second roller, the finish roller, has a typical minimum weight of eight tons. Although not required to have vibratory capability, most rollers are so equipped. Consult the specifications to determine if vibration is prohibited. Each roller must complete two coverages of the open-graded mat. The breakdown roller should start compacting immediately after open-graded is spread. The finish roller will be close behind the breakdown roller, while the open-graded is still warm. The finish roller removes wrinkles or ridges left by the breakdown roller. Vibratory rollers must turn off the vibrator on the final pass of finish rolling. Pneumatic rollers are not used on open-graded surfaces.

6-403.3.2 SURFACE TOLERANCES

Coordinating production, delivery, and placement of open-graded material improves the riding surface quality. Repeated starting and stopping of the paver reduces the pavement smoothness. The pavement smoothness requirements of open-graded are similar to those of dense-grade. Refer to Section 6-402.3.2, Surface Tolerances of Plantmix Bituminous Surface, for additional information. For open-graded that does not meet surface tolerance requirements, the contractor must repair, or remove and replace the material as described in the specifications. The contractor may request to leave the non-conforming material in-place. If the District Engineer approves the request, the Resident Engineer may allow the contractor to repair the non-conforming surface or the Resident Engineer will assess the contractor liquidated damages. Because open-graded paving is the final surface course, grinding is kept to a minimum because it detracts from the appearance. Because the decision to grind open-graded is significant, the District Engineer, in consultation with the Resident Engineer, makes the decision to grind. The specifications describe the terms of assessing liquidated damages for open-graded that does not conform to surface tolerances.

6-403.4 MEASUREMENT AND PAYMENT

Unlike plantmix bituminous surface, miscellaneous paving areas are not measured for surface area payment for open-graded. Payment is only made for the weight of the material placed. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-404 COLD-RECYCLED BITUMINOUS SURFACE AND PRE-MIXED BITUMINOUS PAVING MATERIAL

6-404.1 GENERAL

Existing roadways that have distressed surfaces but acceptable structural strength may only require rehabilitation of the pavement surface. A common rehabilitation method is to remove the existing bituminous surface by coldmilling, mix the milled material with emulsified asphalt and other additives, and place the material back onto the roadway. This process is called cold recycling of bituminous surfaces. The equipment used to perform cold recycling is commonly called a “recycle train.” Section 404 of the specifications describes requirements of the recycle train and other equipment needed for cold recycling. The recycle train is subject to a required calibration procedure described in the specifications. The Construction Division Quality Assurance Section can assist in the calibration process. The recycle train produces a windrow of cold recycled material that is spread and compacted as described in Section 6-401.3.2, Placement, of Plantmix Bituminous Pavements.

6-404.2 BEFORE CONSTRUCTION

6-404.2.1 COMPOSITION OF MATERIALS

The specifications describe the recycled material requirements. Typically, materials include reclaimed asphalt pavement, a recycling agent, and lime. Dry lime is called quicklime. After water is added, the lime is called hydrated lime slurry. After the pavement is milled, a recycling agent, approved by the Materials Division, and dry lime, or quicklime, are mixed with the milled material. All ingredients are blended to produce a homogeneous mixture. Water, used to activate the lime in the cold recycle process, is also subject to the Materials Division pre-approval because certain minerals in water can be detrimental to the cold recycle material. Based on the material requirements contained in the specifications, the contractor, in consultation with the Resident Engineer and the Materials Division, may make adjustments based on field conditions.

6-404.2.2 EQUIPMENT

The specifications describe the requirements of the recycle equipment. A typical recycle train consists of a coldmilling machine, where a hydrated lime slurry and additional water is added. Included in the train is a crusher that reduces oversize recycled materials, as well as a portable plant pugmill mixer for the addition of emulsified asphalt, and water, if required. A paver is also part of the recycle train and places the recycled material on the roadway. Figure 6-404.1 shows a typical recycle train.

Figure 6-404.1. Recycle Train.

The Resident Engineer must confirm that the equipment is interlocked and functioning properly. The contractor selects the paver size based on the width and depth of the cold recycle mat shown in the plans. A paver used for pavement recycling requires more horsepower than would typically be used for plantmix paving. In contrast to plantmix paving in which the paving material is hot and flowable, cold recycled material does not flow well. Rollers are subject to minimum weight limits unique to recycle projects and are described in the specifications. Typically, two pneumatic rollers weighing no less than 25 tons each, and a steel wheel roller weighing at least 10 tons are required. The inspector verifies the roller weights before use.

6-404.3 DURING CONSTRUCTION

The inspector or tester observes the contractor take samples of the emulsified asphalt from each load delivered. The emulsified asphalt is tested for viscosity before it is applied to the roadway.

6-404.3.1 WEATHER LIMITATIONS

Cold recycle operations are best performed in the summer months when hot, dry weather is expected. Cold recycling requires overnight low temperatures above 35º F. During paving, the surface temperature must be at least 60º F and rising. Because warm, dry weather is required for proper curing, the success of the recycling operation and the quality of the pavement are influenced by weather. Suspend work during rain. If work is suspended because of rain, verify that the maximum moisture content in the recycled pavement conforms to the specifications.

6-404.3.2 SPREADING, COMPACTING, AND FINISHING

During cold recycling, unsuitable material or conditions may be encountered. The specifications describe how to address these situations and corrective actions. The quality of the pavement improves if the paver places the recycled material continuously. If the contractor excessively stops and starts the paver, the quality of the pavement is diminished and the Resident Engineer may suspend the recycling operation. If the forward progress of the recycle train is halted after emulsified asphalt is added to the aggregate, the delay may allow the emulsified asphalt to break before the mixture is placed on the roadway. If this occurs, placing and compacting the material may be difficult. The contractor must synchronize the “recycle train” and the paver to maintain a continuous placement operation.

Compacting a recycled plantmix mat is different from compacting a plantmix bituminous surface mat. Because recycled material contains moisture, the recycled material must be given time for some moisture to dissipate. Specifications typically require a one to two-hour delay between spreading and compacting. Performing compaction during early morning or late evening hours, when atmospheric temperatures are low, is undesirable. Recycling operations must be scheduled to accomplish compaction during warmer hours. In the heat of the day, the time between spreading and initial compaction may be reduced. As a guide, the roller may begin compacting the mat when the mat changes color. By recording the rate of placement, the Resident Engineer can determine the optimal time that the material may sit before compaction begins. Monitoring the compaction, timing, and effort is a significant part of the inspector’s duties during this operation. The Construction Division Quality Assurance Section can provide guidance when the recycle operation begins.

The control strip compaction method (Method C) is used for cold recycle projects. Refer to Section 402.03.06, Compaction, of the specifications and Section 6-402.3.1, Compaction of Plantmix Bituminous Surface, for additional information. Cold recycle operations are comprised of an initial compactive effort, followed by recompactive effort several days later and the moisture has dissipated, after traffic has used the recycled roadway. The Resident Engineer may require additional control strips if atmospheric temperatures vary significantly throughout the day. Refer to Section 404.03.07, Spreading, Compacting, and Finishing, of the specifications for additional information.

To seal the surface, the contractor applies an application of emulsified asphalt to the compacted recycled surface. The emulsified asphalt sealer applied to the surface is typically the same type of emulsified asphalt used in the recycling operation. After a significant amount of water in the emulsified asphalt dissipates, sand blotter is applied to reduce the amount of asphalt picked up by traffic. The recycled pavement must cure for a minimum number of days, as stated in the specifications, before it is overlain with another plantmix material. Before placing the plantmix overlay, the recycled pavement must be recompacted with a pneumatic roller and a steel wheel roller. After the final rolling, the inspector uses a 12-foot straightedge to check the surface of the cold-recycled pavement to verify conformance with surface tolerance requirements.

6-404.3.3 CONDITIONS OF ACCEPTANCE

As long as all materials incorporated into the work meet specifications, final acceptance is based on visual inspection. If the mat has areas of raveling, rutting, or areas that are under or over emulsified, the contractor must repair the areas before the plantmix overlay. An acceptable cold recycled pavement is the product of NDOT and the contractor acting as a team.

6-404.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-405 TACK COAT

6-405.1 GENERAL

A tack coat is typically a light application of emulsified asphalt that creates a bond between pavement surfaces. The tack coat primarily helps to prevent development of a slip plane between an existing surface and another course to be placed on it. The contractor applies the tack coat at an application rate as stated in the plans or as otherwise directed by the Resident Engineer, covering the entire area uniformly. If the tack coat is applied too heavily, the tack coat no longer bonds—it becomes a lubricant, creating a slip plane on which the overlying course may creep or push. A tack coat may not be required if the previous plantmix layer is still warm and has not been contaminated with dirt or other debris.

6-405.2 BEFORE CONSTRUCTION

The tack coat is an emulsified asphalt that is diluted (mixed) with water. The project plans state the type of emulsified asphalt to be used as the tack coat. The specifications allow the contractor to substitute other types of emulsified asphalt for the type stated in the plans. Section 405 of the specifications lists the types of emulsified asphalt that may be substituted. The emulsified asphalt is diluted at the rate of 40 percent water by weight of emulsified asphalt. The following is an example calculation:

10 tons	Emulsified Asphalt (SS-1h)
+ 4 tons	water added (10 tons x 40% = 4 tons)
14 tons	SS-1h (Diluted)

The water is added to the emulsified asphalt in the distributor truck. A portion of water is added first, then the emulsified asphalt, and then the remaining water. When all materials are combined in the distributor truck, the materials are circulated in the truck until thoroughly mixed. Because water is added based on the weight of the emulsified asphalt, the contractor must provide an acceptable method of weighing diluted emulsified asphalt.

As material is delivered to the jobsite and before it is placed in storage tanks, the inspector must verify that the grade and type of emulsified asphalt meets specifications.

6-405.3 DURING CONSTRUCTION

When emulsified asphalt is delivered, it must arrive with three copies of a shipping notice—commonly called a bill of lading—and a refinery material certification must be received for the delivery. Section 703 of the specifications describes the required information contained in the shipping notice and refinery test report.

The inspector should refer to Section 106 of the specifications for sampling frequencies. Typically, a sample is taken for each load of emulsified asphalt delivered. The inspector marks the sample container using a marking pen, showing the sample number, type of material, contract number, and date. The inspector completes and attaches NDOT form 020-016, “Transmittal for Asphalt Sample,” to the sample container.

Number each sample sequentially, beginning with the number one. The inspector also numbers each bill of lading sequentially, beginning with the number one. Record the bill of lading and sample number in the liquid asphalt field book. Refer to the *Documentation Manual* for documentation details.

The contractor should notify the Resident Engineer when deliveries will take place so an inspector can be available to observe the delivery and sampling. The inspector observes the contractor taking samples of the emulsified asphalt. Emulsified asphalt samples should be stored in plastic sample containers supplied by NDOT. NDOT reserves the right to require the contractor to provide a sample of undiluted emulsified asphalt at any time.

6-405.3.1 APPLICATION

The plans state the theoretical application rate for the different types of bituminous materials used on the project. The application rate is based on the material being applied, the purpose of the material, and the surface on which it is applied. The Resident Engineer adjusts the application rate based on field conditions.

Figure 6-405.1. Distributor Truck.

The contractor applies the emulsified asphalt using a distributor truck, as shown in Figure 6-405.1. The distributor truck must conform to the specifications. The distributor truck must evenly heat the material, maintaining the material at the required temperature. The distributor truck must apply the emulsified asphalt in an even and uniform pattern. Figure 6-405.2 shows acceptable and unacceptable spray patterns. The distributor truck must not leak engine fuel, lubricants, or hydraulic fluid that may contaminate the emulsified asphalt. After the emulsified asphalt has been diluted, the distributor truck is weighed using certified scales. Before applying the material to the roadway, the distributor truck operator provides the inspector with weigh tickets showing the weight of the undiluted material and the weight of the diluted material (after water is added). From the weights on the weigh tickets, the inspector can determine the actual dilution rate.

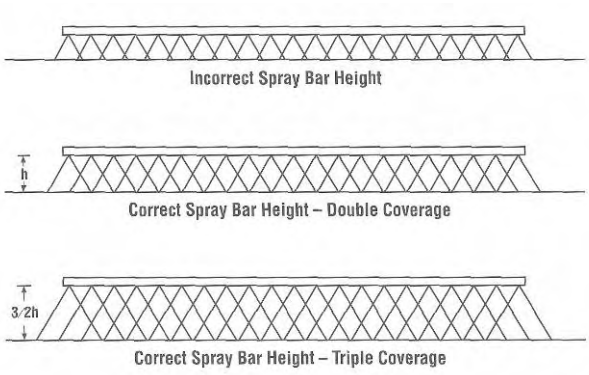

Figure 6-405.2. Distributor Truck Spray Bar Patterns.

To determine the amount of diluted emulsified asphalt applied to the roadway, weights are obtained before and after application. The weight obtained before applying the diluted material is commonly called the “weigh-in.” After application of the material, the truck is weighed again to obtain a “weigh-back.” The difference between the weigh-in and the weigh-back is the amount of emulsified asphalt applied to the roadway. If a distributor truck is equipped with a meter that shows the quantity of material applied, and when weighing the truck is not feasible, the quantity of emulsified asphalt applied can be determined using meter readings. Refer to the *Documentation Manual* for additional information.

The surface to receive the application of emulsified asphalt must be clean, dry, and free of foreign material. The inspector verifies that the surface does not contain unacceptable material such as diesel fuel, oil, or other petroleum products that would degrade the effectiveness of the emulsified asphalt.

The inspector should confer with the contractor and the distributor truck operator to clarify the limits of the application, temperature requirements, application rate, distributor truck ingress and egress, and weigh-in and weigh-back of the distributor truck. The contractor should limit the application area to that which can be paved with plantmix the same day. If the tacked surface is not covered with plantmix, a light application of tack coat may be applied the next day. During tack coat application, the inspector should confirm uniform application of the emulsified asphalt. The distributor truck must evenly coat the entire surface. The contractor must remove excess material using squeegees or brooms.

Immediately after application, the tack coat will have a dull, brown appearance. As the moisture dissipates from the tack coat, the appearance changes to shiny black and the material becomes sticky or tacky. When the water dissipates and the tack coat becomes sticky, it is said to "break." The amount of time that a tack coat takes to break depends upon weather conditions. During the heat of the summer, the tack coat may break in minutes; but when temperatures are cooler, breaking takes longer. Do not place the plantmix over the tacked surface until the tack coat breaks. If plantmix is placed on the tack coat before it breaks, the emulsified asphalt could migrate into the mix, causing bleeding of the compacted material. After the tack coat is applied, the inspector calculates the application rate using the surface area that received the tack coat and the amount of material applied (the difference between the weigh-in and the weigh-back). Record the application rate in the Liquid Asphalt field book.

6-405.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-406 PRIME COAT

6-406.1 GENERAL

A prime coat consists of applying a liquid asphalt material to an untreated aggregate base course. The prime coat bonds the loose aggregate particles, acts as a moisture barrier, and promotes adhesion between the base and the overlying course. A prime coat is a low viscosity liquid asphalt applied directly to the surface of a base, upon which a plantmix bituminous mat is placed. Cutback asphalt (asphalt cement diluted with petroleum products) is an asphalt commonly used for prime coats.

6-406.2 BEFORE CONSTRUCTION

Before applying a prime coat, the base course must be approved by the Resident Engineer. The base course must have the appropriate number of passing compaction tests. Additionally, the base course must have sufficient moisture to maintain compaction and to promote penetration of the prime coat. The compacted base must be smooth and uniform, meeting the established grades and cross slopes. The prime coat should be applied soon after acceptance of the base course to preserve the base course and to provide the longest cure time possible. Specifications typically require a minimum cure time of 48 hours. Traffic control limitations may require shorter cure times. As the cure time increases, the stickiness of the prime coat surface reduces, which reduces the potential for picking the prime coat up by paving equipment or traffic.

6-406.3 DURING CONSTRUCTION

6-406.3.1 APPLICATION

The project plans contain the theoretical application rate for prime coats as well as the type of material to be used. The application rate may be adjusted based on the field conditions. Typically, a sufficient amount of prime coat is applied to obtain full penetration, leaving minimum puddles on the surface.

The construction details of a prime coat are similar to those of a tack coat. Details describing the materials and application process for tack coats apply to prime coats. Refer to Section 6-405, Tack Coat, for additional information. The application rate for a prime coat is typically heavier than a tack coat application rate, but the Resident Engineer determines the application rate based on the surface conditions and the amount of time that will lapse between applying the prime coat and placing a surface course. The application rate is typically decreased when the time lapse is 72 hours or less. Immediately before applying prime coat the contractor moistens the surface to be primed. Moistening the surface improves the ability of the prime coat to penetrate the surface.

After applying the prime coat, the contractor protects the area until the material breaks. If traffic needs to use the primed area, sand blotter conforming to the specifications is applied after the material breaks. If conditions allow, avoid using sand blotter. Excess sand blotter might create a slip plane between the layers; therefore, it is removed by sweeping before paving. If sand blotter is used, the contractor should apply a tack coat before paving.

6-406.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-407 SEAL COAT

6-407.1 GENERAL

A seal coat is an application of bituminous material that is placed on a plantmix bituminous surface or a rehabilitated roadbed to seal the surface. Seal coats provide a non-skid surface as an interim step during staged construction, or preserve and upgrade existing pavement. Seal coats are applied for the following reasons:

- Prevent moisture from entering the pavement
- Reduce oxidation of the pavement
- Rejuvenate a dry, weathered surface
- Reduce raveling of the pavement surface
- Retain moisture during a roadbed modification process
- Provide a temporary surface for traffic

Emulsified asphalts (asphalt cement diluted with water) or cutback asphalts (asphalt cement diluted with petroleum products) are asphalts commonly used for seal coats. On projects having small quantities of seal coat, emulsified asphalts may be substituted for cutback asphalt. In urban areas, air quality regulations may prohibit the use of cutback asphalt.

6-407.2 BEFORE CONSTRUCTION

The plans contain the application rate for seal coats as well as the type of material to be used. The Resident Engineer typically adjusts the application rate based on the field conditions.

6-407.3 DURING CONSTRUCTION

Details describing the materials and application process for tack coats apply to seal coats. Refer to Section 6-405, Tack Coat, for additional information. The application rate for a seal coat is typically heavier than a tack coat application rate, but the Resident Engineer determines this based on the surface conditions. After applying the seal coat, protect the area until the material breaks. If traffic needs to use the sealed area, apply sand blotter conforming to the specifications after the material breaks. If conditions allow, avoid using sand blotter.

6-407.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-408 SURFACE TREATMENT

6-408.1 GENERAL

A surface treatment rehabilitates, preserves, and extends the life of bituminous plantmix pavements. A common type of surface treatment is a chip seal. A chip seal keeps water from penetrating the pavement and improves skid resistance. A chip seal is performed by spraying a thin layer of asphalt, typically an emulsified asphalt, onto an existing distressed pavement and then applying a single size aggregate. The aggregate is evenly distributed over the asphalt material, and then rolled into a smooth surface. The rolled aggregate is then coated with a layer of emulsified asphalt called a fog seal. A fog seal improves aggregate retention on the roadway.

Variable local conditions and environmental factors influence the success of a chip seal operation. Successful chip seal operations require judgment that incorporates knowledge of materials, construction methods, and the effect of environmental factors. The experience of the contractor, construction crew, familiarity with the local materials, and suitable equipment usage improves the probability of a successful chip seal project.

Factors that affect the success of a chip seal are:

- Aggregate and emulsified asphalt spread rates
- Surface preparation
- Construction techniques
- Weather
- Materials

6-408.1.1 AGGREGATE AND EMULSIFIED ASPHALT SPREAD RATES

Spread rates must be tailored to each project. Spread rates are determined based on source and gradation of the aggregate, the pavement surface condition, and the amount of traffic. The ideal aggregate spread rate will result in a mat that is one aggregate piece deep, uniformly covering the road surface. Typically, aggregate is embedded in the emulsified asphalt to about 70 percent of its height after rolling. If the aggregate spread rate is too high, vehicle tires will dislodge aggregate pieces. If the aggregate spread rate is too low, sufficient coverage is not obtained and excess emulsified asphalt may flush onto the aggregate surface.

The emulsified asphalt rate is adjusted based on the road surface condition. Absorbent, weathered, or flushed surface conditions may require different application rates. Too little emulsified asphalt prevents the aggregate from embedding properly, and the aggregate will be dislodged and lost. Too much emulsified asphalt drowns the aggregate in emulsified asphalt, resulting in flushing and a reduction of skid resistance.

6-408.1.2 SURFACE PREPARATION

Before chip sealing a paved surface, the roadway surface is repaired and cleaned—potholes are filled, ruts are leveled, cracks are sealed, and broken edges are repaired.

6-408.1.3 CONSTRUCTION TECHNIQUES

Emulsified asphalt is applied to the roadway with a distributor truck equipped with spray bars. Even though the emulsified asphalt application rate is as directed by the Resident Engineer, an improperly adjusted spray bar can cause a non-uniform application or streaking of the emulsified asphalt. Streaks can result where emulsified asphalt is applied too heavily, causing bleeding. Between streaks, the emulsified asphalt can be too light, causing the aggregate to strip from the emulsified asphalt. Proper adjustments of the spray bar height, nozzle angles, and spray pattern help achieve a uniform distribution.

Aggregate must be spread on the emulsified asphalt within the first few minutes after application. Teamwork among the distributor truck, chip spreader, and truck drivers is essential. If the aggregate is spread too late, it will not adequately adhere to the emulsified asphalt and stripping will result. Another critical activity is rolling, which seats the aggregate in the emulsified asphalt, enhancing a good bond. The aggregate is rolled with a pneumatic tired roller immediately after spreading. A steel wheel roller is not used because it will ride on the high spots, crushing the aggregate, and pass over the low spots, failing to adequately seat the aggregate.

After spreading and rolling the aggregate, light brooming removes loose aggregate. If the sweeping operation is begun too soon, before the emulsified asphalt sets, it will strip away properly seated aggregate. To prevent this problem, brooming should occur after the aggregate application and after the emulsified asphalt sets, typically one to three hours after rolling for light brooming and 12 to 24 hours for heavy brooming. During hot weather, delay sweeping operations until the pavement cools, which typically occurs in the early morning. If sweeping is delayed until early morning hours, traffic control is maintained until sweeping is completed.

6-408.1.4 WEATHER

Hot, dry weather is crucial to the success of a chip seal project. It must be hot and dry for proper emulsified asphalt setting and curing. The best time for chip sealing is during warm weather months—May, June, July, August, and September. Cool daytime temperatures can cause aggregate loss. Monitor weather forecasts to work around potential weather problems. When the atmospheric temperature exceeds 110°F, chip seals should not be applied because the emulsified asphalt tends to flush.

6-408.1.5 MATERIALS

Dirty aggregate is detrimental to the success of a chip seal project. Emulsified asphalt does not adhere to aggregate that is covered with fines, is too dusty, or is too wet. Dirty aggregate leads to stripping, which is dislodging of aggregate from the emulsified asphalt. The ideal solution is to use washed aggregate. The specifications contain requirements for aggregate cleanliness. Refer to Section 705.03.04 of the specifications for aggregate requirements. Aggregate used for chip seals should not be too soft. Soft aggregate crushes during rolling and under traffic. Soft aggregate also breaks down rapidly after freeze-thaw cycles.

6-408.2 BEFORE CONSTRUCTION

6-408.2.1 REPAIRS

Pavement surface deficiencies must be repaired before applying a chip seal to the roadway. District maintenance forces typically repair roadway deficiencies before chip seals are applied. The following activities are examples of repairing deficiencies:

- Repair all holes and depressions
- Fill and seal all cracks
- Level all bumps, waves, and corrugations that will impair riding qualities
- Remove all excess material on patches and joints
- Clean full width of the surface to be treated

Common repair activities completed before a chip seal are hot-mix and cold-mix patching and crack sealing. In addition to preventing water from entering the base, crack sealing reduces loss of emulsified asphalt into existing cracks. Patching levels the pavement surface and corrects areas of isolated pavement distress. The type of material used for the various repairs is important and can affect the quality and longevity of the chip seal. Patching materials and crack sealant need time to cure before placing a chip seal. Patching and crack sealing should be completed several months before the chip seal construction to allow crack sealant and paving materials to cure. As a rule, patching should be completed at least six months before construction and crack sealing should be applied at least three months before the application of chip seals.

6-408.2.2 MATERIALS

Materials must meet specification requirements. The contractor must submit samples of emulsified asphalt and aggregate to the Resident Engineer for testing and transmittal to the Materials Division at least two weeks before the chip seal operation begins.

The contractor should stockpile a sufficient quantity of aggregate to ensure a continuous chip seal operation. To be ready for use, the stockpiled aggregate must be tested for acceptance and be clean and moist, as required by the specifications. The specifications also contain atmospheric and material temperature requirements that must be verified by the inspector.

6-408.2.3 SWEEPING

Prior to placing a chip seal, the contractor sweeps the pavement surface to remove dirt, dust, or debris. The specifications may require the type of sweeping equipment to be used. In certain areas of the state, air quality regulations may require dustless sweepers to be used. Adequate sweeping provides a clean surface that allows good adhesion between the pavement surface and the emulsified asphalt. It is important that the full width of the existing surface be swept to remove all foreign material to provide a clean surface before the emulsified asphalt is applied. If the surface is swept too far in advance, it may need to be swept again on the day of construction.

Sweeping with rotary broom sweepers often creates dust. If dust poses a danger to the traveling public, a water truck may be used to reduce dust. A water truck is also used when the roadway surface is excessively dirty. When a water truck is used, the sweeping should be completed the day before the chip seal operation begins to allow the pavement to dry.

6-408.2.4 EQUIPMENT

Before the chip seal operation begins, the distributor truck, the aggregate (chip) spreader, roller, and broom must be inspected to confirm compliance with specifications and to verify that the equipment is capable of performing the operation in compliance with the specifications.

6-408.3 DURING CONSTRUCTION

The field inspector or tester observes the contractor take samples of the emulsified asphalt from each load delivered. The emulsified asphalt is tested for viscosity before it is applied to the roadway. After the Resident Engineer accepts the emulsified asphalt and before it is applied to the roadway, temporary lane line markers are installed. After installation of the lane line markers, additional sweeping may be required to remove debris and dirt from the roadway surface. Care must be exercised to protect the lane line markers from being removed.

The distributor truck does not begin spraying the emulsified asphalt until it has been calibrated. The distributor truck is calibrated by spraying emulsified asphalt on a test area, noting the gallons of emulsified asphalt sprayed, measuring the area sprayed, and calculating the application rate in gallons per square yard. The aggregate chip spreader is calibrated to confirm the amount of aggregate spread (spread rate, pounds per square yard) is consistent with the specifications. The spread rate is typically verified by operating the spreader over a pan of a known area, weighing the aggregate, and calculating the spread rate in pounds per square yard.

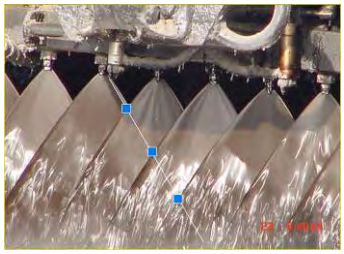

Figure 6-408.1. Emulsified Asphalt Spray Application Pattern.

After the distributor truck and chip spreader are calibrated, all equipment must be in position to begin their functions. The distributor truck operator ensures that the distributor truck's spray bar is perpendicular to centerline before the emulsified asphalt application begins. The emulsified asphalt application should appear as a uniform sheet across the entire width of the spread. Figure 6-408.1 shows a typical emulsified asphalt application spray pattern. The inspector observes each application to verify that all nozzles are spraying correctly. Observing the emulsified asphalt distribution allows early correction of spraying problems—such as a clogged nozzle, nonparallel nozzles, or improper application temperature.

Paper is placed on the roadway surface at the beginning of each spread to allow the distributor truck to attain the proper application speed as the distributor truck crosses the paper, providing a neat line and avoiding a double application of emulsified asphalt at the construction joint. In addition to the beginning of the spread, if the spreader stops for more than three minutes, a transverse paper joint is constructed to provide a neat line for a subsequent application of emulsified asphalt.

Regarding longitudinal joints, each day's spread must be completed to the full-width of the roadway. For a two-lane roadway, a longitudinal joint is constructed by applying emulsified asphalt six inches wider than the aggregate spread on the first pass of the distributor truck. After half of the day's anticipated aggregate tonnage is applied, the operation returns to the starting point to begin the second pass of spreading aggregate. When emulsified asphalt is applied adjacent to the first spread, the distributor truck operator rotates the end nozzle at the longitudinal joint, effectively creating a straight edge, commonly called a "knife edge."

The distributor truck and the aggregate spreader must be aligned perpendicular to the roadway before starting the spread. The emulsified asphalt is applied at the rate stated in the specifications. The aggregate is spread immediately after the emulsified asphalt is applied and before the emulsified asphalt begins to break. (Refer to Section 6-405.3.1, Application, for a discussion of the breaking of emulsified asphalt.) Typically, the spreader is no more than one hundred yards behind the distributor truck. If the weather is hot and windy, the distance between the distributor truck and the spreader is reduced to ensure aggregate placement before the emulsified asphalt breaks. To allow for timely aggregate spreading on the sprayed emulsified asphalt, two or three loaded trucks should be in queue behind the aggregate spreader and before the rollers. Haul truck wheel paths should be staggered so that the compactive effort from the haul trucks is evenly distributed across the width of the mat. If the emulsified asphalt breaks before the aggregate is spread, the spreading operation stops and corrective action is taken. In most situations, a paper joint is installed and the emulsified asphalt that has broken receives an additional application of emulsified asphalt. The aggregate spreading operation resumes after the second emulsified asphalt application. The second emulsified asphalt application rate is typically reduced to minimize bleeding or flushing of the emulsified asphalt.

A self-propelled aggregate chip spreader pulls the dump trucks through the aggregate spread area. As each dump truck is emptied, the aggregate spreader operator releases that truck, and the next truck in queue is attached to the aggregate spreader. (Figures 6-408.3.2 and 6-408.3.3.) Aggregate spreading greater than the specified rate (1) can increase the risk of windshield damage because of dislodged aggregate, (2) is not cost effective, and (3) requires additional sweeping efforts. Aggregate that is spread at a rate less than the specified rate creates areas of uncovered emulsified asphalt. Sparsely applied aggregate results in aggregate loss because the space between the aggregate particles does not allow the emulsified asphalt to rise high enough to hold the aggregate particles securely.

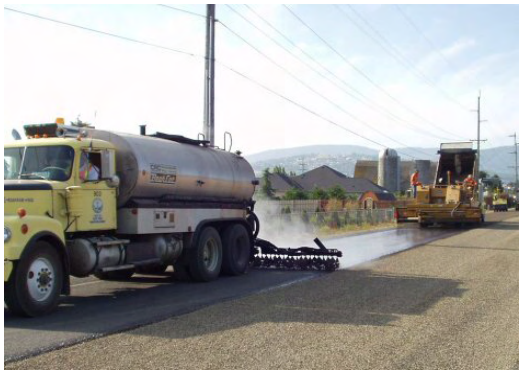

Figure 6-408.2. Emulsion Distributor Truck.

Figure 6-408.3. Chip Spreader and Hauling Trucks.

As the chip seal operation progresses, problems that may occur are as follows:

- Tires Picking Up Emulsified Asphalt – If aggregate is applied at the specified rate and tires pick up emulsified asphalt, then the emulsified asphalt application rate is either too high, causing the aggregate to roll over on contact with the emulsified asphalt, or the aggregate is too wet.
- Aggregate Rollover – If the aggregate spreader is proceeding too fast or if the emulsified asphalt is too viscous, the aggregate may roll over, altering the uniformity of the spread.
- Minor Aggregate Spread Deficiencies – Corrugation or missed areas can be corrected with the use of a drag broom or hand rake. Drag brooms are typically attached to the roller doing the initial rolling and assists in redistributing minor spread deficiencies. If the aggregate is uneven, non-uniform, or irregular for any reason, it should be drag-broomed or hand-raked immediately after spreading and before initial rolling.

The Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, contains a checklist of items that the inspector should review prior to and during the chip seal operation.

6-408.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications. Contact the Construction Division Administrative Section for measurement and payment documentation details.

6-409 PORTLAND CEMENT CONCRETE PAVEMENT

6-409.1 GENERAL

Portland cement concrete pavement (PCCP) is the top layer of the roadway structural section. PCCP is constructed, or placed, on a prepared roadbed. In the structural section, the PCCP layer provides the greatest load-bearing capacity per inch of thickness than any other element of the structural section. Although the initial cost of PCCP is greater than that of plantmix bituminous pavements, the useful life of PCCP is much greater than plantmix, and PCCP has lower annual maintenance costs. The cost of PCCP warrants its use principally on roadways that have high traffic loadings, such as urban interstate highways.

In addition to curbs, gutters, and sidewalks, the principal uses of portland cement concrete are structures and pavement. The characteristics of concrete used for structures or for pavements differ in two distinct ways: strength and coarse aggregate size. Concrete used for structures has a greater compressive strength than that used for pavements. Concrete used for pavements has larger coarse aggregate particle sizes. The remaining attributes relating to materials, proportioning, mixing, and curing are substantially the same for both types of concrete. Refer to Section 6-501, Portland Cement Concrete, for additional information.

During construction, the following weather related environmental factors could influence the quality of the PCCP. Construction practices may require adjustment to reduce the effect of these factors:

- Atmospheric and surface temperatures
- Surface moisture
- Humidity
- Wind

Each step of the PCCP construction process—production, transporting, placement, and curing—may require modifications to reduce the effects of weather. Refer to Section 6-501.5, Weather Limitations, for additional information relating to weather and portland cement concrete.

PCCP is placed monolithically (in large slabs). To allow the PCCP to shrink or contract during cold weather, longitudinal and transverse joints are constructed. The joints are saw-cut to control the location of the cracking in the PCCP. Although cracking occurs, vehicle loading must be transferred from any slab to adjacent slabs for the pavement to perform as designed. The loads are transferred by dowel bars and tie bars. Dowel bars are located along transverse joints and tie bars are located along longitudinal joints. Dowel bars are placed during the paving operation, where saw-cut joints will be constructed. For the pavement to perform as designed, the location and alignment of dowel bars is critical. Tie bars are used to transfer loads across joints with no movement.

6-409.2 BEFORE CONSTRUCTION

Before PCCP is produced at a mixing plant, the contractor must submit a mix design to the Resident Engineer, who forwards it to the Materials Division for review and approval. Aggregates used in the PCCP must be from an approved source. Refer to Section 6-300.2, Aggregate Sources, for information regarding acceptance of aggregate sources. Before mixture production and paving begins, the plant inspector should obtain a copy of the approved portland cement concrete pavement mix design. The contractor must have at least a one-week supply of aggregate, in SSD condition, stockpiled before mixing begins.

6-409.2.1 MIXING

The mixing plant, as shown in Figure 6-409.1, combines the aggregate, portland cement, water, and admixtures as required by the specifications. The PCCP mixture from the plant is loaded into hauling trucks and transported to the paver on the roadway, where it is spread, shaped, and consolidated. Material handling and storage, and operation of the mixing plant influence the quality of the PCCP. The Resident Engineer's plant inspector must be familiar with the specifications, handling and storage of materials, and the operation of the plant.

Figure 6-409.1. Concrete Mixing Plant.

NDOT requires concrete mixing plants and transit mix trucks to be certified by the National Ready Mixed Concrete Association (NRMCA). The NRMCA is a national association of ready mixed concrete producers and plant operators. NRMCA certification of concrete production facilities provides a system for establishing that production facilities of ready-mixed concrete plants are satisfactory. To receive certification, a plant is inspected to assess compliance with an industry checklist. Certifications are valid for a specific period. The inspector must check that the NRMCA certification is current for the plant producing the PCCP material. NDOT also requires that scales must be certified by the Nevada Bureau of Weights and Measures.

After mixing, the portland cement concrete is placed in hauling trucks. Testers must obtain samples before the hauling trucks leave the plant area. The testers use a platform to access the hauling truck, obtain the sample, and perform tests. The specifications require the contractor to provide a platform that the testers use to obtain samples and perform tests.

Portland cement concrete is commonly produced at a job-site plant or at a commercial plant. While the plants have distinct differences, many elements of the plant components and operations are similar. PCCP mixes produced in a commercial plant are transported to the jobsite with transit mixing trucks that have a rotating drum or hauling trucks. Hauling trucks cannot perform additional mixing when transporting the PCCP mixture to the paver. The plant inspector should monitor the following items:

- Water – The amount of water in the mixture significantly influences the strength and durability of PCCP. Too much water reduces the durability by reducing the strength and increasing shrinkage cracks. The plant inspector monitors the amount of water added to the mix.
- Admixtures – Often, chemicals are added to a mixture to alter the physical or chemical characteristics of the PCCP. These added chemicals are called admixtures. Admixtures are commonly added to the mixture at the plant through an automated dispenser. The inspector monitors the admixture amount added to each batch. Admixtures can affect when and where testers obtain samples. The specifications describe sampling and related requirements for admixtures.
- Mixing – A plate attached to the mixer must show the manufacturer's mixing drum capacity and speed. The inspector monitors the plant operation to verify that the capacity and speed do not exceed the manufacturer's recommendations. Additionally, the inspector must observe the material emptied from the mixer, confirming that the material is well mixed with no segregation.
- Aggregates – Before mixing PCCP at the plant, the plant inspector obtains aggregate gradation and moisture test results from the NDOT field testers to verify the material meets specifications. The moisture test results confirm that the aggregate from the stockpile is in SSD condition and determines the amount of water that may be added to the mix.
- Batch Weights – Concrete mix designs state the proportion or quantity of each component of the mix: course aggregate, fine aggregate, water, cement, and admixtures. The proportion of materials is based on an aggregate moisture condition in which the aggregate is saturated with a dry surface (saturated surface dry, SSD), which is the condition assumed for the mix design. The component batch weights must be adjusted to reflect the condition of the moisture content of the aggregate in the field. Because the aggregate moisture content is variable, the batch weights must be adjusted to reflect the current moisture content. Refer to Section 6-501.5, Mixing Plant, for additional information on adjusting batch weights.

Communication among the plant inspector, street inspector, and tester is important to monitor the quality of the PCCP being produced. The contractor may make adjustments at the plant and at the paver. Because the contractor's adjustment at one location can affect the PCCP quality and operations at other locations, better decisions are made when the plant inspector and street inspector share information.

6-409.2.2 ROADWAY

As with plantmix paving, the roadway surface must be prepared prior to placing PCCP. While the aggregate is being prepared and the Materials Division is reviewing the mix design for approval, the contractor prepares the roadway surface.

The plans and specifications describe how the contractor is to prepare the roadway surface for paving. PCCP is usually placed on plantmix, or other suitable base course surfaces. Before PCCP is placed, the base material must be finished and in an acceptable condition. The base is acceptable when required testing has been successfully completed, and grades and surface tolerance requirements conform to the plans and specifications. For testing requirements, refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. To determine if the grade and surface tolerances are acceptable, confer with the survey crew. Inspect the surface of the base to confirm that no defects exist. Finally, if a prime coat is applied, it must be properly cured. If PCCP is placed on plantmix bituminous base, a curing seal is applied and must properly cure before PCCP placement. The base is then ready to receive the PCCP.

In reviewing the plans and specifications, the inspector should focus on the following areas:

- Concrete mix design
- Mixing requirements
- Placement requirements
- Dowel bars and tie bars
- Spreading and consolidating
- Joints
- Finishing
- Curing
- Surface tolerances
- Protection of the surface
- Method of measurement and payment

After the contractor describes the method of automated grade control to be used, the survey crew chief should determine the survey control point requirements. The contractor uses the established grade controls for the automated grade control operation. Before placement, the Resident Engineer schedules a pre-pave meeting with the contractor. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a PCCP pre-pave meeting checklist. At the pre-pave meeting, the contractor describes the equipment to be used for placing, spreading, and consolidating the PCCP. Verify that the equipment conforms to specifications.

The contractor may place dowel bars by inserting them into the PCCP with an automatic dowel bar inserter attached to the paver, or by placing them in baskets in front of the paver and paving over the bars. Both methods require approval by the Resident Engineer before paving begins. The specifications provide direction on the submittal process to be followed by the contractor. The inspector must confirm that the Resident Engineer has approved the contractor's dowel bar placement method.

If the contractor uses the wire basket method of bar placement, the baskets are placed in advance of the paver, typically 200 feet. Placing the baskets in advance of the paver allows the inspector to verify that the contractor has installed and anchored the baskets according to the approved shop drawings. Baskets that are not securely anchored can shift or move during the paving operation, causing the dowel bars to become misaligned. The inspector confirms the correct size dowel bars are accurately positioned in the baskets. Incorrectly placed or misaligned dowel bars do not allow the pavement to transfer loads or allow the joint to move, as designed.

Similar to dowel bars, tie bars transfer loads at longitudinal joints. Tie bars have smaller diameters than dowel bars, typically 1/2-inch diameter.

Immediately before placing PCCP on the base surface, the contractor must moisten surfaces that will contact the mix. The surfaces should be moist enough to preclude water demand on the mix. The contractor should not place the concrete on a base where pools of water have formed. When PCCP is placed on plantmix bituminous pavement having a surface temperature greater than 90°, water is applied to cool the surface, which reduces the water demand on the mix. Trucks delivering concrete should not disturb the base surface.

Additionally, coordinate with the contractor about the planned sequence of operations so that inspection and testing can be performed effectively and efficiently. Before concrete production begins, the inspector should coordinate with the tester to ensure that required testing is scheduled. .

6-409.3 DURING CONSTRUCTION

The Resident Engineer typically assigns the NDOT field crew to monitor the contractor's paving operations as follows:

- Plant inspector
- Field testers
- Street inspector
- Tining and curing inspector
- Sawed joint cutting inspector

Depending on the size and complexity of the PCCP paving operation, the Resident Engineer may increase or decrease the staffing level. Regarding materials testing, materials incorporated into the PCCP are tested to determine if the material is acceptable for incorporating into the work. Such testing is called "acceptance testing." The Resident Engineer's field testers perform acceptance testing. Some acceptance tests, however, are performed by the Materials Division, which has specialized testing equipment. Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* identifies acceptance tests that are performed by the Materials Division.

During construction, grade-sensing control, placement of dowel bars and tie bars, surface finishing, and curing of the PCCP are significant aspects of the construction phase. For grade control, a wire line is a common technique in which a wire is set along the roadway shoulder. Placement equipment electronically senses the wire elevation and adjusts the grade of the PCCP being placed. When required by the specifications, dowel bars are placed in the PCCP to transfer vehicle loads to adjacent PCCP slabs. The plans show placement configurations, and the specifications describe the requirements and tolerances of the dowel bar placement. Proper placement of the dowel bars steel is critical. Misaligned bars may cause damage or failure of the PCCP.

Finishing is the process of creating a uniform PCCP surface with a texture that establishes sufficient friction between the pavement surface and vehicle tires. Hand finishing is discouraged because it may bring excess paste to the surface, causing irregularities in the surface smoothness. Acceptable finishing balances a uniform surface, measured with a straightedge or profilograph, and texturing with a moist burlap drag and tining. Deep grooves from tining can create areas in which water can accumulate or weak ridges that can break under traffic loading. PCCP consistency is important for proper tining. Specifications require texturing the surface using a moist burlap drag before tining. The timing of texturing with the burlap drag and tining is important because PCCP that is either too soft or too hard will not achieve or retain the proper texture. The specifications prohibit tining across transverse and longitudinal joints. Refer to Section 409.03.10, Finishing, of the specifications for tining requirements.

Instead of tining, the PCCP surface may be finished by grooving with grinding equipment. If PCCP grooving is specified, the inspector must verify that the pavement to be grooved meets surface tolerance specifications. The inspector must also be aware of pavement grooving time limitations. The inspector should periodically check the location, alignment, depth, and spacing of the finished grooves to assess conformance with specifications. The inspector should observe and document damage caused by the grooving operation. The contractor must repair damage caused by the grooving equipment or its operation.

For proper curing of the PCCP, the contractor applies curing compound immediately after final finishing or after free water leaves the PCCP surface. If the contractor cannot apply the curing compound immediately, the contractor fogs the surface with water or an approved evaporation retarder. Maintaining moisture in the concrete reduces shrinkage cracking. Curing prevents the loss of moisture. Moisture is required to hydrate the cement so that the concrete cures. Curing compound must completely cover the PCCP to seal the exposed pavement surface. The specifications require two applications of curing compound, the direction of each application being opposite to the other. The curing compound must have a white pigment, which allows the inspector to determine if uniform and complete coverage is achieved.

Because concrete expands and contracts under various load conditions and with variations in temperature, cracking may occur. Joints are constructed to allow for the controlled release of stresses created by traffic loads and temperature changes. Joints are weakened planes that direct cracking to a planned location. The joints are constructed by sawing at locations designated in the plans. The contractor saws joints when concrete has hardened but before random cracks develop. The contractor must prepare a joint sawing schedule that considers the unique conditions of the project. The specifications contain detailed requirements on the timing of sawcutting joints.

PCCP is constructed with two types of joints: Weakened plane joints and contact joints. A weakened plane joint is a sawcut across the PCCP, which weakens the PCCP, allowing the pavement to purposely crack at the joint. A contact joint is the surface where fresh concrete is placed against hardened concrete. Each type of joint may be aligned perpendicular or nearly perpendicular to the direction of travel (transverse joint), or parallel to the direction of travel (longitudinal joint). Prior to sawcutting joints, the contractor must mark the location of the joints on the PCCP, as detailed in the plans. The contractor must perform sawcutting in conformance with the plans, specifications, and the approved joint sawing schedule. The inspector observes the contractor's joint marking and sawing operation and verifies that it complies with specifications.

Placement of PCCP is commonly done with either side-forms or a slipform paver. The specifications describe the equipment and process requirements for each PCCP paving method. The following sections provide additional information on side-form and slipform paving.

6-409.3.1 SIDE-FORM PAVING

Placing PCCP within stationary side forms is called side-form paving. A side form paver is shown in Figure 6-409.2. The contractor uses side-form paving when the area to be paved has irregular dimensions, small PCCP quantities, or limited working space. With side-form paving, the contractor places and secures forms on the prepared base course. Equipment rides on the forms to spread and finish the concrete. The specifications describe equipment requirements for side-form paving. When using side-form paving to place PCCP, the inspector should consider the following:

Figure 6-409.2. Side Form PCCP Paver.

- Type of finishing equipment
- Verify forms conform to specifications
- Check that the paver path is clear of debris and excess material
- Check location, elevation, cross slope, and grade of forms
- Verify that forms will not deflect during the paving and finishing operation
- Check that forms are secured, checking for movement in all directions
- Forms must be clean from debris and coated with an approved release agent
- Require resetting of misaligned forms
- Require forms to remain in place until PCCP has set sufficiently to hold the edge

6-409.3.2 SLIPFORM PAVING

With slipform paving, PCCP is placed using a self-propelled machine with attached side forms. A slipform paver is shown in Figure 6-409.3. The machine operates on the prepared base. A wire guide controls the alignment and thickness of the PCCP placement. The slipform paver spreads, screeds, consolidates, and finishes the concrete in a single pass. The specifications describe equipment requirements for slipform paving. When using a slipform paver to place PCCP, the inspector should consider the following:

Figure 6-409.3. Slipform PCCP Paver.

- Material Delivery – When PCCP is delivered to the paver, the contractor should ensure the material is evenly distributed in front of the paver without mounding. The paver should operate with a full head of material in front of it to prevent an abrupt reduction in slab thickness.
- Edge Slump – Monitor edges to confirm that slumping does not occur after the forms have passed. Edge slump of unsupported sides behind the paver is one of the major problems with slipform paving.
- Trailing Forms – Forms that extend beyond the paver are called trailing forms. Trailing forms may be used to address edge slump problems. However, using trailing forms may cause problems, because drag resistance from the form may pull down edges of the PCCP or vibration from the paver may alter the freshly placed PCCP.
- Water – Water may only be applied to the PCCP surface as a fog. Applying water to the PCCP surface can wash the surface, weaken the surface of the concrete, or result in surface scaling.
- Vibration Equipment – The contractor uses vibration units inserted into the wet concrete to consolidate the wet concrete uniformly. Vibration equipment must comply with the requirements of the specifications.

6-409.3.3 PROTECTION OF PAVEMENT

In areas where vehicle, pedestrian, or animal traffic can be reasonably expected, the contractor must protect the new concrete pavement from damage. Contractors use the following methods and devices to protect new PCCP:

- Barricades
- Windrows
- Proper signing
- Fences, temporary or permanent

In addition to protecting new PCCP from traffic, the contractor must also protect it from adverse weather conditions. As described in the specifications, the PCCP must be protected from freezing, typically by placing thermal blankets on the pavement. In unique situations, heaters may be used. Protection from rain before the initial set may require covering the surface to protect it from washing of the aggregate by the rain.

6-409.3.4 RIDING TOLERANCES

Before public traffic is allowed on the PCCP, the inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The inspector reports the straightedge results on NDOT form 040-056, “Daily Construction Report.” If the specifications have profilograph requirements, the contractor performs profile testing of the PCCP surface. The profilograph is operated to take two test readings in the planned vehicle wheel paths in each land and in the direction of traffic.

The Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, “Report of Profilograph Test.” Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications, typically seven days after the tests are taken. If the profilograph test results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements. Excessive high points in the pavement—called “must grinds”—as described in the specifications, should be marked with paint during the profilograph testing. With timely notification, the contractor may be able to alter placement operations to reduce “must grinds” and improve the pavement smoothness. If the contractor is required to grind to meet specification requirements, the grinding must be completed before the Materials Division cores the pavement to determine the average pavement thickness.

6-409.3.5 SAW AND SEAL JOINTS

Sawing of joints must not cause damage to existing joints. A clean joint is required for the sealant to perform properly. After sawing the joint, the contractor cleans the joint, usually with water or sandblasting. The contractor must recover and dispose of the residue from the cleaning operation. If residue remains on the walls of the joint, the sealant material will not adhere properly.

After sawing and cleaning the joint, the contractor installs the size and type of closed cell backer rod specified in the plans. The inspector confirms that the contractor uses the correct diameter and type of backer rod for each width of joint. Backer rod is typically installed with a tool that places the backer rod at the required depth.

The installation must comply with the specifications and details shown in the plans to function as intended. The function of the joint is sensitive to the proper sealant recess depth. If the depth of the material is too shallow (too close to the surface), traffic could pull out the sealant. If the material is too deep, the joint could collect dirt and other debris that could cause spalling. In either case, incorrect installation will diminish the design life of the concrete pavement. The inspector observes sealing operation to verify conformance with the specifications.

6-409.3.6 OPENING TO TRAFFIC

Before allowing traffic to use the new PCCP surface, the pavement must meet strength requirements, be free of debris, and have appropriate pavement markings or traffic control devices. Debris to be removed typically consists of curing compound, residual debris from joint sawing and sealing, and dust. This material, if not removed from the roadway, can create driving hazards and environmental problems. The specifications describe the strength requirement. If the roadway is to be opened to traffic before it meets minimum compressive strength requirements, the Resident Engineer must consult with the Materials Division.

6-409.4 MEASUREMENT AND PAYMENT

PCCP is measured and paid by the square yard. Because of the importance of pavement thickness to strength and durability of the PCCP, the specifications provide for reduction in payment to the contractor when pavement thicknesses are deficient. The specifications describe the method for determining the reduction in payment, or liquidated damages.

The Resident Engineer coordinates with the Materials Division to schedule pavement coring. Coring must be done after the contractor completes required grinding to meet riding tolerance requirements. Cores are taken at the frequency listed in Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. The thickness of each core is measured and compared to the thickness required by the plans. If the thickness of any individual core is deficient by more than 0.6-inch, secondary cores are taken to identify the limits of the deficiency. The area of the deficiency is called the “secondary unit area,” while the original area is called the “primary unit area”. The Materials Division summarizes the test results and distributes copies to the Resident Engineer, the District Engineer, and the Construction Division. Secondary unit areas are either removed and replaced, or left in place with no payment to the contractor, following discussion among the Resident Engineer, the District Engineer, and the Construction Division. In the remaining primary unit area, liquidated damages are determined based on the average pavement thickness as described in the specifications.

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-410 CONCRETE PAVEMENT RESURFACING

6-410.1 GENERAL

Concrete pavement resurfacing includes a variety of construction techniques and methods. Concrete pavement resurfacing extends the life of portland cement concrete pavement. The type of resurfacing or rehabilitation used in a specific situation depends on the type of distress exhibited by the pavement and the constraints presented by maintaining traffic through the work zone. When the condition of the concrete pavement is unacceptable but the base is in acceptable condition, resurfacing and rehabilitation is a cost-efficient means to extend the life of the pavement.

Following are various concrete resurfacing or rehabilitation techniques:

- Rubblizing
- Cracking and seating
- Spall and joint repair
- Slab replacement
- Profile grinding
- Saw and seal joints
- Dowel bar retrofit

Depending on the pavement condition, the techniques listed above may be used independently or in combination. The Design Division prepares the plans and specifications in coordination with the Materials Division. If the Resident Engineer observes the roadway to be significantly different than that shown in the plans, the Resident Engineer should describe the current condition to the District Engineer, Materials Division, and the Design Division. .

6-410.2 BEFORE CONSTRUCTION

The Resident Engineer must thoroughly understand the specifications and scope of work. A unique characteristic of PCCP resurfacing and rehabilitation projects is that construction methods and field experience, strongly influence the success of the repair. The Resident Engineer should review the field conditions to assess the following issues:

- Scope and objective of work
- Equipment to be used and trial runs
- Sequence of operations
- Traffic control
- Constraints
- Testing requirements
- Rehabilitation techniques
- Concrete pavement grinding
- Sawcutting and joint sealing
- Random crack repair

If the Resident Engineer determines that field conditions changed significantly to warrant modification of the repair strategy, the Resident Engineer should contact the District Engineer, Materials Division, and the Design Division. Prior to the contractor starting work, the Resident Engineer schedules a pre-operations meeting or workshop to discuss the planned activities and other critical aspects of the work. The Resident Engineer should develop an agenda with input from the Materials Division and the Construction Division Quality Assurance Section.

6-410.2.1 RUBBLIZING

The intent of pulverizing the existing concrete pavement by rubblizing is to produce a structurally sound base that reduces reflective cracking by obliterating the existing pavement distresses and joints. Rubblizing produces demolished particles that are the size of large aggregate, typically smaller than 12 inches. The pulverized layer provides a foundation for the pavement overlay.

Although the rubblizing specifications contain a gradation requirement, producing small particles can reduce the structural strength of the roadway. If the subgrade is weak, the rubblizing pattern can be altered to produce larger particle sizes that maintain more of the existing concrete pavement's structural support.

Density testing can not be performed on rubblized concrete pavement because of the large particle sizes. Therefore, the compaction process is monitored to determine the stability of the pulverized layer. After compaction, if concerns exist regarding the sufficiency of the compactive effort, a quick and effective way to determine the stability of the pulverized layer is to roll it with a loaded tandem-axle truck, such as a loaded water truck, and look for deflection of the pulverized pavement. After pulverization and compaction, a bituminous plantmix pavement is constructed on the compacted surface.

The contractor should perform and complete a rubblizing operation in the same construction season. If the Resident Engineer expects the project to carry into the winter months or the next construction season, the Resident Engineer should confer with the contractor to identify options that preclude leaving open, unpaved sections of pulverized concrete exposed to the elements.

6-410.2.2 CRACK AND SEAT

Crack and seat is a process that is similar to rubblizing, with the difference being the size of the pulverized concrete pavement. A crack and seat operation produces particles that are approximately 20 inches across. The intent of pulverizing the existing concrete pavement is to produce a structurally sound base that reduces reflective cracking by obliterating the existing pavement distresses and joints. The pulverized layer provides a foundation for the pavement overlay.

Concrete pavement that has been pulverized by the crack and seat process prohibits density testing. The compaction process is monitored to determine the stability of the cracked pavement. After compaction, if concerns exist regarding the sufficiency of the compactive effort, a quick and effective way to determine the stability of the cracked pavement is to roll it with a loaded tandem-axle truck, such as a loaded water truck, and look for deflection of the cracked pavement. After cracking and seating the concrete pavement, a bituminous plantmix pavement is constructed on the compacted surface.

The contractor should perform and complete a crack and seat operation in the same construction season. If the Resident Engineer expects the project to carry into the winter months or the next construction season, the Resident Engineer should confer with the contractor to identify options that preclude leaving open, unpaved sections of cracked concrete exposed to the elements.

6-410.2.3 SPALL REPAIR

Concrete spalling occurs when small pieces of concrete separate from the slab. Spalling typically occurs at slab joints and corners. Spall repairs can be made to existing or to new concrete pavement.

The Resident Engineer should assess the actual pavement condition to confirm that the scope of work described in the plans and specifications is still appropriate. Before beginning repairs, the contactor provides the Resident Engineer with the product information for the proposed repair material, including Material Safety Data Sheets. The material must be listed in the specifications or in the Qualified Product List. If the proposed material does not conform to the specifications or is not in the Qualified Product List, the Resident Engineer must request and receive approval from the Materials Division before using the material.

The quantity for spall repairs is difficult to establish during design. Also, during the period between design and construction, additional spalling may take place. Because the quantity of spall repair will likely change from the amount listed in the plans, the Resident Engineer should conduct a field review to determine if the amount of spall repair within the project limits is consistent with the design scope and budget. The Resident Engineer should discuss warranted changes with the Construction Division, District Engineer, and Design Division. The inspector marks the spalls to be repaired by the contractor.

6-410.2.4 SLAB REPLACEMENT

At times, an isolated slab of concrete pavement may require removal and replacement. When a slab is removed, it must be removed so that it does not disturb adjacent slabs or the underlying base. Slab removal is often done by sawcutting the perimeter of the slab, inserting lifting pins into the slab, and removing the slab by lifting. Other methods may be used for removing a slab, none of which should disturb adjacent slabs and the underlying base.

As with spall repairs, the Resident Engineer should assess the actual pavement condition to confirm that the number of slabs identified in the plans for replacement is still appropriate. If, after a field review, the Resident Engineer determines significant quantity or scope changes are warranted, the Resident Engineer should discuss the changes with the Construction Division, District Engineer, Design Division, and Materials Division.

Before beginning slab replacement, the contactor notifies the Resident Engineer of the proposed slab removal method. Depending on the requirements of the specifications, the contractor may be required to submit a formal plan. Before work begins, the Resident Engineer and contractor should discuss contingencies if the slab removal operation exposes unacceptable base material. The Resident Engineer may need to consult with the Materials Division on the proposed contingency plan. Because the specifications may limit work hours, a contingency plan is critical to returning traffic to the roadway by the time stated in the specifications. Additionally, the contractor must submit a concrete mix design to the Resident Engineer for review. The Resident Engineer submits the contractor's concrete mix design to the Materials Division for approval. The contractor must receive approval of the mix design before removing slabs. The inspector will mark the slabs to be replaced.

6-410.2.5 PROFILE GRINDING

When a concrete pavement exhibits minor distresses such as uneven surfaces at joints, inadequate surface drainage, or poor riding characteristics, the pavement surface may undergo grinding to improve the problem areas. Grinding may also be needed to improve skid resistance. The pavement is ground full width to reestablish an acceptable profile and cross slope as detailed in the plans.

The Resident Engineer should meet with the contractor to clarify the specifications and review the equipment to be used. After the Resident Engineer is satisfied that the contractor's equipment will achieve the desired results, the inspector will mark the area to be ground. The specifications will describe the required surface texture and surface smoothness.

6-410.2.6 SAW AND SEAL JOINTS

Concrete pavements contain joints that are created by sawing. Once sawed, the joints are sealed to keep incompressible particles and water out of the joint. Over time, seals deteriorate or break down, exposing the joint, which allows particles to enter the joint and cause cracking of the pavement. To correct this problem, joints are re-sawed and re-sealed.

If the contractor proposes to use sealing material that is not listed in the Qualified Product List, the contractor submits a certificate showing conformance with the specifications to the Resident Engineer. The Resident Engineer submits the certificate to the Research Division for approval before operations commence. The contractor must install the joint sealer material according to the manufacturer's recommendations. The Resident Engineer may require the contractor to have a manufacturer's representative present to verify proper installation. The Resident Engineer should discuss the saw and seal procedure with the contractor before beginning work. Additionally, the Resident Engineer and the contractor should discuss the traffic control plan for sawing and sealing operations to confirm compliance with specifications.

6-410.3 DURING CONSTRUCTION

6-410.3.1 RUBBLIZING

Rubblizing demolishes the existing concrete pavement. Rubblizing produces demolished particles that are the size of large aggregate, typically smaller than 12 inches. Pavement demolishing equipment must have sufficient capacity to demolish the existing pavement to full depth. Two types of machines are commonly used. One is the resonant breaker, which produces low amplitude, high frequency blows by vibrating a large steel beam. The other machine is a multi-head breaker with drop hammers that provide continuous breaking up to 13 feet wide. The multi-head breaker rubblizes a full lane width in a single pass.

Although other rubblizing equipment exists, the specifications prohibit certain types of equipment. Therefore, the specifications should be consulted regarding acceptable equipment. The equipment proposed by the contractor is tested to determine if it produces the desired results. The Resident Engineer designates a test strip location where the equipment is tested, as required by the specifications. Once the equipment demonstrates that it produces the desired results, the contractor must use the same equipment and method of operation for the remainder of the work.

For rubblization, the approved equipment and rubblization method are used on the roadway to be rehabilitated. During the rubblizing operation, the contractor must protect traffic passing by the work area from flying debris created by the operation. A full depth test hole measuring 3 feet by 13 feet is excavated for each day's rubblizing operation to verify that the equipment is achieving full depth rubblization. The test hole allows the inspector to verify that the particle size conforms to the specifications or the size recommended by the Materials Division. Test holes are backfilled with aggregate base. After rubblizing and backfilling of test holes, the rubblized surface is compacted with vibratory steel wheel rollers and a pneumatic rubber tired roller. The compacted surface then receives a prime coat, followed by a plantmix leveling course. The leveling course is then followed by a plantmix bituminous overlay. The specifications contain detailed requirements for the rubblizing operation. Refer to Section 410 of the specifications.

6-410.3.2 CRACK AND SEAT

Crack and seat operations demolish the existing concrete pavement by producing demolished pieces that are approximately 20 inches across. Pavement demolishing equipment must have sufficient capacity to demolish the existing pavement to full depth.

Crack and seat operations typically use a guillotine-type impact hammer. Although other crack and seat equipment exists, the specifications prohibit certain types of equipment. Therefore, the specifications should be consulted regarding acceptable equipment.

The equipment proposed by the contractor is tested to determine if it produces the desired results. The Resident Engineer designates a test strip location where the equipment is tested, as required by the specifications. Once the equipment demonstrates that it produces the desired results, the contractor must use the same equipment and method of operation for the remainder of the work.

Before the contractor begins cracking the concrete, the pavement is flooded with water to check for existing cracks. As the pavement dries, cracks will retain moisture after the pavement surface has dried, making cracks easy to see. By identifying the extent of existing cracking, the effectiveness of the pavement breaking operation can be determined. After the pavement cracking operation, the pavement is flooded again to verify that the contractor has achieved the required crack spacing of the pavement. If traffic is to be returned to the roadway, the contractor must sweep the surface of the roadway to remove debris and dust. Following the cracking of the pavement, the cracked concrete is seated by operating a pneumatic roller over the surface for three complete passes. The contractor removes loose debris from the cracks and joints. The contractor then places a plantmix stress relief course within 24 hours of the cleaning. The stress relief course is then followed by a plantmix bituminous overlay. The specifications contain detailed requirements for the crack and seat operation. Refer to Section 410 of the specifications.

6-410.3.3 SPALL REPAIR

On concrete surface rehabilitation projects that include spall repair and grinding, the contractor completes the spall repair before grinding. Specifications describe the size of the spall to be repaired. Although the size of the spalls may vary, the plans typically show a uniform size for the repair. Loose or delaminated material is typically removed from the spall area using a lightweight jackhammer or mechanical chipping hammer. Heavy-duty jackhammers are not used because the energy can cause micro-cracking in the surrounding concrete. After removing loose material, the contractor sandblasts the area clean.

Most spall repair products are sensitive to weather conditions. Manufacture's recommendations must be followed to achieve the desired results. In addition, specifications typically require the product manufacturer's representative to be present during placement of the material.

The manufacturer's representative determines the appropriate method of perpetuating any joints in the spall repair material. The spall repair material should be flush with the surrounding surface. Repair any surface irregularity. If grinding is included as part of the project, the spall repair may be left slightly higher than the surrounding surface to allow for grinding.

6-410.3.4 SLAB REPLACEMENT

The inspector observes the contractor's slab removal operations to confirm that the base is not damaged. If the contractor damages the underlying base, the base must be repaired at the contractor's expense, using a method approved by the Resident Engineer. If the underlying base requires repair unrelated to the contractor's operations, the base is repaired on a force account basis. The Resident Engineer consults with the Materials Division to determine an appropriate repair method.

After the excavated slab area is cleaned and inspected, the contractor installs dowel bars or tie bars as detailed in the plans and specifications. After preparing the underlying base, the contractor applies a bond breaker to the base and vertical sides, then places the new concrete pavement in the excavated area. If re-opening traffic lanes is critical, a high strength, early setting concrete mixture should be considered. Refer to Section 6-409, Portland Cement Concrete Pavement, for construction details relating to PCCP.

6-410.3.5 PROFILE GRINDING

Concrete pavement grinding is combined with other concrete rehabilitation operations, such as spall and joint repair. The sequence of repair activities is important to achieve the rehabilitation objectives. Grinding takes place after spall repairs and slab replacement but before joints are sawed and sealed.

Perform grinding in a longitudinal direction. After the initial grind, the inspector checks the surface to confirm that the requirements of the specifications are met. The grinder makes a corduroy-type texture with grooves on the surface. The inspector checks the initial grind using a 12-foot straightedge. The contractor must perpetuate the existing profile grade, cross-slope, and surface drainage.

If the existing surface has deep ruts in the wheel paths, the contractor may need to adjust the depth of the grinding to achieve the requirements of the specifications. The contractor should be aware that the depth of the grind could cause cross-slope drainage problems. To correct cross-slope drainage problems, the shoulder may require grinding to taper the edge of the roadway to allow drainage.

After profile grinding, the inspector checks the pavement smoothness with a 12-foot straightedge, both longitudinally and transversely. The inspector reports the straightedge results on NDOT form 040-056, "Daily Construction Report." The contractor performs profilograph testing to determine if the ground pavement surface complies with the specifications. The profilograph is operated to test the pavement surface in the planned vehicle wheel path and in the direction of traffic.

After the profilograph testing is complete, the Resident Engineer assigns a person to collect, analyze, and report the data on NDOT form 040-073, "Report of Profilograph Test." Copies of the test reports are supplied to the contractor as soon as possible, but no later than the time stated in the specifications. If the profilograph testing results indicate an unacceptable pavement profile, corrective action may be required by the contractor to meet surface tolerance requirements.

6-410.3.6 SAW AND SEAL JOINTS

Sawing of joints must not cause damage to existing joints. A clean joint is required for the sealant to perform properly. After sawing the joint, the contractor cleans the joint, usually with water or sandblasting. The contractor must recover and dispose of the residue from the cleaning operation. If residue remains on the walls of the joint, the sealant material will not adhere properly.

After sawing and cleaning the joint, the contractor installs the size and type of backer rod specified in the plans for the size and width of joint. The inspector confirms that the contractor uses the correct diameter and type of backer rod for each width of joint. Backer rod is typically installed with a tool that places the backer rod at the required depth.

The installation must comply with the specifications and details shown in the plans. The function of the joint is sensitive to the proper sealant recess depth. If the depth of the sealant is too shallow (too close to the surface), traffic could pull out the sealant. If the sealant is too deep, the joint could collect dirt and other debris that could cause spalling. In either case, incorrect installation will diminish the design life of the concrete pavement. The inspector observes the sealing operation to verify the installation conforms with the plans and specifications. The inspector performs sealant testing after installation. The specifications describe the required tests. The contractor must remove and replace unacceptable sealant material.

6-410.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. To complete full-width grinding that complies with specifications, multiple passes of the grinding equipment may be needed. If the grinder passes over pavement that was previously ground, such as an overlap or regrind, no payment is made for the re-ground area.

Rubblized, and crack and seat surfaces are measured and paid by the square yard. Measure the area to be demolished before pavement demolition.

6-496 BRIDGE DECK SEAL CONCRETE

6-496.1 GENERAL

Concrete bridge decks are often sealed to create a barrier to prevent salt and other corrosive chemicals from entering the concrete. A common method of sealing bridge decks is applying a liquid chemical, such as methacrylate, to the existing bridge deck. Another means to seal the deck is to seal the deck with a sealant, such as methacrylate, and then overlay the bridge deck with a polymer concrete or an epoxy material. Deck overlays can also be used to restore a riding surface or repair a severely cracked or delaminated bridge deck. In some situations, a bituminous pavement wearing surface may be constructed on the polymer concrete or epoxy overlay. Because the most common overlay material is polymer concrete, Section 6-496 discusses only polymer concrete. Polymer concrete consists of graded aggregate, that is pre-bagged, and a liquid polymer resin, which acts as a binder. The typical placement depth of polymer concrete is ¾ inch. If thicknesses exceed 1½ inches, multiple lifts may be necessary because of the high temperatures generated by polymer concrete during curing.

Because polymer concrete is a specialized material, the Resident Engineer should be knowledgeable of the specification requirements. The specifications provide detailed information on the required experience of the contractor, materials, and construction details of polymer concrete.

6-496.2 SAFETY

Materials used in bridge deck sealing and overlays require special handling and safety procedures because of the chemicals used. All personnel working, handling, or transporting the materials, as well as inspectors and material testers, must attend safety training before materials arrive at the jobsite. Because of the volatile nature of the chemicals used in making polymer concrete, strict adherence to handling and safety procedures is required to avoid violent chemical reactions.

The inspector should carefully review and understand the Material Safety Data Sheets (MSDS) that the contractor provides. If chemicals are not shipped, handled, and combined precisely as required by the MSDS and the specifications, the combined chemicals, including chemical vapors, can cause an explosion.

6-496.3 BEFORE CONSTRUCTION

Because of the highly specialized nature of polymer concrete, the specifications contain requirements relating to the contractor qualifications and experience, materials, on-site skilled technical support from the material supplier, testing of the materials, and safety and handling of the materials. Before work can begin, the contractor must complete all submittal requirements contained in the specifications.

Before the contractor begins operations with the materials, the contractor must address several safety issues. Because of the hazards associated with the materials used in polymer concrete overlays, the manufacturer's recommendations for personal protective equipment should be followed. Also, the contractor must provide MSDS that are maintained on site. The inspector should review the information contained in the MSDS, paying special attention to safety considerations. The contractor must have an on site wash station for workers in case of chemical accidents. The contractor must also provide health and safety training for all personnel who will be working with the materials.

Polymer concrete is mixed on the jobsite either in a mechanical mixer operated manually or in a truck-mounted mixer, commonly called a volumetric mixing vehicle. When polymer concrete is mixed manually, the aggregate is pre-bagged and delivered to the site. The manual mixing process includes adding coarse and fine aggregate, measured by the bag, with a polymer resin and a chemical hardener, measured in ounces. When a volumetric mixing vehicle is used, the equipment must bear a rating plate from the Volumetric Mixer Manufacturer Bureau (VMMB). The VMMB rating plate identifies the capacity and performance of the mixer. In a volumetric mixing vehicle, raw ingredients are stored in separate compartments on the truck and metered out for incorporation into the mix. Regardless of the units of measurement used by the vehicle—weight or volume, the quantity of polymer concrete must be consistent with the unit of measurement for payment. This may require a correlation between volume and weight of the ingredients to be incorporated into the polymer concrete. Figure 6-496.1 shows a volumetric mixing vehicle and Figure 6-496.2 shows a typical measurement display on a volumetric mixing vehicle.

Figure 6-496.1. Volumetric Mixing Vehicle.

Figure 6-496.2. Display on Volumetric Mixing Vehicle.

The contractor must construct a trial overlay as required by the specifications. The purpose of constructing a trial overlay is too mimic the conditions and operations that will occur during the placement of the polymer concrete overlay. The trial overlay verifies that the materials will perform as desired and that the contractor's operations will yield acceptable results. The trial overlay must be constructed under the same conditions that would likely occur during construction. This includes atmospheric temperature and the temperature of the existing overlay surface. Also, if the polymer concrete placement will occur at night, then the trial overlay must be constructed at night. A skilled technical representative from the material supplier must be present during the trial slab placement. The technical representative adjusts the resin content as required to achieve the desired results.

The specifications require the contractor to construct an overlay that meets surface tolerances. The Resident Engineer should obtain initial profilograph readings of the bridge deck before the contractor places the polymer concrete. The initial profilograph readings provide a baseline in case disputes arise regarding final surface tolerance readings.

The bridge deck must be prepared before receiving a prime coat and polymer concrete overlay. Preparation includes the following:

- Identifying and repairing any areas within the bridge deck that are delaminated or require repair
- Roughening the deck to remove oil, asphalt, and dirt
- Grinding epoxy paint and deeply soiled areas
- Removing loose debris

After preparing the deck and before applying the prime coat, the inspector coordinates with the survey crew to establish a grid of deck elevations. The survey crew takes elevations again after placing the polymer concrete. The contractor establishes the finish grade using survey information and a string line to maintain elevation. After establishing finish grades, the contractor will use placement equipment that will consolidate, vibrate, and finish the material to the required grade.

The Resident Engineer identifies areas within the bridge deck that require repair. To identify areas of delamination, refer to test method ASTM D4580, “Measuring Delaminations in Concrete Bridge Decks by Sounding.” The Materials and Structures Divisions can provide assistance with equipment and training needed to perform bridge deck delamination testing. The contractor must make bridge deck repairs in accordance with Section 502.03.15 of the specifications.

In preparing the deck, the objective is to remove the cement paste and expose the deck aggregate, providing a clean, sound concrete surface. After the deck is cleaned, traffic is prohibited from using the deck until the placement of the polymer concrete is complete.

The contractor may use several methods for roughening or scarifying the bridge deck. Shot blasting is similar to sandblasting, except that small metal beads impact the concrete surface instead of sand. Shot blasting produces a scarified surface texture and has a good production rate. Shot blasting typically requires two passes to produce the desired surface texture. Hydroblasting, also similar to sandblasting, uses water under high pressure to impact the concrete surface. Hydroblasting produces an acceptable surface texture but requires a water management plan and additional time to remove the moisture from the deck. Hydroblasting may not be practical on projects that have limitations on working hours, such as night projects that must be open for traffic in the morning. A scabbler is a piece of equipment that uses compressed air to hammer piston-mounted bits into the concrete surface. Because a scabbler impacts the concrete surface, it can produce cracks. Small cracks are acceptable. When a scabbler is used, sandblasting is commonly required to complete the preparation of the surface. Typically, sandblasting is not used to prepare the deck. Sandblasting alone will not produce the required texture, and is not allowed in most urban areas due to air quality regulations.

Some bridge decks may have waterproof membranes that contain bituminous materials. Shot blasters are ineffective because the hot metal shot melts the membrane, gumming up the shot blaster. When waterproof membranes are encountered, hydroblasting is typically effective in removing the waterproof membrane and preparing the bridge deck.

Areas that are heavily soiled and epoxy striping are removed by grinding. Because grinding can produce variable results, the inspector must closely monitor the grinding operation.

6-496.4 DURING CONSTRUCTION

After the bridge deck has been prepared in accordance with the specifications, the inspector confirms that all materials to be incorporated into the work meet the requirements of the specifications and are on site. All material certifications and tests required by the specifications must be received and approved by the Resident Engineer before the contractor begins using the materials.

The contractor should isolate expansion joints to protect the joints from polymer concrete entering the joint. The contractor has the option to sawcut joints after placement of the polymer concrete. If the contractor elects to sawcut joints, sawcutting must occur within four hours of placement of the polymer concrete.

After joints are marked or isolated, the deck should be cleaned with compressed air to remove residual debris. After cleaning, a deck moisture test must be conducted. Refer to Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* for required tests and frequencies.

With the deck cleaned and the deck moisture content within the acceptable range required by the specifications, the contractor applies the prime coat, typically methacrylate. A prime coat is used to bond the polymer concrete to the bridge deck. The application of the prime coat must be uniform and it must cover the deck completely. A uniform prime coat reduces variable adhesion between the deck and the polymer concrete. Complete coverage provides a barrier between the deck and the polymer concrete. If polymer concrete contacts the concrete deck, a chemical reaction can occur, which significantly decreases the bond between the polymer concrete and the deck. Therefore, the coverage of the prime coat is important.

The prime coat is flooded onto the bridge deck and evenly applied using squeegees and brooms. Placement of the prime coat should be done expeditiously to reduce the potential for contamination from dust and other debris. Prime coat is also placed quickly to maintain workability and reduce the potential for uneven application. Monitor the prime coat application, checking that the contractor corrects ponding and uneven distribution of the prime coat on the scarified bridge deck. Because the materials used for prime coat have relatively low flash point temperatures, prime coats can be hazardous. The inspector must be aware of the safety requirements contained in the MSDS. If the prime coat is contaminated or unevenly applied, the inspector may reject the prime coat, in which case the contractor cleans the surface and reapplies the prime coat. After the prime coat has set or hardened, polymer concrete placement can begin. Except for the contractor's construction equipment, vehicle and foot traffic, equipment, and materials are not allowed on the prime coat, because of the risk of introducing contaminants that can cause debonding of the overlay.

Batching the polymer concrete takes place manually with a mechanical mixer or on a truck-mounted mixer. In either case, a skilled technical representative of the polymer concrete and prime coat supplier must be present when the initial batching begins. The contractor must thoroughly blend the resin before adding the aggregates to the resin. Refer to the specifications for detailed requirements. The contractor batches the polymer concrete using the appropriate mix formula based on the results of the trial overlay. The material supplier technical representative may recommend adjustments to the formula based on atmospheric and surface temperatures. The contractor must place and finish the batched polymer concrete within 15 minutes of mixing, or before it gels. Polymer concrete not placed within this time frame must be discarded.

Prior to placement of the polymer concrete, calculate the approximate quantity of polymer using the bridge deck surface area, the planned thickness of the overlay, and the contractor's mix formula. Confirm that the contractor has enough material on the project to complete the work. During placement of the polymer concrete, observe that the screed of the paver is adequately finishing the surface, but not over working the material. A small amount of resin coming to the surface is normal. Verify that the grade control equipment is functioning correctly. During the placement operation, the inspector monitors and documents material quantities. The polymer concrete must be placed and finished within 15 minutes or before gelling. Any material not used within these limits must be discarded. Immediately after the contractor finishes the material, and before it gels, the contractor mechanically broadcasts sand uniformly onto the surface. Typically, polymer concrete begins to harden within 30 to 120 minutes after it is mixed. The polymer concrete commonly hardens completely within four hours of mixing. After placement, the contractor must protect the surface from moisture, equipment, and traffic for at least four hours. Prior to opening to traffic, the polymer concrete overlay is tested to detect delaminations. Refer to the specifications for required tests.

6-496.5 MEASUREMENT AND PAYMENT

Bridge Deck Preparation and Concrete Placement is typically paid by the square yard, which includes all work associated with preparing the bridge deck surface, furnishing and placing the prime coat, and placing the polymer concrete.

The contractor is also paid for aggregates and resins used in the polymer concrete. The method of measurement for aggregate and resin is by the pound. The contractor is paid for the actual amount of aggregate and resin used in the polymer concrete placed. The quantity may vary significantly from the plan quantity contained in the estimate because of the profile variations on the existing bridge deck. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-501 PORTLAND CEMENT CONCRETE

6-501.1 GENERAL

Concrete is a mixture of aggregate (coarse and fine), cement, water, and admixtures, which are substances that modify the characteristics of the concrete. The primary advantage of concrete is its high compressive strength. However, the tensile strength of concrete—pulling the concrete apart—is very low. Reinforcing steel is added to concrete to give it tensile strength. Important characteristics of reinforcing steel include strength of the steel used, size or diameter of the steel bar, and the location of the steel within the concrete. Reinforced concrete combines the compressive strength of concrete and the tensile strength of reinforcing steel.

The design of a structure is based on materials, especially concrete and reinforcing steel, performing in a certain manner. During construction, the ability of these materials to behave as anticipated by the designer relies on a closely controlled mix of aggregates, cement, water, and admixtures incorporated into the work as required by the specifications.

By varying the amounts and types of components of the concrete mixture, the characteristics of the concrete can be altered to achieve the results required by the design. Common types of modified concrete used in Nevada are high early strength, high performance, and self-consolidating.

6-501.1.1 HIGH EARLY STRENGTH CONCRETE

As the name implies, high early strength concrete cures, or hardens, faster than standard concrete. High early concrete is made with cement specifically designed to achieve design strength quickly. High early concrete is used when the finished concrete must be used soon after it is placed.

A common use for high early concrete is on an existing roadway that must quickly be reopened to traffic. In this situation, high early concrete allows traffic to use the roadway as soon as four hours after finishing, compared to three days or more with standard concrete.

6-501.1.2 HIGH PERFORMANCE CONCRETE

High performance concrete is a term that generally describes concrete that has an extended life expectancy because of modifications in the mix design, placement, and curing. The American Concrete Institute defines high performance concrete as concrete that meets special combinations of performance and uniformity requirements that cannot always be achieved routinely when using conventional components and normal mixing, placing, and curing practices. High performance concrete may be a high-strength concrete, but this comes only as a by-product of requiring a durable concrete.

Historically, durable concrete was achieved by specifying air content, cement content, and water-cement ratio. With high performance concrete, durability is determined by an additional variable: permeability. Because durability characteristics are more difficult to define than strength characteristics, specifications often use a combination of performance and prescriptive requirements, such as permeability and a maximum water-cement ratio.

Low permeability is desirable in a durable concrete such as high performance concrete. If the concrete cracks, it loses the benefits of low permeability, and the concrete durability diminishes. To reduce cracking, the contractor cures the concrete by supplying sufficient moisture during the curing process. One of the best methods for controlling moisture loss is the wet cure method, which is typically used for high performance concretes. Contractor quality control is important to achieve the desired results in producing and placing high performance concrete.

6-501.1.3 SELF-CONSOLIDATING CONCRETE

Self-consolidating concrete flows easily into tight and constricted spaces without segregating and without mechanical consolidation. To reduce segregation, self-consolidating concrete must be fluid, yet stable. To achieve a flowable mix, use smaller, finer-graded aggregates with admixtures. The required level of fluidity depends greatly on the particular application. Generally, the higher the required flowability of the self-consolidating concrete mix, the higher the amount of fine material needed to produce a stable mix. In some cases, a viscosity-modifying admixture can be used instead of, or in combination with, an increased amount of fine aggregate to stabilize the concrete mixture.

Bridges may require a large amount of reinforcing steel in a confined space. Because of this congestion of reinforcing steel, conventional concrete may not consolidate completely within the forms and around the reinforcing steel. Additionally, the use of mechanical consolidating tools is constrained or physically prohibited. In such situations, the specifications may require the use of self-consolidating concrete.

When using self-consolidating concrete, carefully consider the forms. Because the material constrained by the forms is more fluid than conventional concrete, the concrete may create greater pressure on the form. The contractor should consider the additional pressure, called liquid head, during design of the forms. Additionally, form construction must result in a watertight, leakproof barrier to confine the concrete. .

6-501.2 CONCRETE AGGREGATE

Concrete aggregate consists of sand and gravel. For a good concrete mix, aggregate should be clean, hard, free of absorbed chemicals or coatings and other fine materials that could deteriorate concrete. Aggregates account for 60 to 75 percent of the total volume of concrete. Concrete aggregates are classified as either fine or coarse. Fine aggregates typically consist of natural sand or crushed stone with particles smaller than 3/8-inch. Coarse aggregates range in size from 3/8-inch to two inches.

Aggregate processing consists of crushing, screening, and washing the aggregate to obtain proper cleanliness, gradation, and other characteristics. Once processed, the aggregates are handled and stockpiled in a way that minimizes segregation and degradation, and reduces contamination. Aggregates strongly influence concrete's freshly mixed and hardened properties, proportions, and economy. Consequently, aggregate selection is an important process. Although some variation in aggregate properties is expected, following are characteristics to consider when selecting aggregate:

- Grading
- Durability
- Particle shape and surface texture
- Abrasion and skid resistance
- Unit weights and voids
- Absorption

Grading refers to the distribution of the aggregate particle sizes. Aggregate grading and size affect the amount of aggregate used as well as cement and water requirements, workability, pumpability, and durability of concrete. During concrete aggregate production, the aggregate is stored in stockpiles. The contractor is responsible for constructing stockpiles that provide aggregates required by the specifications. Proper stockpile construction consists of the following:

- Minimizing segregation. Avoid high, cone-shaped stockpiles.
- Minimizing equipment on the aggregate stockpile because the concrete aggregate can break down, changing the gradation and introducing foreign particles.
- Separating the stockpile from other materials to avoid contamination and to maintain the integrity and gradation of the concrete aggregate.
- Monitoring the effect of weather on stockpiled aggregates. Mist during extreme heat and protect from high wind to maintain proper moisture conditions, saturated surface dry (SSD) conditions. During cold temperatures, protect aggregate from freezing.

As the contractor produces concrete aggregate, the aggregate is stockpiled using methods to preserve the quality and to ensure that sufficient quantities are available to complete the planned concrete production for the day. Contractors should dedicate stockpiles to specific projects and clearly identify the project where the aggregate will be used.

6-501.3 ADMIXTURES

Admixtures are chemical ingredients that are added to the concrete mixture immediately before or during mixing. Admixtures are used primarily to do the following:

- Modify the properties of concrete to improve workability
- Modify the properties of hardened concrete
- Preserve the quality of concrete during mixing, transporting, placing, and curing

Successful use of admixtures depends on the use of appropriate methods of batching, delivering, and placing concrete. Most chemical admixtures are supplied in ready-to-use liquid form and added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids, are used in extremely small amounts and are usually added to a batch by hand using pre-measured containers. Because admixtures can be incompatible with each other, a new mix design may be required. Confer with the Materials Division for guidance.

The following factors determine the effectiveness of an admixture:

- Type and amount of cement
- Water content
- Aggregate characteristics
- Mixing time
- Timing of admixture introduction into concrete mix
- Time between addition of admixture and placement of concrete
- Slump
- Concrete temperatures
- Atmospheric temperature
- Manner in which admixture is introduced to the mix

Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture—reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

Following are five general classes of chemical admixtures:

- Air-entraining – Air-entraining admixtures are used to place microscopic air bubbles into the concrete. Air entrainment is used principally to improve resistance to freezing when exposed to water and deicing chemicals. The microscopic air bubbles relieve internal pressure on the concrete by providing tiny chambers for the expansion of water when it freezes. Air-entraining agents improve the workability and durability of concrete.
- Water-reducing – Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent. Consequently, concrete containing a water-reducing admixture needs less water to reach a required slump than untreated concrete. The treated concrete can have a lower water-cement ratio, which increases the strength of the concrete without increasing the amount of cement.
- Retarding – Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting. Retarding admixtures allow a longer period between concrete production and placement. Retarders may also be used when a longer set time is required. High temperatures often cause an increased rate of hardening, which makes placing and finishing difficult. Retarders keep concrete workable during placement and delay the initial set of concrete. Most retarders also function as water reducers and may entrain some air in concrete.
- Accelerating – Accelerating admixtures increase the rate of early strength development, allowing finishing operations to begin sooner. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather, allowing required chemical reactions to take place so the concrete can harden. Accelerating admixtures do not prevent freezing of the concrete.

- Plasticizers (superplasticizers) – Plasticizers, also known as superplasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent. Superplasticizers are added to concrete with a low-to-normal slump and water-cement ratio to make high-slump, flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little vibration or consolidation. The effect of superplasticizers lasts approximately 30 to 60 minutes, depending on the brand, dosage rate, handling, and weather. After the effect of the superplasticizer wears off, workability of the concrete decreases rapidly. Because superplasticizers have a short effective life, superplasticizers are usually added to concrete at the jobsite. Superplasticizers)

All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring.

Corrosion-inhibiting admixtures are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can be used for concrete structures, such as marine facilities, bridges, and parking garages that will be exposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while alkali-silica reactivity inhibitors aid in controlling durability problems associated with alkali-silica reactivity. Workability enhancers, such as viscosity modifying admixtures, are used in self-consolidating concrete to increase flowability and decrease aggregate segregation.

In addition to admixtures that alter the characteristics of a concrete mix, other products can also be used to change concrete characteristics. Flyash, slag, and silica fume are by-products of industrial processes, are less expensive than cement, and have properties similar to cement. These materials are substituted for cement and modify the concrete mix as follows:

- Flyash
  - Enhance workability
  - Reduce bleed water
  - Reduce slump loss
  - Increase the long-term strength
  - Reduce permeability
  - Increase the durability
  - Reduce the potential for sulfate attack
  - Reduce the heat of hydration
  - Reduce the potential for alkali-silica reactivity

- Slag
  - Increase workability, finishability, and pumpability
  - Increase compressive and flexural strength
  - Reduce permeability
  - Increase resistance to chloride intrusion and corrosion
  - Mitigate moderate to severe sulfate attack
  - Reduce the potential for alkali-silica reactivity
  - Reduce thermal stress in mass concrete through lower heat generation
- Silica Fume
  - Reduce permeability
  - Increase the resistance of concrete to chloride penetration

For additional information on admixtures and additives, refer to the FHWA website, http://www.fhwa.dot.gov/infrastructure/materialsgrp/admixture.html.

6-501.4 PROPORTIONING

Carefully proportioning and mixing concrete ingredients produces a strong and durable concrete. A concrete mixture with insufficient paste to fill all the voids between the aggregates is difficult to place and produces rough, honeycombed surfaces and porous concrete. A concrete mixture with excess cement paste is easy to place and produces a smooth surface, but it is susceptible to increased shrinkage cracking and spalling.

A properly designed concrete mixture possesses the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10 to 15 percent cement, 60 to 75 percent aggregate, and 15 to 20 percent water. Entrained air in many concrete mixes may also take up another 5 to 8 percent.

Concrete ingredients are proportioned to make the most economical use of available materials, meeting specifications to produce concrete of the required workability, durability, and strength. Because the mixture must meet multiple objectives, increasing one ingredient may achieve one objective, but detract from another. Achieving optimum concrete proportions requires balancing the characteristics of each component and the physical and chemical characteristics of the components in combination. Initial proportioning of component material (mix design) is based on the theoretical characteristics of the components. The final proportions are often established by adjustment in the field and must remain consistent with the approved mix design and specifications.

Water plays an important role in the chemistry of concrete. Although the specifications state the water quality requirements, follow the guideline that if water is suitable for drinking (potable), then it is acceptable for mixing in concrete. Water is required for chemical reactions that transform cement and aggregates into concrete. Cement and water form a paste that coats each particle of stone and sand. Through a chemical reaction called hydration, the cement paste hardens and strengthens. During hydration, chemical energy is converted to heat, commonly called the heat of hydration. The character of the concrete is determined by the quality of the paste. The strength of the paste, in turn, depends on the ratio of water to cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. High-quality concrete can be produced by lowering the water-cement ratio without sacrificing the workability of fresh concrete. Generally, using less water produces a higher quality concrete, provided the concrete is properly placed, consolidated, and cured.

Aggregates from different sources may produce significant differences in concrete strength even though the amounts of water and cement remain constant. Cement quality may vary between manufacturers. Although components of the mix are variable, variability of the aggregates influence concrete strength more than changes in the quality of the cement.

Different types of cement are manufactured to meet various physical and chemical requirements. Cement is manufactured in five standard types.

- Type I
  - Type I cement is commonly used on construction projects. It is used to construct such things as buildings, bridges, pavements, and precast concrete products.
- Type II
  - Type II cement is used when the structure will be in contact with sulfates. Type II cement has a moderate resistance to sulfate attack. It generates less heat at a slower rate than Type I cement.
- Type III
  - Type III cement is commonly called high early strength cement because it causes concrete to set and gain strength rapidly. Type III is chemically and physically similar to Type I, except that its particles have been ground finer.
- Type IV
  - Type IV cement has a low heat of hydration and develops strength at a slower rate than other cement types, making it ideal for use in dams and other massive concrete structures where there is little chance for heat to escape.
- Type V
  - Type V cement is used in concrete structures that will be exposed to severe sulfate action, typically where concrete is exposed to soil and groundwater with a high sulfate content.

Each of the standard types of cement can be modified to respond to specific environmental conditions. When a standard type of cement is modified, a letter designation is added to the standard type designation, such as Type IP or Type IA. The “P” indicates the addition of pozzolan, and “A” indicates air-entraining characteristics in the cement.

After the components are combined into a concrete mix, two factors that are commonly used to evaluate and monitor the concrete mixing process are cement factor and water-cement ratio. Concrete is typically measured in cubic yards. Cement factor is the amount of cement, measured in pounds, in one cubic yard of concrete. Cement is sometimes measured in sacks per cubic yard (one sack of cement weighs 94 pounds). NDOT specifications typically require cement factors that range from five sacks per cubic yard (470 pounds per cubic yard) to eight sacks per cubic yard (752 pounds per cubic yard). Although concrete strength is influenced by several factors, the cement factor is a measurement that identifies the amount of cement incorporated into the concrete mix.

To monitor the cement factor during concrete production, the inspector must record the weights of the various ingredients. Because the cement factor is measured in weight of cement per volume of concrete, mathematical conversions must be made to determine the actual cement factor of the mix. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of determining an actual cement factor. The cement factor is calculated for every load of concrete that is incorporated into the work. The cement factor is recorded on NDOT form 040-025, "Transit-Mix Concrete Delivery Form."

The water-cement ratio helps to monitor the appropriate amount of water in the concrete mixture. It is a design criterion that influences the final properties of concrete by measuring the weight of water to the weight of cement in the mixture. It provides control over two opposing, yet desirable, properties: strength and workability. The advantages of a low water-cement ratio are as follows:

- Increased strength
- Lower permeability
- Increased resistance to weathering
- Reduced shrinkage cracking tendencies

The less water used, the better quality of concrete, provided it can be consolidated properly. A mixture with a high water-cement ratio will be more workable than a mixture with a low water-cement ratio. A less workable mixture (low water-cement ratio) results in a stronger concrete. A water-cement ratio is chosen to give the best result for a given situation. This is not an entirely free choice because the water-cement ratio must be about 0.25 to complete the hydration reaction. Typical values of water-cement ratios are between 0.35 and 0.45 because they give a good amount of workability without sacrificing a lot of strength. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of how to determine the water-cement ratio.

On NDOT projects, the contractor develops a concrete mix design and submits it to the Resident Engineer, who reviews and submits it to the Materials Division for final approval. The Materials Division sends a memorandum to the Resident Engineer stating the acceptance or rejection of the mix design. The Resident Engineer notifies the contractor of the acceptance or rejection of the mix design.

Producing a concrete mixture requires balancing several objectives and managing materials to produce the desired outcome. Aggregates, cement, water, and admixtures are combined to produce a concrete mix that achieves the design objective. Key measurements used to monitor the concrete mixture are the cement factor and the water-cement ratio. Not only are the materials and the proportioning of the materials important, the mixing plant and its operation can affect the quality and durability of the concrete.

6-501.5 MIXING PLANT

The contractor is responsible for the plant and its operations. Although the plant is the contractor's responsibility, the inspector observes and monitors the plant operation to verify that the mixing plant conforms to the requirements of the specifications and that components of the concrete mixture are consistent with the approved mix design. NDOT requires concrete mixing plants and transit mixing trucks to be certified by the National Ready Mixed Concrete Association (NRMCA). The NRMCA is a national association of ready mixed concrete producers and plant operators. NRMCA certification of concrete production facilities provides a system for establishing that production facilities of ready-mixed concrete plants are satisfactory. To receive certification, a plant is inspected to assess compliance with an industry checklist. Certifications are valid for a specific period. The inspector must check that the NRMCA certification is current for the plant producing the concrete. The Nevada Bureau of Weights of Measures must also certify the plant scales.

Concrete is produced several different ways, and the characteristic of each type are as follows:

- Transit-Mixed – Raw ingredients are loaded directly in the transit mixing truck. The mixer drum is turned at a fast speed while the materials are loaded. Once loaded, the concrete is mixed in one of two ways:
    - Jobsite – The drum is turned at slow speed (agitating speed) while traveling to the jobsite. At the jobsite, the concrete is completely mixed at a high speed (mixing speed) for 70 revolutions.
    - Plant site – The drum is turned at mixing speed for 70 revolutions, and then checked for consistency. The transit mixing truck rotates the drum at agitating speed during transit to the jobsite.
- Shrink-Mixed – Raw ingredients are partially mixed in a plant mixer and then discharged into the drum of a transit mixing truck to complete the mixing. Central mixing plants are often used to shrink mix, or partially mix the concrete. The amount of mixing in the transit mixing truck depends on the application of the concrete and delivery constraints.
- Central-Mixed – Raw ingredients are completely mixed in a plant mixer before being discharged into a hauling truck. The hauling truck, either a dump truck or transit mix truck, is used primarily to transport the mix.
- Volumetric-Mixed – Raw ingredients are stored separately in a truck-mounted, volumetric mixing unit. These mobile mixing units can supply freshly mixed concrete in fairly precise quantities for small-volume placements. The unit consists of a truck with bins of sand, coarse aggregate, cement, water, and admixtures. The Construction Division must approve the use of volumetric mixing units.

Of these mixing types, the central-mixed process provides the fastest production time and better control of materials. Additionally, when transit mixing trucks are used for mixing purposes, the consistency of the concrete mixture can be variable because each truck and operator can have different mixing characteristics and capabilities. Regardless of the type of mixing process, the inspector should become familiar with the plant and its operation before concrete production begins. By becoming familiar with the plant, the inspector can effectively monitor the quality and quantity of the materials and mix.

Before concrete is produced each day, a gradation test and a moisture test are taken. The test results are reviewed to verify the consistency of the aggregate and to confirm compliance with specification requirements. Field testers, or the plant inspector, conduct moisture tests to calculate the maximum allowable water that may be added to the mix. Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual* lists the appropriate frequencies.

Concrete mix designs state the proportion or quantity of each component of the mix: course aggregate, fine aggregate, water, cement, and admixtures. The proportion of materials is based on an aggregate moisture condition in which the aggregate is saturated with a dry surface (saturated surface dry, SSD), which is the condition assumed for the mix design. The component batch weights must be adjusted to reflect the condition of the moisture content of the aggregate in the field. Adjusted batch weights can be calculated using the Worksheet for Calculating Water in Concrete Aggregate. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a copy of the worksheet and an example calculation. Concrete mixing plants are typically computerized and the mixing plant computer prints the concrete mix batch weights, based on SSD conditions. Although the mixing plants are computerized, inspectors still must calculate adjusted batch weights for aggregate.

Based on the adjusted batch weights for aggregate, the inspector calculates the maximum amount of water that can be added to the mix. The amount of water that may be added to the mix—at the plant, at the structure, or both—is the difference between the maximum allowable water established in the mix design and the free water available from the moisture in the aggregates. Aggregate moisture greater than the SSD moisture is free moisture. By using the mix design and the daily moisture content test results, the inspector uses the Worksheet for Calculating Water in Concrete Aggregate to calculate the maximum allowable water that can be added to the mix. Following is an example of how to calculate maximum allowable water that can be added to a mix:

Theoretical (from mix design):
Water = 275 lbs per cubic yard, based on SSD condition
Total absorbed water in aggregate = 87 lbs, in SSD condition

Field conditions (from moisture tests):
Total water in aggregate = 190 lbs, actual conditions

Calculation:
Free water = 190 lbs – 87 lbs = 103 lbs

Maximum allowable water = 275 lbs – 103 lbs = 172 lbs
Converting to gallons = 172 lbs / 8.333 lbs per gallon = 21 gals per yd^3

For a typical 8 yd^3 load, the maximum allowable water would be 21 gals x 8 yd^3 = 168 gals

After calculating the maximum allowable water, the inspector notes this information on NDOT form 040-025, “Transit-Mix Concrete Delivery Form.” The inspector also notes on the form the actual water added at the plant, admixtures, and additional information relating to the plant operation. The form is prepared for each load and given to the transit truck driver, who gives it to the inspector at the structure. The inspector confirms that the total water does not exceed the maximum allowable water noted on the form.

Not only are the mixing and proportioning of the materials important, weather conditions during concrete placement can constrain and affect the quality and durability of the concrete.

6-501.6 WEATHER

6-501.6.1 GENERAL

Weather conditions during placement and curing can affect the quality of concrete, even though weather may not be extreme. The inspector should be aware of the following general considerations to reduce the effects of weather during concrete placement:

- Pre-wetting surfaces that will be in contact with freshly placed concrete to reduce water loss from concrete
- Limiting transit time to reduce the potential of stiffening of the mixture, typically within 90 minutes of introducing mixing water to the cement and aggregates
- Limiting concrete temperatures to less than 90°F during placement to maintain workability and to reduce water demand
- Placing curing seal as soon as possible after finishing to reduce evaporation
- Limiting finishing time to reduce migration of water to the surface, leading to additional evaporation
- During finishing, adding of water to the surface by fogging or misting should be minimal; application of water by sprinkling is not allowed because it leads to inconsistencies in the mixture which can lead to scaling or cracking
- Monitoring concrete surface temperature to determine if corrective measures are needed to offset the effects of weather

Cold weather, hot weather, and windy conditions can all affect the quality of concrete. During the spring and fall seasons, temperature differentials can be significant and require special attention. Coordination between the Resident Engineer, inspector, and contractor ensures that the contractor's planning for weather conditions provides sufficient protection of the concrete during placement and curing. At the time of concrete placement, the contractor must closely monitor the weather forecast and the temperature of the concrete. Having sufficient materials available before placement begins increases the options available for protecting the concrete. Wind accelerates the loss of moisture from newly placed concrete. Constructing windbreaks to protect fresh concrete reduces the effect of wind. The following sections describe the effects of cold and hot weather on concrete and precautions that the contractor takes to ensure that the concrete cures as desired.

6-501.6.2 COLD WEATHER

Cold weather concreting is common throughout Nevada, even in the southern Nevada climate. Every cold weather application must be considered carefully to accommodate unique situations. The American Concrete Institute defines cold-weather concreting as "a period when for more than three successive days the average daily air temperature drops below 5°C (40°F) and stays below 10°C (50°F) for more than one-half of any 24 hour period." Such temperature conditions can lead to problems with concrete freezing before it hardens or delayed cure time due to reduced heat of hydration.

During cold weather, the primary objectives of concrete placement are as follows:

- Prevent concrete from freezing
- Assure concrete reaches sufficient strength for loading or form removal
- Maintain normal curing conditions
- Limit rapid temperature changes

During cold weather, humidity can be lower than it is during hot weather. The lower humidity can cause greater moisture loss than during hot weather. Therefore, the contractor must protect concrete from moisture loss during cold weather concrete placement and curing.

During cold weather, the placement and curing of the concrete requires close observation by the inspector. Before the contractor places concrete in cold weather, the inspector checks that the temperature of surfaces in contact with the concrete are above freezing and that the contractor has removed snow, ice, and frost. Materials to be embedded in the concrete, such as reinforcing steel, should have temperatures above 40°F. The temperature differential between the coldest or warmest part of the surface and the delivered concrete must be less than 30°F. When concrete is placed on steel structures, the contractor may heat the under side of the structure to reduce the temperature differential. The contractor should never place concrete on a frozen surface. To protect the surface from freezing before concrete placement, the surface can be covered with insulated blankets a few days before concrete placement.

Concrete's exposure to cold weather will extend the time required for it to gain strength. In structures that will carry large loads prior to completion of the curing process, the concrete temperature must be maintained at a minimum of 50°F to accommodate stripping of forms and shoring and to permit loading of the structure.

Never allow concrete to freeze during the curing period. As concrete cures, it produces heat. Some concrete may need protection to reduce the heat from escaping while it cures; more severe temperatures may require supplemental heat, such as heaters. The contractor should not apply heat directly to the concrete surface; heat the air, not the structure. Monitoring concrete temperature during cold weather requires a recording thermometer, as described in the specifications.

If the specifications require a Concrete Quality Control Plan, the plan should address the following cold weather considerations:

- Maintain specified temperatures throughout the entire operation. Fresh concrete has temperature requirements as well as the hardened concrete.
- Protect individual components used in concrete from the adverse effects of cold weather.
- Protect aggregate stockpiles from freezing, so that frozen aggregate is not introduced into the mix. Use insulating blankets and steam to keep aggregate from freezing.
- Warm reinforcing steel and beams before placing concrete to preclude differential temperatures in the concrete.
- Heat mixing water, either at the plant or in the trucks. Take care to use water that is not too hot.
- Typically, do not heat cement; merely protect it from the elements.
- Follow the manufacturer's recommended temperature ranges, as liquid admixtures are susceptible to degradation from extreme temperatures.
- Use insulating blankets to protect underlying base materials and the forms from freezing
- Use insulating blankets to protect freshly placed concrete from cold weather.

6-501.6.3 HOT WEATHER

When mixing, transporting, and placing concrete, it is important to understand the effects of hot weather, low humidity, solar radiation, and wind on concrete properties and construction operations. Hot weather can result in rapid moisture loss on the surface of recently placed concrete, resulting in plastic shrinkage cracking and accelerated setting time. Hot weather can also speed up cement hydration and create the potential for cracking in large concrete structures. Although hot weather–related problems usually occur in the summer, the combination of low humidity and high winds can also lead to rapid moisture loss, even during winter months, particularly in arid climates. Generally, high humidity reduces the effects of high temperatures.

In hot weather, the following conditions can cause problems during concrete mixing or placement:

- Water demand
- Rate of slump loss, which increases the tendency to add water at the jobsite
- Rate of setting, resulting in difficult handling, finishing, and the risk of cold joint

Improper curing during hot weather can cause the following problems with the concrete:

- Decreased strength
- Increased rate of evaporation, causing shrinkage and thermal cracking
- Decreased durability from cracking
- Increased permeability
- Increased potential for reinforcing steel corrosion due to increased cracking

The contractor can take a variety of precautions to reduce the effects of hot weather on concrete. The precautions used for a specific situation depend on the conditions when the concrete is placed. According to the American Concrete Institute, if the temperature at the time of concrete placement will exceed 77°F, precautions must be taken to address the effects of hot weather. The contractor's Concrete Quality Control Plan, as described in Section 6-502.2, should incorporate precautions that reduce the effects of high temperatures. The precautions may include some or all of the following:

- Maintain specified temperatures throughout the operation. Both fresh concrete and hardened concrete have temperature requirements.
- Reduce the delivery time.
- Moisten subgrade, steel reinforcement, and forms before placing concrete.
- Erect temporary wind breaks to limit wind velocities and sunshades to reduce concrete surface temperatures.
- Cool the components of the concrete to reduce its initial temperature. Follow these temperature-reducing guidelines:
    - Reducing the aggregate temperature two degrees reduces the concrete temperature one degree.
    - Reducing the water temperature four degrees reduces the concrete temperature one degree.
    - Reducing the cement temperature eight degrees reduces the concrete temperature one degree.
- Substitute ice for a portion of the water in the concrete to lower the temperature. When substituting ice for a portion of the water, account for the ice in the mix.
- Use a concrete consistency that allows rapid placement and consolidation.
- Apply water to the outside of transit truck drums, being careful to keep water from entering the drum.
- Use water-chilling systems internal to the freshly placed concrete for large concrete placements.

- Protect the concrete surface during placement with plastic sheeting or evaporation retarders to maintain the initial moisture in the concrete.
- Provide sufficient labor to minimize the time required to place and finish the concrete, as hot weather conditions substantially shorten the time for the concrete to harden.
- Fog or mist the area above the concrete placement to raise the relative humidity and reduce the evaporation rate. Care must be taken not to allow accumulation of water on the concrete surface.
- Provide appropriate curing methods as soon as possible.
- Adjust the time of concrete placement during the day to take advantage of cooler temperatures, such as early morning or nighttime placement.

6-501.7 CURING

Curing is the process of controlling the concrete moisture content and temperature while the chemical reaction between cement and water (hydration)—which started during mixing—continues, and the concrete begins to harden. Proper curing is essential to quality concrete. Curing influences the properties of hardened concrete, such as durability, strength, permeability, and resistance to abrasion, freezing, thawing, and deicer chemicals. Proper curing is critical on large concrete surface areas exposed to the atmosphere. Improper curing can significantly reduce the strength of concrete. Section 6-501.6, Weather Limitations, provides guidance on temperature control.

Curing the concrete aids the chemical reaction called hydration. Although most freshly mixed concrete contains more water than required for complete hydration, any appreciable loss of water by evaporation can delay or prevent hydration. If temperatures are favorable (50°F to 75°F), hydration is relatively rapid the first few days after concrete is placed. Retaining water during the first 48 hours is important to the hydration process. Good curing prevents or reduces evaporation. The inspector monitors the environmental conditions during the curing period and records information on NDOT form 040-024, "Concrete Evaporation Rate and Cure Monitoring."

Using the subgrade or forms to restrain the concrete helps to maintain temperatures and control evaporation. For concrete exposed to the atmosphere, following are the two most common methods of curing:

- Wet cure method – This method, called the water method in the specifications, consists of applying water to the concrete for at least seven days after placing. Bridge decks and approach slabs, which typically use high performance concrete, require a wet cure of at least 10 days. To maintain moisture, the contractor places moist burlap or cotton mats on the concrete. On bridge decks and approach slabs, use of wet burlap and plastic coverings are required.
- Curing compound method – This curing method consists of applying a liquid chemical to the surface of the wet concrete, forming a membrane that retains moisture in the concrete. Apply curing compounds after finishing and immediately after the initial sheen dissipates. Where curing compound has been applied, protect the surface by minimizing foot traffic that could damage the membrane. Immediately repair damaged membranes.

Membrane-forming curing compounds are typically clear or white pigmented. Clear curing compounds may contain a dissipating dye (usually red) that makes it easier to see if the concrete surface is completely covered with the compound. The coloring disappears after several days. White pigmented curing compounds have the added benefit of light reflectivity, which helps keep the concrete cool, thereby improving the hydration process. White-pigmented curing compounds are used on concrete pavements where reflectivity aids in cooling the large surface areas exposed to the atmosphere.

Regardless of the curing method, the concrete may require supplemental heating or cooling to maintain favorable curing temperatures.

The reactions between cement and water are accompanied by escaping heat. A part of this heat escapes through the surface of the concrete mass, but some heat is retained, creating a rise in the internal concrete temperature. Excessive internal temperatures may reduce the concrete strength and create internal stresses that cause cracks. In large concrete masses that may be part of major bridge structures, internal cooling may be necessary to control increasing temperatures in the concrete. Chilled water, circulated through a network of pipes embedded in the concrete, controls the temperature and cools the concrete mass. Figures 6-501.1 and 6-501.2 show a cooling system and component piping for a footing prior to the placement of concrete.

Figure 6-501.1. Cooling System for a Mass Concrete Footing.

Figure 6-501.2. Component Cooling Pipes in Footing.

6-501.8 MAJOR AND MINOR CONCRETE

Depending on the size of the concrete structure being constructed, concrete items of work may be classified as Major Concrete or Minor Concrete. Although the physical characteristics of major and minor concrete are the same, major concrete is used on structures such as bridges and box culverts, and minor concrete is used on structures such as drop inlets and catch basins. Minor concrete has higher labor and forming costs associated with a relatively small quantity of concrete, in contrast to major concrete, which has costs distributed over a larger quantity of concrete. To account for small concrete quantities, the work item of “Minor Concrete” is used. The term “Minor Concrete” refers only to the work item and the manner of payment, not to testing, sampling, and inspection.

6-502 CONCRETE STRUCTURES

6-502.1 GENERAL

This section covers items related to constructing structures. Structures include bridges, grade separations, structure approach slabs, culverts, headwalls, endwalls, drainage inlets, and retaining walls. Structures can be constructed with concrete or steel. Even steel structures contain a number of components that are made with concrete.

A major structure, like a bridge, consists of the following components:

- Piles
- Footing
- Pier columns
- Pier cap
- Abutments
- Girders and diaphragms
- Bridge deck
- Parapet (bridge rail)
- Approach slab

Figure 6-502.1 shows the bridge components.

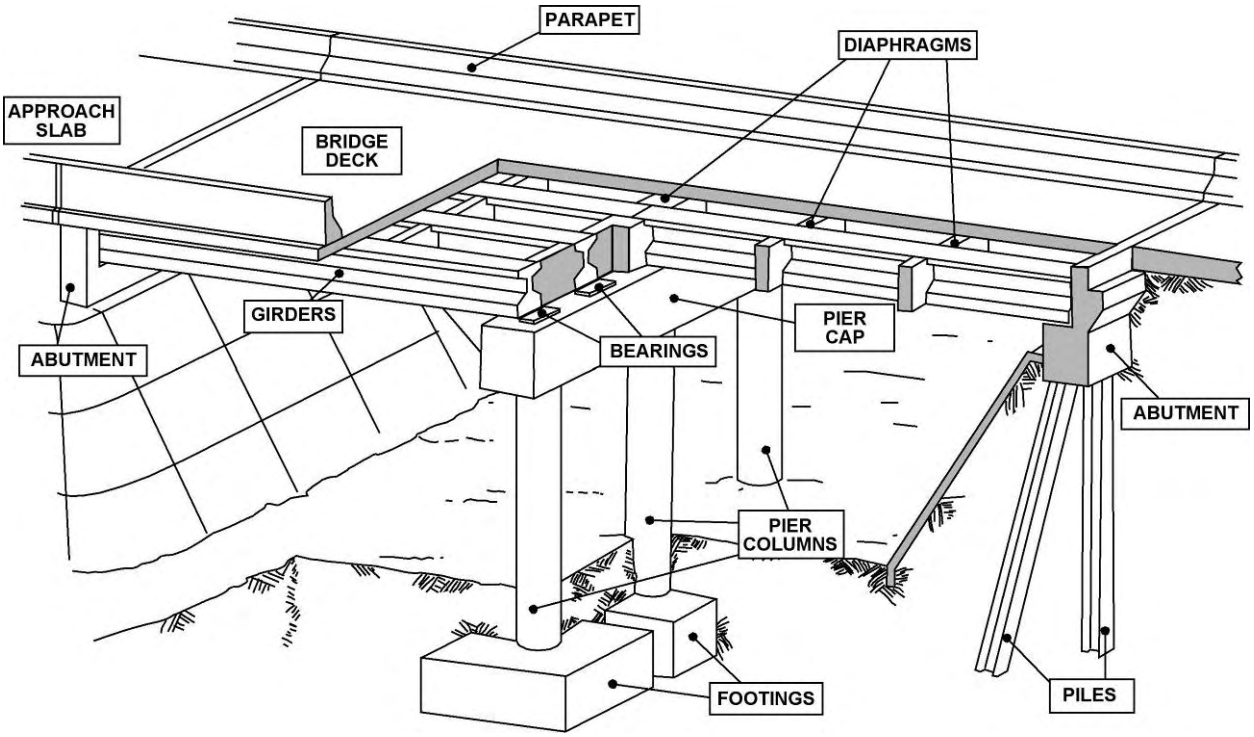

Figure 6-502.1. Typical Bridge Components.

The basic purpose of a bridge is to carry traffic across an obstacle or depression. The vehicles travel on the bridge deck, which is supported by the superstructure. The superstructure is supported by abutments at the ends of the bridge and columns between the abutments. Columns and abutments are supported by foundations, which rest on the soil. On the sides of the bridge deck are parapets that keep vehicles from straying off the bridge.

NDOT designs and constructs several types of bridges. The selection of the bridge type depends on the following criteria:

- Ability to maintain traffic during construction
- Construction time constraints
- Availability of construction materials
- Cost of construction materials
- Roadway geometry constraints
- Design complexity related to roadway geometry
- Environmental constraints
- Hydraulic constraints
- Subsurface characteristics
- Aesthetics
- Cost to maintain

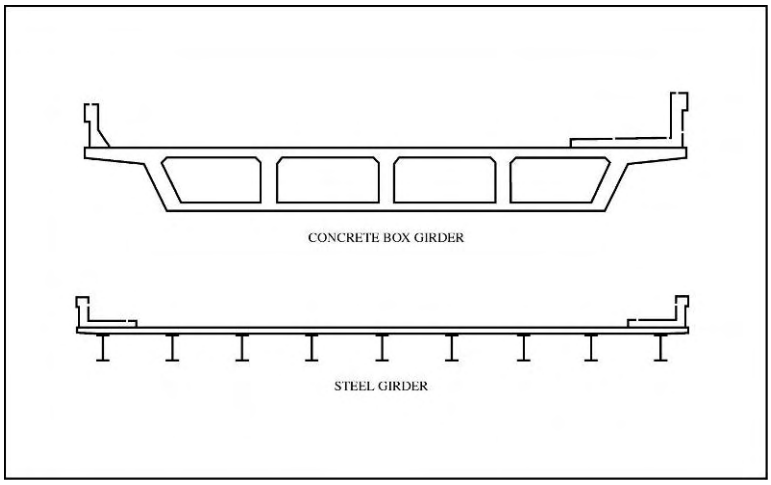

Figure 6-502.2. Common NDOT Bridge Types.

Most NDOT bridges are constructed of concrete or structural steel. Figure 6-502.2 shows the cross section of a typical concrete box girder and a steel girder bridge. Although timber structures still exist in rural areas where traffic volumes are low, new construction typically consists of cast-in-place concrete box girders (Figure 6-502.3), precast concrete girders (Figure 6-502.4), and structural steel girders (Figure 6-502.5). Cast-in-place concrete box girder bridges are the most common type of bridge in Nevada.

Figure 6-502.3. Cast-in-Place Concrete Box Girder Bridge.

Figure 6-502.4. Segmental Precast Concrete Box Girder Bridge Under Construction.

Figure 6-502.5. Structural Steel Bridge.

Many of the construction details required for concrete bridges apply to steel bridges. The difference between concrete bridges and steel bridges is that the superstructure of a steel bridge is made of steel.

Bridge construction begins with foundations constructed on prepared soil or aggregate base. A basic foundation is a large block of concrete, called a footing, which sits on the soil. If the soil does not have sufficient strength to support the design loads, a footing with more surface area is used, spreading the load over a larger area. This is called a spread footing. When the native soil does not have sufficient strength to support a spread footing, deep foundations are constructed to support the footing. Deep foundations are steel or concrete columns, called piles, placed in the ground. Deep foundations support loads through friction between the pile and the soil and through end bearing.

Columns and abutments are constructed on footings. The superstructure is constructed on the columns and on the abutment. Depending on the design, the superstructure may rest on the columns or be connected to them. Concrete structural members may be cast-in-place (concrete is placed in forms at the jobsite) or precast (concrete is placed in forms offsite, then transported to the jobsite). In Nevada, most concrete structures are cast-in-place. For cast-in-place concrete superstructures, a temporary framework supports the forms, equipment, people, and concrete when the superstructure is being built. This temporary framework is called falsework. Following construction of the superstructure, the bridge deck is constructed, followed by the parapets. After the concrete has reached a sufficient strength, the falsework and forms are removed.

Construction of major bridge structures are complex and require continuing coordination and communication among the Resident Engineer, inspector, testers, survey crew, bridge designer, and the contractor. Because of the complexity associated with constructing a bridge, poor materials or inferior construction methods can significantly impact quality and the safety of project personnel and the public. Therefore, the Resident Engineer, inspector, testers, and survey crew must thoroughly understand the bridge construction details to verify that the contractor constructs the project consistent with the plans and specifications. Unique situations may involve railroads, other utilities, environmental factors, or new construction techniques. Early coordination between the contractor, Resident Engineer, Structures Division, and third parties increases the understanding of all parties and provides greater efficiencies during construction.

6-502.1.1 SAFETY

During the construction of structures, personnel regularly handle and move materials and equipment. Therefore, everyone on the project must be alert to movement of materials and equipment. By being aware of surroundings, personnel avoid placing themselves in unsafe situations and reduce the chances of being struck by a moving vehicle, backing transit truck, construction equipment, or the traveling public.

A worker may be required to perform duties that require protection against falls. For construction projects, OSHA requires fall protection if a worker is at risk of falling six feet or more. However, regardless of the fall distance, fall protection is required when working over dangerous equipment, machinery, or traffic.

The contractor is required by specifications and by OSHA to develop a safety plan. The contractor submits a safety plan to the Resident Engineer for review and comment. NDOT employees must follow NDOT safety policies. NDOT safety policies provide direction on personal protective equipment. Personnel should wear personal protective equipment, such as gloves, foot and eye protection, protective hearing devices, hard hats, and respirators, to minimize exposure to a variety of hazards. Additionally, the contractor may require NDOT employees to comply with the contractor's safety plan.

When constructing structures, reinforcing steel is present throughout the structure jobsite. Reinforcing steel presents situations that require the full attention of workers and other field personnel. Field personnel must exercise care when walking on reinforcing steel to guard against twisted ankles and sprains. If inspectors and workers must walk on horizontal reinforcing steel, which is common in footings and bridge decks, they should only walk on the uppermost horizontal bar. Vertical reinforcing steel can also create safety problems. The contractor must cap exposed ends of reinforcing steel bars with blunt, protective caps that can protect a person who may fall on the steel.

6-502.2 BEFORE CONSTRUCTION

An inspector must thoroughly understand the plans and specifications relating to construction of bridges or other structures. The specifications will describe specific limitations or requirements associated with environmental permits or agreements with third parties, such as railroads or utilities. Additionally, coordinate with the contractor about the planned sequence of operations so that inspection and testing can be performed effectively and efficiently. An important part of communication and coordination is the Concrete Quality Control Plan that the specifications may require the contractor to prepare on projects with major concrete structures. The specifications require the contractor to prepare a Concrete Quality Control Plan that addresses the following items:

- Concrete production
- Quality control testing
- Transport
- Placement
- Finishing
- Curing
- Contingency plans for equipment breakdown or inclement weather

Because the Concrete Quality Control Plan responds to the unique requirements of each project, the Resident Engineer must verify that the contractor's plan conforms to the specific requirements of the project. It is acceptable for a contractor to submit a Concrete Quality Control Plans for an entire project, and then submit a supplemental plan that includes details for concrete placement at specific structures. After the contractor prepares a Concrete Quality Control Plan, the Resident Engineer reviews and approves it. During the review, the Resident Engineer may consult with the Construction Division, Structures Division, and Materials Division. If review comments require modification to the plan, the Resident Engineer provides the comments to the contractor who revises the plan and resubmits it for approval. The Resident Engineer must approve the plan before the contractor can place any concrete. The field crew should be familiar with the contents of the approved Concrete Quality Control Plan. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for an example of a contractor's Concrete Quality Control Plan.

For concrete structures, the contractor must perform engineering and surveying for various elements of the work.

- Engineering – The contractor engineers the form design, falsework, and other construction details relating to the means and methods that the contractor elects to use in the construction of the structure. Any engineering performed by the contractor must be stamped or certified as described in the specifications. The contractor's approved engineered drawings become the basis for the inspector to verify that the work is constructed as planned. Refer to Section 3-403.3, Submittals, of this *Construction Manual* for additional details.
- Surveying – The contractor performs the surveying needed to construct all parts of the bridge. The inspector confirms that the contractor completes the required surveying needed to construct the work. In addition, the survey crew verifies the accuracy of the contractor's surveying.

Falsework is the temporary structure that the contractor builds to support forms for the structure being constructed. The contractor is required to submit engineered drawings for falsework. The contractor should also include falsework erection and demolition plans. The Resident Engineer reviews the falsework drawings to determine if the drawings are complete and conform to the specifications. If the Resident Engineer finds the submitted drawings acceptable, the drawings are submitted to the Structures Division for review and approval. If the structure will cross a railroad, sufficient time should be allowed for review by the railroad company.

Following an initial review, the contractor may be required to revise the drawings or to submit additional information. Once approved, the contractor must erect the falsework in conformance with the approved drawings. Deviation from the approved falsework drawings is not allowed without prior approval from the Structure's Division. The inspector observes the construction of the falsework to verify conformance with the approved drawings.

During the Resident Engineer's review of the contractor's submitted drawings, the following should be considered:

- Confirm that the contractor's falsework drawings conform to the plans and specifications and that the drawings incorporate structure-specific details
- Determine if a falsework erection or a demolition plan is needed, and that a traffic control plan has been incorporated
- Verify that the falsework drawings include details to prevent falling debris, and protection of pedestrians and motorists
- Verify that the falsework drawings include details that would prevent water from dripping on pedestrians and motorists during deck curing

When inspecting falsework, the following should be considered:

- Confirm that soil compaction test results for falsework support elements conform to specifications
- Observe the contractor's installation of tattle-tales. Tattle-tales are devices used to monitor falsework settlement and movement. Confirm tattle-tale readings are taken prior to concrete placement.
- Verify that the contractor follows the approved safety plan and provides fall protection and other personal protective equipment during falsework installation
- Confirm that the contractor's Engineer of Record for the falsework reviews the falsework system onsite and provides written certification that the falsework system has been assembled according to the approved falsework drawings and approved revisions

All elements of bridge construction must strictly conform to the plan details, including reinforcing steel, steel spacing, steel clearances, and concrete dimensions. Project personnel cannot substitute or modify the plan details without prior approval from the Resident Engineer, who consults with the Structures Division. Even apparent minor modifications can significantly alter a structure's performance or behavior. For example, using reinforcing steel of a larger diameter than specified or increasing concrete dimensions can increase the rigidity and loading of the structure, conflicting with the structural designer's assumptions.

A pre-pour conference is required before concrete placement of any major structure. Required attendees include key NDOT personnel (including representatives from the Construction Division, Structures Division, and Materials Division), the contractor, concrete material suppliers, and other appropriate invitees of the Resident Engineer. Discussions at the pre-pour conference include key aspects of the concrete placement activities, such as mixing, finishing, curing, and traffic safety. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a structures pre-pour conference agenda.

Before concrete placement, the contractor and inspectors make final preparations at the concrete mixing plant and at the structure site. Each location, mixing plant and structure site, typically has an inspector who monitors materials and operations. Section 6-501.5, Mixing Plant, describes mixing plant inspection.

As with the plant inspector, the inspector at the structure must be completely familiar with the plans and specifications to monitor the work and materials effectively. Before concrete arrives at the structure, the forms and reinforcing steel must be inspected. The testers must be familiar with the concrete mix design, and the materials specifications related to concrete.

Forms can be made of many types of materials, depending upon the type of construction, methods of placement, and in many cases, economics. Wood is the most common form material. Plywood is used extensively for forms. Lumber with knots, splits, warps, and other defects that may affect the concrete surface is not allowed. Lumber used in forming should have adequate strength and rigidity, as well as surface smoothness where required. Corrugated metal and prefabricated metal can also be used for forms. Fiber forms, shaped as circular tubes, may be used for constructing small columns of limited height

Bracing prevents forms from moving or becoming misaligned when they are supporting concrete, people, or equipment. If forms move or become misaligned, they must be corrected. Form oil or other approved coating is applied before the forms are placed. The contractor must be careful not to get the coating on reinforcing steel. Coating on the reinforcing steel will reduce the bonding between the steel and the concrete. The coating allows the forms to be removed without damaging the concrete.

When inspecting formwork, follow these tolerance guidelines.

Variation from plumb or batter in the lines and surfaces of columns, piers, abutment, and girder walls	
In any 10-foot or less length:	3/8-inch
Maximum for the entire length:	1-inch
Variation in cross-sectional dimensions of columns, piers, girders, and thickness of walls and slabs	
+1/2-inch	
-1/4-inch	
Girder alignments (deviation from a line parallel to center line of girder measured between diaphragms)	
1/2-inch up to 40-foot lengths	
3/4-inch up to 60-foot lengths	
1-inch greater than 60 foot-lengths	
Variations from the level of the grades indicated on the drawings in slabs, beams, horizontal grooves, and railings	
Exposed, in 10 feet:	1/2-inch
Backfilled, in 10 feet:	1-inch
Variations in footing dimensions	
Greater than specified:	No limit (does not apply to reinforcing steel placement)
Less than specified:	5 percent of specified thickness up to a maximum of 1-inch
Variations of precast members	
Tolerances for precast members are in Section 503.03.10 of the specifications	

Once the forms are in place, the contractor places the reinforcing steel. Before placement of the reinforcing steel, the contractor supplies samples and certificates of compliance. Reinforcing steel details in the plans describe reinforcing steel size (diameter), length, shape, and configuration. If the contractor wants to deviate from the details contained in the plans, he or she must submit shop drawings or bending diagrams to the Resident Engineer for review and approval. If reinforcing steel diagrams have been accepted, the inspector must have the current shop drawings to verify that proper reinforcing steel is placed at the prescribed locations in the structure. If the structure incorporates prestressing, refer to Section 6-503, Prestressed Concrete Members.

During placement, the inspector must monitor clearances between adjacent reinforcements and between reinforcing steel and forms. It is important that bars are placed and held in position as shown on the plans. Improper positioning of reinforcing bars can affect the strength of any concrete structure. Refer to Section 6-505.3 for allowable tolerances for reinforcing steel placement and for sampling requirements. On horizontal flat surfaces, such as bridge decks, the reinforcing steel is supported by a variety of supports-like wire frames, called chairs, or precast concrete blocks, called dobies. A layer of reinforcing steel is called a mat. Within a mat, as a piece of reinforcing steel, or bar, crosses over another, the bars are tied together with “tie wire.” The specifications state the amount of bar intersections that must be tied, depending on the spacing between adjacent bars. Refer to Section 6-505, Reinforcing Steel, for additional details. Refer to Section 6-503.2 for guidance on placement of post-tension ducts.

With forms and reinforcing steel in place, the inspector confirms that the equipment and tools that will be used in the placement, consolidation, and finishing operations are onsite and in good working order. On most parts of a structure, forms cover concrete surfaces that will be exposed. In these cases, the primary equipment is a vibrator used to consolidate the concrete. In the case of a bridge deck, the large surface area is exposed throughout the placement, consolidation, and finishing operations. To accomplish the operation efficiently, a self-propelled mechanical paving machine is used for bridge decks. The paving machine requires substantial setup and preparation. Once setup is complete, the machine is operated without concrete to confirm it will produce the required grade and depth. The inspector observes the trial run, and measures the distance between the bottom of the screed and the top reinforcing steel in the deck (top clearance), and the bottom of the screed and the form (deck thickness). Figure 6-502.6 shows a bridge deck paving machine in operation.

The key to a successful concrete placement and finishing operation is careful preparation. By inspecting materials, forms, reinforcing steel, and equipment, the bridge is prepared to receive concrete.

Figure 6-502.6. Bridge Deck Paving Machine.

6-502.3 DURING CONSTRUCTION

With the concrete plant beginning production, the inspector coordinates with the testers to confirm their availability. The inspector, through coordination with the contractor, estimates the projected quantity of concrete to be placed and the duration of the daily placement operation. By anticipating the quantity of concrete and duration of placement, the inspector can better coordinate activities associated with the operation.

Because transit-mix trucks cannot always access the specific location of the placement, the following alternative placement methods are available:

- Unloading the transit-mix truck into a pumping truck, which pumps the concrete to the forms for placement.
- Loading the concrete into a bucket with a minimum capacity of three cubic yards. The bucket is hoisted by a crane and moved to the placement location, where the concrete is released into place.
- Using a portable conveyor belt system.

Regardless of the placement method, the concrete cannot freefall more than five feet. Typically, a tremie is used to comply with this requirement.

Because the specifications contain time limitations on mixing and delivery, the inspector must know the limits for the type of mixing and delivery used for the concrete. For example, the time limitation for transit-mix delivery is 90 minutes from the time water is introduced to the mix until the mix is discharged. In contrast, for concrete mixed at a central plant and transported using non-agitating hauling equipment, the time limitation is 45 minutes from the time water is introduced to the mix until the mix is discharged. Time limits may be extended with the addition of admixtures. However, the effects of the admixture on the concrete must be considered during the mix design process. Admixtures can not be used without the approval of the Materials Division.

As the first transit-mix truck arrives, the inspector receives the Transit-Mix Concrete Delivery Form. From the Delivery Form, the inspector identifies the amount of water that may be added at the jobsite and completes appropriate sections of the form. The inspector visually inspects the mix for consistency. Typically, at this point, an initial slump test is conducted to confirm that the slump conforms to specifications. If the contractor wants to add water to increase the slump, the inspector may allow it if the Transit-Mix Concrete Delivery Form indicates that the maximum water content has not been reached and the maximum slump has not been exceeded.

Water can be added only before the truck begins unloading the mix for placement. If water is added at the jobsite, the drum must revolve 30 times at mixing speed to produce a homogenous mix. Additional revolutions must be at agitation speed, which is two to six revolutions per minute. The specifications describe the requirements relating to the addition of admixtures. The inspector observes admixtures being added at the jobsite and confirms that the required mixing takes place. Sampling and testing of concrete mixtures must be in accordance with Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*. Samples taken for concrete testing must be from the middle third of a load.

When concrete mix is delivered by hauling trucks instead of transit-mix trucks, water and admixtures are added only at the mixing plant because hauling trucks are not equipped for mixing. As with transit-mix trucks, samples taken from a hauling truck are from the middle third of the load.

Immediately before the concrete is placed in the forms, all surfaces contacting the concrete are sprayed with water. Moistening the surfaces reduces the tendency of water being drawn out of the wet concrete, which negatively affects the hydration process. When the concrete is placed in the forms, the inspector should observe any movement or deflection of the forms or reinforcing steel. The inspector should also inspect the forms to confirm they are leak-proof.

Because an entire concrete structural element is rarely completed with a single concrete placement operation, joints are constructed at the end of the placement operation. These joints are called construction joints. The plans may identify locations for construction joints or the plans may identify locations where construction joints are prohibited. With approval from the Structures Division, the Resident Engineer may allow the contractor to place construction joints at other locations. Proper planning of the placement operation must address the planned joint locations. The Resident Engineer must thoroughly understand the plans to confirm that the contractor is placing construction joints at the proper locations.

Emergencies, such as equipment breakdowns or delivery complications, may arise that require joint placement at unplanned locations. Structures have a variety of stresses throughout all elements. In areas where stresses can be high, the quality and durability of the concrete must also be high. Construction joints are prohibited in areas that require high strength concrete. If the concrete stops at a point at which a joint is prohibited, the contractor may need to remove concrete to construct the joint in an acceptable location. Construction joints are prohibited in the following locations:

- Locations identified on the plans as “no splice” areas for reinforcing steel
- Locations identified on the plans as “no construction joint” areas
- Longitudinal joints (parallel to girders) at mid-points between girders or directly over girders
- Locations identified as negative moment areas (areas denoted with (-) in Figure 6-502.7), located on either side of piers

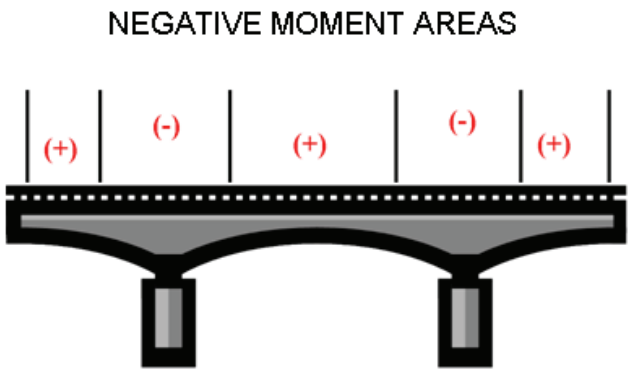

Figure 6-502.7. Negative Moment Areas.

Do not finish construction joint surfaces with a trowel. The joint surface should be straight and unfinished. The rough surface provides improved interlock between the hardened concrete and the newly placed concrete. When the daily concrete placement operation is complete, and joints are constructed, the curing process begins.

Surfaces exposed to the atmosphere must be cured properly to enhance the hydration process, as described in Section 6-501.7, Curing. The contractor must monitor the curing process, the temperature of the concrete, and the adequacy of the wet curing. The inspector should verify that the contractor is monitoring the wet cure operation and that excess water is being contained. Excess water can create environmental problems, interference with traffic, and freezing problems. For bridge decks, after sufficient curing, the deck surface is tested to determine smoothness and rideability. Grinding is required on areas of the bridge deck that do not conform to the specification requirements. Generally, grinding is not permitted until after a 14-day cure and the concrete has reached its specified 28-day compressive strength.

Allowing the forms to remain in place for at least seven days after concrete placement is another means of curing the concrete. If the forms are removed before the concrete has cured seven days, appropriate curing methods must be used on the exposed concrete. Forms are removed when the concrete has hardened sufficiently to prevent spalling or chipping during form removal. The proper time to remove forms depends on the atmospheric temperatures and humidity.

The condition of the concrete should be observed when forms are being removed. The inspector should stop the form removal if the concrete is being damaged. After removal of the forms, a curing compound is applied to the exposed concrete if the specified curing time has not been reached. Forms are always removed from columns before concrete is placed for the superstructure. Removing the column forms first allows the inspector to determine the condition of the concrete in the columns before the weight of the structure is placed on the columns. Bridges that utilize pre-stressed or post-tensioned beams or girders must be stressed before falsework or other support is removed. Refer to Section 6-503, Prestressed Concrete Members.

The inspector observes the workmanship and quality of the materials as soon as the forms are removed because this is the best time to detect any faults in the structure. All defects in exposed concrete must be corrected soon after the forms are removed. Surface areas damaged during form removal must be repaired in conformance with the specifications. The contractor should remove and replace unconsolidated concrete with appropriate concrete patching material as soon as possible.

6-502.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-503 PRESTRESSED CONCRETE MEMBERS

6-503.1 GENERAL

Another reinforcing technique utilizes steel strands threaded through conduits or ducts contained in the completed concrete in conjunction with reinforcing steel. The steel strands are tightened, or tensioned, producing stresses in the beam or girder that counteract those created during the lifecycle of the structure. This reinforcing technique is called prestressing.

Prestressing concrete takes advantage of the concrete's compressive strength and overcomes its weakness in tensile strength. Bridges that utilize prestressed concrete can have longer spans than would be practical using only reinforcing bars to reinforce the concrete. Prestressing tendons (generally of high tensile steel cable or rods) are used to provide a clamping load. Each tendon consists of multiple steel strands. The clamping load produces a compressive stress in the structure that offsets tensile stresses that would otherwise exist when the concrete is loaded. On NDOT projects, prestressing is typically accomplished in two ways, pre-tensioning and post-tensioning:

- Pre-Tensioning – Concrete is cast around tensioned tendons. The cured concrete adheres and bonds to the bars. When the tension is released from the tendons, the tension is transferred to the concrete as compression by static friction. This method requires substantial anchoring points between which the tendon is stretched. The tendons are usually in a straight line. The bond between the tendons and the concrete protects the tendons from corrosion and provides for direct transfer of tension. Pre-tensioned elements are typically prefabricated in a plant and transported to the jobsite. Because pre-tensioned elements fabricated at a factory require transport, the size of the members is limited. Pre-tensioned elements may be beams, girders, foundation piles, pier caps, and columns.

- Post-Tensioning – Concrete is cast around plastic, steel, or aluminum ducts. The alignment of the ducts follows the areas where tension would occur in the concrete element. Concrete is cast around the ducts. The stressing tendons are fished through the ducts either before or after the concrete is cast. After the concrete has gained sufficient strength, hydraulic jacks, which react against the concrete member, tension the tendons. When the tendons have been stressed to the load specified by the design, the tendons are wedged in position, transferring stress to the concrete. The duct is then grouted to protect the tendons from corrosion and to transfer the load to the structure. Post-tensioning is used to construct a variety of bridge types.

6-503.2 BEFORE CONSTRUCTION

Representatives of the Structures Division inspect prestressing that is performed at an off-site factory or yard. For prestressing that is performed on-site, the inspector's responsibilities before the stressing operation are those as described in Section 6-502, Concrete Structures.

6-503.2.1 PRE-TENSIONED GIRDERS

The Structures Division reviews and approves pre-tensioned girder shop drawings after they are submitted to the Resident Engineer. Girder construction can begin as soon as the shop drawings are approved. Typically, the Structures Division Nondestructive Testing Section provides inspection of the pre-tensioned girders. Depending on workload, consultants or the Resident Engineer's inspector may be required to perform inspection and testing. Inspectors assigned by the Resident Engineer must have the required ACI certification. Refer to Section 5-300, Tester Qualification Program, for additional information on materials tester qualifications. The Nondestructive Testing Section provides training on inspection and testing for assigned personnel. Because of the specialized nature of pre-tensioned girders, the Resident Engineer coordinates with the Construction Division and the Nondestructive Testing Section regarding inspection and testing of the pre-tensioned girders. The Resident Engineer should allow two weeks to coordinate personnel and to schedule travel and training, as required.

During the fabrication of pre-tensioned girders, an inspector samples and tests the materials to verify conformance to specifications and the approved mix design. When an inspector samples materials during the fabrication of pre-tensioned girders, the inspector must be ACI-certified. Refer to Section 5-300, Tester Qualification Program, of this *Construction Manual* for additional information on tester qualifications. The inspector also observes the fabrication of girders to verify the girders are constructed in conformance with the approved shop drawings. The girders must be properly sized, the reinforcing steel placed correctly, strands placed in the proper locations, and girders cured and handled in conformance with the specifications.

6-503.2.2 POST-TENSIONED STRUCTURES

The Structures Division reviews and approves post-tensioning shop drawings after they are submitted to the Resident Engineer. The post-tensioning shop drawings typically include the following details:

- Stressing duct locations
- Post-tensioning anchorages and system components
- Number of stressing strands per duct
- Post-tensioning force
- Grouting procedures
- De-tensioning procedures (to be used if de-tensioning is required)
- Acceptable strand losses per tendon, duct, and the structure
- Information on the calibrated pressure gauge and hydraulic ram to be used for post-tensioning operations

When the contractor places the ducts, the inspector must verify that the ducts are placed within 1/4-inch of the location shown on the approved post-tensioning shop drawings. Accurate placement of the ducts is important so that the structure performs as designed.

The stressing tendons or strands are delivered to the project before the stressing operation begins. The Materials Division must test samples of the strands before the material is incorporated into the work. Each spool containing strands has a fabrication number, called a heat number. The inspector must obtain and document the heat number of each spool delivered to the project and verify that each spool is tested and approved by the Materials Division. Each spool must be visually inspected to confirm that it is undamaged. Ducts must be clean of foreign material and debris, which is typically done by blowing air through the duct. The Resident Engineer's inspector should observe that post-tension ducts are properly located as detailed on the approved shop drawings and that system-specific reinforcing steel is properly placed. Before the ducts are enclosed by girder formwork, the inspector should verify that the ducts are not damaged. The primary responsibility of the Resident Engineer's inspector at the structure is to prepare the structure, forms, and materials so that the Structures Division prestressing inspector can begin oversight of the stressing operation.

Typically, the Structures Division Nondestructive Testing Section inspects and monitors the post-tension process. Depending on workload, consultants or the Resident Engineer's inspector may be required to perform inspection and testing. In these instances, the Nondestructive Testing Section provides training on inspection and testing for assigned personnel. When the Resident Engineer's inspector performs the inspection and testing, the Nondestructive Testing Section may still be present during portions of the work. Because of the specialized nature of post-tensioning, the Resident Engineer coordinates with the Construction Division and the Nondestructive Testing Section regarding inspection and testing of the post-tensioning activities. The Resident Engineer should allow two weeks to coordinate personnel and to schedule travel and training, as required.

During the post-tensioning activities, the inspector samples and tests the materials to verify conformance to specifications and the approved mix design. The inspector also observes that the post-tensioning activities conform to the approved shop drawings—the reinforcing steel is placed correctly, strands are placed in the proper locations; and the post-tensioning, concrete placement, and curing all conform to the specifications.

6-503.3 DURING CONSTRUCTION

The Structures Division inspector is supported by the Resident Engineer's inspector during the stressing operation. The Resident Engineer's inspector observes the loading of the strands into the ducts. As strands are loaded, the inspector documents the spool number and heat number of the strand loaded into each duct. On most NDOT prestressing projects, strands are loaded into the ducts after concrete is cast around the ducts. The contractor may, however, load the strands into the ducts first, and then cast the concrete. If the contractor loads the strands first, the contractor must protect the strands according to the specifications. The protection of the strands may include the application of an approved rust inhibitor. Typically a rust inhibitor is not used if stressing is planned to occur within 10 days after placement, unless inclement weather is anticipated. In either situation, the strands are not tensioned until the concrete reaches its specified strength. With the ducts loaded with strands, the contractor stresses the tendons in the sequence detailed in the approved shop drawings. After all tendons are stressed, each duct is grouted. Because of the equipment and activities, all personnel near the stressing operation must be aware of safety considerations.

6-503.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-505 REINFORCING STEEL

6-505.1 GENERAL

Reinforcing bars are steel that has been milled into rods with cross-hatchings, called deformations, that help concrete bond with the reinforcing steel. Reinforcing steel is commonly called rebar. When exposed to deicing salts and other chemicals, rebar can corrode, leading to possible accelerated deterioration of the structure. To protect the steel from corrosive elements, reinforcing steel is coated with epoxy. Epoxy coated rebar is typically used in northern Nevada where deicing chemicals are commonly used on roadways. Reinforcing steel is classified by several characteristics. The principal ones are grade (strength of the steel) and diameter of the bar. Common grades of reinforcing steel are as follows:

- Grade 40: Minimum strength 40,000 pounds per square inch (psi)
- Grade 60: Minimum strength 60,000 psi
- Grade 75: Minimum strength 75,000 psi

Reinforcing steel used in NDOT structures must comply with American Association of State Highway and Transportation Officials (AASHTO) M31 (Grade 60) or American Society for Testing and Materials (ASTM) standards (A706). The plans will state the type of steel to be used.

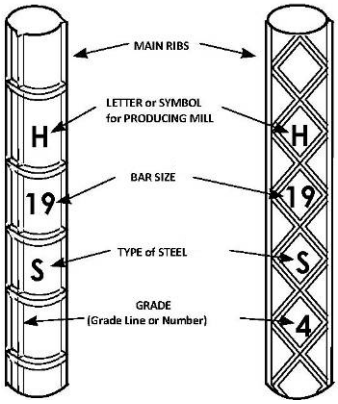

Figure 6-505.1. Reinforcing Bar Markings.

For reinforcing steel bars up to an inch in diameter, the size designation is based on the cross-sectional diameter of the bar, measured in eighths of an inch. Bars are marked with markings that identify producing mill, bar size, steel type, and grade. Most mills use metric bar size markings. Figure 6-505.1 shows typical bar markings. Table 6.1 describes common sizes of reinforcing steel.

TABLE 6.1 – Standard Reinforcing Bar Designations					
Bar Designation Number	Metric Bar Designation Number	Nominal Bar Diameter (fractions of an inch)	Nominal Bar Diameter (decimals of an inch)	Weight (pounds per foot)	Cross Sectional Area (square inches)
3	10	3/8	0.375	0.376	0.11
4	13	1/2	0.500	0.668	0.20
5	16	5/8	0.625	1.043	0.31
6	19	3/4	0.750	1.502	0.44
7	22	7/8	0.875	2.044	0.60
8	25	1	1.000	2.670	0.79
9	29	1-1/8	1.128	3.400	1.00
10	32	1-1/4	1.270	4.303	1.27
11	36	1-3/8	1.410	5.313	1.56
14	43	1-3/4	1.693	7.650	2.25
18	57	2-1/4	2.257	13.600	4.00

Reinforcing steel has deformations, or ridges, that bind it mechanically to the concrete with friction. Even with these deformations, reinforcing steel can still be pulled out of the concrete under high stresses. To prevent this type of failure, reinforcing steel is either deeply embedded into adjacent structural members, or is bent and hooked to lock it around the concrete and other reinforcing steel.

Each structure has unique bent bar requirements. The bent bar requirements are detailed in the plans. The details identify the type of steel, bar size, and the dimensions of the reinforcing steel. Figure 6-505.2 shows a typical bending diagram for reinforcing steel on an NDOT project. The bar is 2 feet 8 inches long and is to be bent with three legs—two 9 inches and the other 1 foot 2 inches. The identifying designation of the bar is W4028. The characters in the designation describe the following:

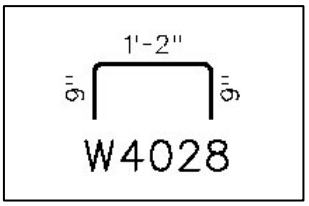

Figure 6-505.2. Example Rebar Bending Designation.

W: The bar will be placed in the wingwall.

4: Diameter of the bar (No. 4 bar – 1/2-inch or 0.50-inch diameter)

028: Length of bar, measured in feet and inches (2 feet, 8 inches)

Note: If the bar is to be epoxy coated, the designation would contain the letter E after the length (W4028E).

At times, reinforcing steel must be joined to create a continuous length of reinforcement. Joining one piece to another is called splicing. Reinforcing steel splices allow loads to be transmitted continuously along the total length of the joined reinforcing steel. The three methods of splicing are lap splices, mechanical splices, and welded splices.

- Lap Splices – Lap splices are the most commonly used splice and are typically used for smaller-diameter horizontal and vertical reinforcing steel. A lap involves two pieces of rebar overlapped to create a continuous line of rebar. The length of the lap varies depending on a number of things, including the concrete strength, the rebar grade, size, and spacing. Project plans state lap length based on the diameter of the reinforcing steel.
- Mechanical splices – Mechanical splices are typically used when space limitations prevent a lap splice or for larger-diameter horizontal and vertical reinforcing steel. Mechanical splices are proprietary and supplied by a number of manufacturers. A common type of mechanical splice is a threaded coupler in which two pieces of rebar are threaded and screwed into the coupler. The use of mechanical splices must be approved by the Structures Division.
- Welded Splices – Welded splices are typically used to splice two pieces of reinforcing steel with large diameters. The two pieces are welded end-to-end, called butt-welded. The use of welded splices must be approved by the Structures Division. Use of welded splices requires a submittal of welder's qualifications and welding procedures.

6-505.2 BEFORE CONSTRUCTION

In preparation of construction, the inspector observes the delivery and placement of reinforcing steel. When delivered to the project, the inspector obtains certificates of compliance for each heat, or production run, represented by the delivery. Also contained in the certification is information that allows for the determination if the steel complies with Buy America requirements. Refer to Section 3-403.3.1.4, Buy America Certification. In storage, the reinforcing steel should be protected from corrosive elements, including water and soil. Reinforcing steel is typically stored on wooden blocks, called dunnage, keeping the steel off the ground.

Depending on the steel's exposure to the elements, rust may form on the steel. While some rust is not detrimental, excessive rust may warrant cleaning of the reinforcing steel or rejection of the reinforcing steel if the cross-sectional area is reduced because of the rust.

6-505.3 DURING CONSTRUCTION

Inspecting reinforcing steel requires attention to the condition of the reinforcing steel and placement. The steel must be clean and free of foreign material and other debris, including grease. Bonded rust or mill scale can remain on the steel as long as the rust does not create section loss (Figure 6-505.3). Most loose rust will be removed by the handling of the steel during placement. A small amount of loose, powdery rust is not detrimental. The Construction Division can answer questions regarding the acceptable amount and type of rust.

Figure 6-505.3. Reinforcing Steel.

Cutting and bending bars affects the quality of the steel. Because heat alters the tempering of the steel, making it weak or brittle, heat should not be used to cut or bend steel. The contractor uses an abrasive saw to cut reinforcing steel. For uncoated reinforcing steel in non-critical areas, the contractor may use a torch for cutting, if approved by the Structures Division. The specifications do not allow the use of heat for bending reinforcing steel. If steel is bent at the jobsite, the contractor must submit field bending procedures for review and approval by the Structures Division.

Before placement of reinforcing steel, the contractor must supply two samples of each bar size, per manufacturer, per project, per year. If the Resident Engineer feels that the quality of reinforcing steel is questionable, the Resident Engineer may require the contractor to supply samples for each heat, or production run, delivered to the project. The steel samples are transmitted to the Materials Division using NDOT form 020-018, "Transmittal for Test Samples and Certifications." Refer to the *Documentation Manual* for information required on the transmittal. Certificates of compliance allow the contractor to incorporate the steel into the work, pending acceptable test results from the Materials Division.

The contractor must place the specified size and grade of reinforcing steel as detailed in the plans, including spacing with adjacent steel and clearance from forms, and quantity of bars. The Structures Division must approve all substitutions or other modifications to reinforcing steel. Even apparent minor modifications can significantly alter the performance or behavior of the structure. For example, using reinforcing steel of a larger diameter than specified in the plans can increase the rigidity and loading of the structure, conflicting with assumptions made by the structural designer. In general, reinforcing steel is placed in the forms at or within 1/4-inch of the location specified in the plans. Guidance on tolerances for placing reinforcing steel at various locations within a structure is shown below.

- Footings. Horizontal reinforcing steel is placed within 1/2-inch vertically of the bottom clearance shown in the plans and 1 inch from the side clearance shown in the plans. Reinforcing bars cannot deviate more than 1/2-inch from the location shown in the plans.
- Dowel Bars. Dowels are placed within 1/2-inch of the position shown in the plans.
- Columns. Vertical reinforcing steel is placed within 1/2-inch of the position shown in the plans. The side clearance must be within 1/4-inch of the clearance shown in the plans.
    - Column ties are placed within 1 inch of the position shown in the plans for a specific tie, accumulating tolerances between ties is not permitted.
    - Side form clearances for any tie must be within 1/4-inch of the clearance shown in the plans.
- Walls. Side form clearances must be within 1/4-inch of the location shown in the plans. Reinforcing steel spacing must be within 1 inch of its plan location for any one bar. Accumulating tolerances between bars is not permitted. Bar spacing may be shifted out of tolerance where necessary to clear a fixture. If bars are shifted to clear a fixture, the quantity of shifted bars in the affected area remains per the plans. Bars not shifted are placed within the specified 1-inch tolerance.
- Beams and Caps. Longitudinal reinforcing steel is placed with a bottom and top clearance within 1/2-inch of the vertical dimensions shown in the plans for all layers of reinforcing steel. The spacing from side forms is within 1/2-inch of the clearance shown in the plans. Stirrups are spaced and tied within 1 inch of the position shown in the plans, without accumulating tolerances.
- Deck Slabs. Top and bottom horizontal reinforcing steel must have top and bottom clearances within 1/4-inch of the location shown in the plans. Horizontal spacing, and end and edge clearances of reinforcing steel in the top and bottom mats must be within 1/2-inch of the dimension shown in the plans. Curb, sidewalk, and barrier reinforcing steel must be placed within 1/2-inch of the locations shown in the plans.
- Prestressing Reinforcing Steel. Tolerances for placement of prestressing reinforcing steel are located in Section 503 of the specifications.

The contractor maintains clearance between reinforcing steel and forms by using spacers separating the steel from the form. Spacers are made of concrete blocks, called dobies, or manufactured frames, called chairs. Figure 6-505.4 shows examples of reinforcing steel spacers and supports. During the placement of steel by the contractor, the inspector checks that splices are located and constructed in accordance with the plans and specifications.

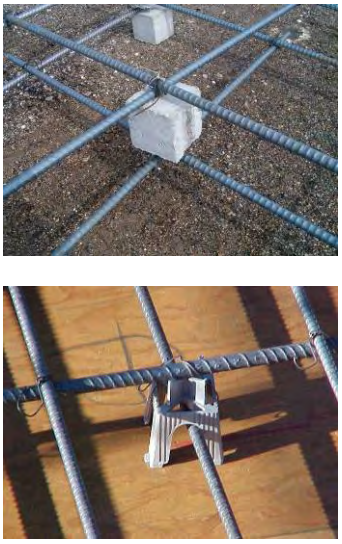

Figure 6-505.4. Typical Reinforcing Steel Spacers.

When lapping reinforcing steel for a splice, the contractor uses tie wire to connect the two pieces of steel together firmly. When rebar intersects another piece of rebar, connect the pieces using tie wire. The specifications state requirements relating to the amount of intersections to be tied. The inspector should refer to the appropriate specification relating to the type of structure being constructed. Regardless the amount of intersections required by the specifications, the rebar mat must be sufficiently stable to withstand activity associated with concrete placement, such as movement of workers and concrete being placed.

When placing epoxy-coated reinforcing steel, preserve the integrity of the coating. Where the epoxy coating is damaged or penetrated, recoat the area with an approved product. If stored for extended periods, the epoxy coated rebar must be protected from sun damage. Specially coated tie wire, supports, and concrete vibrators are required when using epoxy coated rebar.

6-505.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-506 STEEL STRUCTURES

6-506.1 GENERAL

Few differences exist between concrete and steel structures. Both structures have concrete footings, columns, abutments, and decks. The only difference is that the superstructure is constructed with structural steel. Based on design and economic considerations, the bridge designer may specify that the superstructure be constructed with steel as opposed to concrete.

For bridges made of steel, the Structures Division oversees the inspection of the steel fabrication and the placement at the jobsite. Because the structural steel material, length, and configuration are unique for each bridge project, the steel elements are assembled at a fabrication plant. During the fabrication process, the Structures Division inspector is on-site to monitor the fabrication and testing activities. When complete, the structural members are transported to the jobsite. At the site, the Structures Division inspector should be present during the erection process, where the steel girders are put in place and connected to adjoining members.

Depending on the bridge construction and erection conditions, the contractor may have additional requirements, as stated in the specifications. A common requirement is an erection plan. The erection plan may be a separate plan or included as part of the shop drawings. The Resident Engineer and inspectors must have a thorough knowledge and understanding of the requirements stated in the plans and specifications.

6-506.2 BEFORE CONSTRUCTION

Because of the specialized nature of structural steel shop drawings and the need for timely review and approval to facilitate ordering materials, shop drawings for structural steel bridge girders are processed differently than other shop drawing submittals. Structural steel shop drawings are sent directly from the fabricator to the Structures Division or the designer of record, if a consultant designed the structure. Typically, the contractor and the Resident Engineer receive a copy of the transmittal letter or the transmittal letter and shop drawings. The Structures Division or designer of record communicates directly with the steel fabricator as necessary to resolve issues or concerns during the shop drawing review. The Resident Engineer receives copies of all correspondence, and the Structures Division sends copies of the approved shop drawings to the Resident Engineer.

Structural steel shop drawings detail all elements of steel girder fabrication, including the following:

- Material specifications
- Dimensions and sizes of plates and shapes
- Number and location of shear studs (for field installation)
- Cross frame/diaphragm details
- Stiffener and connection plate details
- Weld designations
- Welded shop splice/bolted field splice details
- Bolted connection details
- Camber of girders
- Painting details
- Procedures for shop handling and assembly

The level of detail in the shop drawings ensures that the steel members are fabricated and erected in accordance with the plans and specifications. After the Structures Division approves the shop drawings, the contractor must fabricate and erect the steel members in conformance with the approved drawings. Deviation from the approved shop drawings and erection plan is not allowed without prior approval from the Structure's Division. The inspector observes the erection of the steel to verify conformance with the approved erection plan.

When inspecting steel erection, the following should be considered:

- If steel is to be erected near traffic, confirm that the Resident Engineer has approved the contractor's traffic control plan
- Before the contractor begins erecting steel, confirm that the contractor has surveyed the elevations of the substructure and that the Resident Engineer's survey crew has verified the survey
- Check the elevation of the temporary supports and the falsework relative to the required cambers
- Check that the falsework is constructed in accordance with the approved shop drawings and that it is monitored daily by the contractor for tightness of bolts, wedges and cables
- Check the surface that will support the beam to confirm the following:
    - Bearing elevation is correct
    - Anchors are set accurately as detailed
    - Expansion bearings are properly placed for ambient air temperature
- Check that the structural steel stored at the jobsite is supported above the ground on skids, platforms, or other supports and properly drained and protected from corrosion
- Verify that the contractor follows the approved safety plan and provides fall protection and other personal protective equipment during steel placement
- Check that temporary bracing or blocking is in place during erection and remains in place until the structure is fully erected and connections are complete
- Significant deviations from the erection plan must be reported immediately to the Resident Engineer

All elements of steel erection must strictly conform to the erection plan, including steel placement, splices and field connections, and bracing and diaphragms. Project personnel cannot substitute or modify the plan details without prior approval from the Resident Engineer, who consults with the Structures Division. Minor modifications can affect the stability and performance of the structure, conflicting with the structural designer's assumptions.

Stay-in-place deck form systems are commonly used to form the bottom of the deck slab between steel girders. Connection details for stay-in-place deck form systems, overhang jacks (used to form the deck overhang beyond the exterior girder), safety railing, and any other construction items that may be attached to the steel girders must be included in the shop drawings.

Because of the technical aspects in the design, the Resident Engineer must consult with the Structures Division regarding any proposed field modifications. Welding, heating, or cutting of structural steel items on the jobsite are prohibited without approval of the Structures Division.

6-506.3 DURING CONSTRUCTION

Nondestructive Testing Section personnel, or their consultants, perform fabrication inspections. Observations by inspectors confirm that techniques used to fabricate structural steel girders conform to industry requirements. During fabrication inspection, Nondestructive Testing Section personnel document progress of the work and materials used for partial payments. This information is transmitted to the Resident Engineer for inclusion in progress payments.

The steel erector must submit an erection plan that details the procedures used to erect the steel members. The Structures Division must review and approve the erection plan. The plan describes the equipment, sequence, and other details of girder erection in the field. Nondestructive Testing Section personnel typically provide inspection during the erection process, which includes inspection and testing of bolting components. Nondestructive Testing Section personnel also inspect field painting of the girders.

6-506.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-508 DRIVEN PILES

6-508.1 GENERAL

Figure 6-508.1. Pile Driving Operation.

A driven pile usually consists of a steel sheet pile, concrete-filled steel pipe, steel H-pile, prestressed concrete, timber, or a combination of materials. NDOT typically uses steel piles. Piles are made of preformed material having a predetermined shape and size that are installed by impact hammering or vibrating into the ground. Driven piles are typically used to support the foundation of structures. Figure 6-508.1 shows a pile driving operation.

6-508.2 BEFORE CONSTRUCTION

Before piles are driven, the contractor stakes the structure footing. The pile locations are then staked. The contractor submits a pile installation plan to the Resident Engineer, who provides a complete listing of equipment to be used in the pile driving operation, including the type of pile driving hammer and a wave equation analysis. The contractor's geotechnical engineer conducts the wave equation analysis, which incorporates design information from the plans and geotechnical report, and information pertaining to the contractor's proposed equipment. The wave equation analysis uses data and assumptions to develop a graph that relates theoretical blow counts and driving load resistance. A blow count is the number of blows that the hammer delivers to the pile to move the pile a given distance, typically one foot. The graph estimates the blow counts required to achieve the driving load resistance shown on the plans. The wave equation analysis can also help predict pile stresses and delivered hammer energy. The Resident Engineer submits the contractor's pile installation plan to the Materials Division Geotechnical Section for review and approval. The Geotechnical Section must approve all changes to the approved pile installation plan.

After the pile installation plan is approved, the contractor delivers the piles to the project and begins a dynamic load test, which validates or verifies the contractor's pile installation plan. The dynamic load test accomplishes the following:

- Verifies the driving load resistance of the pile
- Determines the ease or difficulty in penetrating through soil layers
- Evaluates the performance of the contractor's proposed pile driving system
- Determines the pile lengths required for production piles
- Establishes the driving criteria (number of blows per foot required to obtain design driving load resistance) for production pile driving

As piles are delivered to the jobsite, the inspector monitors delivery and storage. If steel piles are used, the inspector obtains the certificate of compliance for each production run. The inspector compares the specification requirements with the information contained in the certificate. Piles should be inspected to verify they are not damaged or flawed. The inspector should monitor the unloading of piles to verify piles are unloaded using the appropriate number of pick-up points and locations. Pick-up points are selected to prevent bending. Typically, the pile length requires a minimum of two pick-up points—at the one-third and two-thirds points of the pile length. The contractor must place piles on blocks, called dunnage, to prevent them from sagging and to protect them from corrosive elements, including water and soil. Place dunnage so that the piles do not sag.

The inspector should become familiar with the plan details related to pile driving, identify key elements of the pile installation plan, and identify key inspection elements of the specifications. When specifications require that the pile tip be protected, the inspector should verify that the protection is installed correctly. Two key elements of a pile installation are splice details and tip elevations. Because a pile length cannot be exactly determined before driving, piles might be spliced to achieve the length needed to develop the driving load resistance shown on the plans. The plans and specifications include splice details. A pile's tip is the leading end of the pile as it is driven into the ground.

The plans specify the minimum tip elevation and the design tip elevation. The minimum tip elevation is the minimum depth that the pile tip must be driven. The design tip elevation is the depth at which the driving load resistance is expected. Based on the data developed during the dynamic load testing, a tip elevation is established, which reflects actual conditions. The tip elevation established during the dynamic load testing can be above or below the design tip elevation, but it is always deeper than the minimum tip elevation shown on the plans.

6-508.3 DURING CONSTRUCTION

Coordination and communication among key personnel ensures pile driving progresses efficiently and without delays. The Materials Division Geotechnical Section staff plays a key role in pile driving. Because piles are the foundation on which the structure is supported, deviations from the plans or specifications may have significant impacts. The Resident Engineer should contact the Geotechnical Section when the specifications need clarification or when work or materials require approval. The Resident Engineer must keep the Geotechnical Section informed of the pile driving progress. If required, communicate daily with the Geotechnical Section to keep them adequately informed.

The inspector has a key role during the pile driving operation. The inspector communicates with other key personnel, observes the pile driving operation, records relevant information, and documents the pile driving activities. The inspector does not direct the contractor's pile driving activities, but if the inspector observes a potential for non-conformance, the inspector notifies the contractor of that potential. Notifying the contractor of the non-conformance potential allows the contractor to take corrective action and avoid having non-conforming work. Timely communications between the inspector and the contractor can eliminate delays to the contractor's operations.

Mark piles in one-foot increments before lifting the piles from the ground and driving them. Use the markings to monitor and document the length of pile driven into the ground. Pile driving can begin by either placing the pile tip directly on the ground or by driving the pile into a pre-drilled pilot hole. Check the specifications to confirm that pre-drilled pilot holes are allowed. Once the pile is placed under the pile driving hammer, and before driving begins, the inspector confirms that the pile is in the right location and at the proper angle to the ground. During pile driving, as the tip reaches the proper depth, the inspector verifies that the pile has reached the driving load resistance shown on the plans.

A driven pile reaches its proper depth when the bottom tip of the pile is driven at or below the minimum tip elevation shown in the plans. The pile capacity is the amount of vertical and lateral force that a pile is designed to resist for different loadings, such as scour and seismic events. The required blow counts needed to achieve the driving load resistance shown on the plans is estimated initially by the wave equation analysis. A dynamic load test is conducted while driving the first pile or piles, as stated in the specifications. The dynamic load test establishes the number of blows per foot, when the pile tip is below the minimum tip elevation shown on the plans, to attain the driving load resistance for each pile.

The inspector observes the pile driving operation and records the number of blows per foot, for each foot the pile is driven. When the tip of the pile reaches the minimum tip elevation and the target blows per foot is obtained, the inspector immediately informs the contractor that the driving requirements have been met. The pile is then cut off to the designated elevation. After successfully driving a pile, the contractor proceeds to the next pile. The next pile to be driven should not be adjacent to the last pile driven, but should be spaced some distance away in the pile grouping. Inspectors should review the specifications for specific restrictions and limitations on pile driving.

When piles are driven adjacent to each other consecutively, pore water pressure could build up in the underlying soil layers to the point that the pile would not drive any further, creating a condition called "false practical refusal." To alleviate false practical refusal, the contractor stops the pile driving and resumes the driving later (usually the next day), after allowing the pore water pressure to dissipate. In contrast to false practical refusal, practical refusal occurs when the pile cannot be driven any deeper without exceeding the target maximum number of blows per foot and possibly damaging the pile.

If a pile does not attain the specified driving load resistance when driven to the design tip elevation or the dynamic load test tip elevation, the contractor stops driving the pile and allows the pile to stand for a period without driving. This period is called a "set period." During the set period, soil resistance typically increases. When driving resumes, if the target blow count is still not achieved during restriking, a splice may be required to increase the pile length. When splicing is required on a pile, refer to the plans and specifications for requirements.

The contractor surveys the elevation of the top of the pile, referenced to a fixed datum, after installation and periodically thereafter as adjacent piles are driven. The purpose of the survey is to monitor the elevations of the pile tops. Driving a pile can cause upward movement of adjacent piles, commonly called "pile heave." If piles heave more than 1/4-inch, the contractor must re-drive the heaved pile.

During the pile driving operation, the inspector should be close enough to the hammer and pile to observe the operation and to count the blows per foot. Because the area around the pile driving operation can be hazardous due to the exhaust of the hammer, the overhead danger of the crane and the pile, and the noise of the operation, all personnel must wear appropriate safety gear, such as a hardhat and hearing protection. The inspector should be aware of the pile driving activities and have a route to escape if necessary.

During the pile driving operation, the inspector must complete NDOT form 040-059A, "Continuous Pile Driving Record," and NDOT form 040-058, "Piling Driving Record." The forms record key information such as the ground elevation and the number of blows to drive the pile a foot, for every foot the pile is driven. The inspector can and should enter much of the form data before the driving operations begin so he or she can pay full attention to the pile driving operation.

In addition to the pile driving forms, the inspector completes a daily inspector report, which documents the following:

- Pile driving activities
- Relevant communications
- Progress of operations
- Equipment and materials used in the work

Hammers for pile driving fall into two general categories: drop hammer and vibratory hammer. A drop hammer falls onto the pile under its own weight, transferring the driving force to the pile. A vibratory hammer rests on the top of the pile, vibrating the pile and temporarily negating the friction between the pile and the soil. The pile sinks into the subsoil under its own weight and the weight of the vibrator.

6-508.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-509 DRILLED SHAFT FOUNDATIONS

6-509.1 GENERAL

Drilled shaft foundations provide support similar to driven piles. Shafts are drilled; reinforcing steel cages are placed in the shaft; and, concrete is placed in the shaft, encasing the steel. Because drilled shafts can have a greater diameter than driven piles, drilled shaft foundations are used when a bridge or structure requires greater support or when using driven piles is impractical. Drilled shaft piles are also referred to as Cast-in-Drilled-Hole, or CIDH, in the plans and specifications. Figure 6-509.1 shows construction of a drilled shaft foundation in which the reinforcing steel cage is being installed.

Figure 6-509.1. Drilled Shaft Foundation.

Methods of constructing the shaft, or bore, depend on the geology of the site. Use a “dry method” when dry, stable soils are anticipated. Use a “wet method” when unstable soils are anticipated or groundwater creates unstable conditions. Use a “casing method” when the dry or wet methods are inadequate in preventing soil caving or excessive deformation of the bore. Use either temporary or permanent casings with either the dry or the wet drilling methods, depending on the geologic conditions.

Consultants are retained by NDOT to perform crosshole sonic log (CSL) testing on drilled shaft foundations. CSL testing assesses the quality of the concrete placed in drilled shaft foundations. CSL testing requirements are described in the specifications. Typically, CSL testing requires the installation of two-inch diameter tubes in the concrete foundation. The tubes are secured in the foundation’s reinforcing steel cage before the cage is placed in the borehole. After the concrete is placed and cured, the consultant performs CSL testing.

6-509.2 BEFORE CONSTRUCTION

Before beginning work, the Resident Engineer, inspector, and testers must familiarize themselves with the plans and specifications. Concrete used for drilled shaft foundations has special requirements detailed in the specifications. The contractor must submit a mix design to the Resident Engineer for approval by the Materials Division. If assistance is needed, the Materials Division or the Construction Division can provide guidance. Before constructing drilled shafts, the contractor submits qualifications to perform drilled shaft construction, as required by the specifications. The contractor stakes the structure footing and excavates to grade before the shaft locations are staked. Each pile is assigned a unique identifier. A drawing that shows pile locations and designations is prepared as a reference document for project personnel. The contractor prepares a drilled shaft installation plan that describes the key personnel, equipment, and proposed operations. The plan also includes safety and fall protection provisions for contractor and NDOT personnel. The Resident Engineer submits the contractor's installation plan to the Materials Division for review and approval. The Materials Division must approve all changes to the approved installation plan.

6-509.3 DURING CONSTRUCTION

Throughout the construction of drilled shaft piles, the inspector continuously monitors the operation and documents activities and observations on NDOT form 040-060, "Drilled Shaft Inspection Report." Each drilling method begins with drilling the shaft, or bore. The inspector observes the drilling operation and uses NDOT form 040-060 to record the soil types and depths at which the soil types are encountered. With the wet method, the next step is to stabilize the borehole perimeter using water or slurry. With the casing method, a casing is installed by pushing or lowering into the borehole. After stabilization, the borehole is cleaned of debris and, with the dry method, seepage water is removed. The reinforcing steel cage is lowered into the borehole and concrete is placed into the hole.

Reinforcing steel is assembled into a cage that will be lowered into the borehole. The inspector must inspect the reinforcing steel cage to verify the appropriate number and sizes of reinforcing steel are used and that the construction conforms to the plans and specifications, including the number and placement of longitudinal bars. The specifications require that the contractor must tie every other reinforcing steel intersection twice, double tied. When the cage is complete, the inspector should evaluate the construction of the cage to confirm that the cage will not deform when placed in the borehole.

Before placement of reinforcing steel in the borehole, identify each cage to verify that the cage is placed in the correct borehole. The reinforcing steel cage must be lowered into the borehole within 30 minutes of cleaning the borehole. The cage is supported in the borehole until the concrete is completely placed. During the placement, the cage cannot touch the bottom of the borehole. Verify the elevation of the top of the cage, allowing for the appropriate cover between the steel and the top of the footing so that the ultimate elevation of the concrete is consistent with the plans.

With the cage properly placed in the borehole, the inspector must check to make sure that the material from the borehole perimeter has not dislodged into the borehole. If any material is dislodged, the contractor is required to remove the material before placing concrete. Report any dislodged material on NDOT form 040-060, "Drilled Shaft Inspection Report."

With the bore and reinforcing steel cage inspected and approved, the inspector observes the concrete placement. Concrete placement must begin within one hour of cleaning the borehole. Before concrete is placed, the contractor fills the crosshole sonic log tubes with water, which helps to equalize the pressure in the tube with the pressure from the concrete. Using a tremie, place concrete continuously from the bottom elevation to the top of the borehole, and continue after the borehole is filled until quality concrete is observed at the top of the borehole. Immerse the discharge end of the tremie at least five feet in the fluid concrete throughout the placement operation. During placement of concrete, the slump is closely monitored. The specifications incorporate special requirements relating to slump testing for concrete used in drilled shaft foundations. After the concrete is placed, cure the exposed concrete surface.

Crosshole sonic log tubes are used to test the concrete within three days of concrete placement. If any shaft has unacceptable crosshole sonic log test results, the contractor must submit a plan for corrective action. The Materials Division Geotechnical Section, or consultants retained by NDOT, performs crosshole sonic log testing. The frequency of the testing is based on the size and type of the drilled shaft. Coordinate testing through the Materials Division.

The inspector completes NDOT form 040-060, “Drilled Shaft Inspection Report,” during the boring operation for each bore. This form provides a written record of activities, observations, and progress made during the construction of drilled shaft piles. Use the Drilled Shaft Concrete Volumes worksheet and information provided by the contractor to monitor concrete volumes in drilled shaft foundations. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a copy of this form.

6-509.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-601 PIPE CULVERTS—GENERAL

6-601.1 GENERAL

Proper drainage affects a roadway's service life. In addition to providing for existing natural drainage channels through the project, a roadway drainage system provides for the collection and disposal of surface runoff. Runoff that is collected from the roadway is carried to natural drainage channels or existing drainage systems within the right of way. In areas with groundwater that may affect the roadway structural section, groundwater drainage systems are incorporated into the design.

During the design phase, drainage systems are designed to accommodate existing drainage channels and roadway runoff. In urban areas, surface drainage is conveyed underground through a storm drain system. A storm drain system is a network of drop inlets, catch basins, pipes, and box culverts. In storm drain systems, because drainage flows by gravity, culvert grades and elevations must be closely controlled and monitored. Conditions can change from the time when the design was completed until the start of construction. The Resident Engineer should evaluate the adequacy of the designed drainage systems in relation to current field conditions. The Resident Engineer should carefully review the plans and specifications, giving special attention to environmental and right-of-way provisions. The plans and specifications reflect the environmental, right-of-way, and other NDOT commitments made before construction of the project.

To identify areas where drainage may be a concern, the Resident Engineer should observe drainage flows during storms. Observing the flow characteristics of the storm water runoff allows the Resident Engineer to assess the adequacy of existing and proposed drainage improvements. When reviewing drainage flows, observe the sufficiency of openings and the size and alignment of ditches and culverts. NDOT periodically constructs drainage facilities for other governmental entities. Because drainage facilities on a project are part of a larger, more complex drainage system, the Design Division Hydraulics Section plays an active role in decisions affecting drainage facilities. The Resident Engineer should discuss any concerns or proposed changes with the Design Division Hydraulics Section, which must approve any changes.

Culverts used in roadway projects are constructed of several types of materials, such as concrete, steel, and plastic. Common types of culverts used on NDOT projects are nonreinforced and reinforced concrete pipe, corrugated metal pipe, plastic pipe, and metal arch pipe. Culverts may have a variety of treatments at the ends of the culvert. Examples include end sections, headwalls, manholes, drop inlets, or riprap basins.

Figure 6-601.1. Reinforced Concrete Pipe.

Figure 6-601.2. Corrugated Metal Pipe.

Figure 6-601.3. Plastic Pipe.

Figure 6-601.4. Metal Arch Pipe.

Construction and installation of culverts include excavation of trenches. Trench excavation may require shoring or sloping back of the trench walls to reduce the risk of the trench collapsing. Confirm that required shoring or sloping has been completed before entering a trench. If the trench dimensions require shoring or sloping back the trench walls for safety, the inspector should monitor the contractor's operations to verify that activities comply with the approved safety plan. The contractor must comply with the approved safety plan and Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) regulations.

6-601.2 BEFORE CONSTRUCTION

One of the first items of work relating to drainage is staking the culverts and other drainage improvements by the survey crew. Based on the information contained in the plans, field books are prepared consistent with the requirements of the *Documentation Manual.*

The objectives of any drainage improvement are to perpetuate existing drainage conditions and to accommodate modified flows resulting from the roadway project. Typically, the flow line grade and alignment of a culvert should be the same as the channel that it replaces. To meet the objective of perpetuating an existing drainage channel, the grade of a culvert may be changed, and it may also be extended, shortened, or realigned.

Based on information in the plans, and modifications required due to field conditions, the survey crew will stake the culverts. The survey crew chief documents the culvert survey information in a field book called the "pipe book." If the survey stakeout results in changes to pipe lengths, the Resident Engineer will inform the contractor of the modified pipe length quantities for each culvert. As stated in the specifications, the contractor orders pipe after the Resident Engineer furnishes a list of pipe sizes and lengths.

If field conditions require modifying a culvert, the following flow characteristics should be considered:

- A steep grade tends to allow debris and sediments to pass easily through the culvert, but it can increase abrasion along the flow line and increase erosion potential at the outlet.
- A flat grade tends to allow sediment to deposit in the culvert.
- The transition between an inlet channel and a culvert should be smooth without constricting the flow.
- Disturbance of vegetation and riprap may increase erosion around the culvert.
- The channel at the outlet of the culvert is susceptible to damage, even under normal flow.
- Modifying culvert inlets or outlets may require additional channel protection. Protection may extend upstream or downstream. Adjustments to the flow line require approval of the Design Division Hydraulics Section.

Before culvert installation begins, the inspector should review the plans and specifications for the location, type and size of culverts, and bedding required.

When inspecting culverts, consider the following:

- Upon delivery of material, verify receipt of proper material certifications. Inspect pipe material for cracks, defects, and damage that may have occurred during shipping.
- Obtain samples, if required, as indicated in Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.
- Check pipes for proper:
- Class, type, and size
- Thickness, gauge, and schedule
- Coating and lining
- Lengths of sections
- Review the safety requirements for trenching operations and confined space entry.
- Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.
- Check that manholes, inlets, and pipes are properly staked.
- Verify that staked locations and elevations are appropriate for existing field conditions.
- Verify that the contractor has contacted the "Underground Service Alert (USA)," located all underground utilities, and resolved all utility conflicts.

As with all elements of a construction project, safety is an NDOT priority. Construction and installation of culverts includes excavation of trenches that may require shoring or sloping back the trench walls to reduce the risk of trench collapses. The plans contain trenching details. Culvert installations frequently include movement of materials such as concrete and metal pipes being hoisted. Special attention is required to maintain an awareness of safe working conditions. The Resident Engineer and crew should review the contractor's safety plan related to trenching and excavations and be familiar with its requirements. Concerns or questions about the contractor's safety plan should be discussed with the contractor's safety officer.

6-601.3 DURING CONSTRUCTION

Installation of culverts includes excavation of material to construct the trench, preparation of the trench, placement of bedding material, placement of culvert, and backfilling. If a culvert is located in an embankment, the embankment is constructed and then the trenching operation is performed.

6-601.3.1 TRENCHING

If the trench dimensions require shoring or laying back the trench walls for safety, the inspector should monitor the contractor's operations to verify that activities comply with the approved safety plan. During the excavation operations, the inspector should frequently check the survey grade stakes. If discrepancies are noted or questions arise, the inspector should consult with the survey crew. The inspector should also be familiar with the requirements of the plans and specifications for excavating culverts. The inspector must check the excavation for correct depth, width, and alignment. Verify that the bottom of the trench has been properly graded and compacted. Compaction test results should be obtained from the tester to verify that the required compaction is achieved prior to pipe installation. Refer to Section 6-206, Structure Excavation for additional information.

6-601.3.2 BEDDING

The quality of the bedding directly affects the load supporting capacity of a culvert pipe. Bedding material for culverts must conform to the requirements of the specifications. The inspector must check the type and depth of bedding for conformance with the plans and specifications. Culvert installation begins at the downstream end unless otherwise specified in the plans or specifications. When installing culvert pipe, check that the entire length of pipe rests in contact with the bedding material at the proper flow line. Frequently check the alignment and elevation. Be exact in checking grade and alignment for sewer pipes. Because sewer pipes are commonly gravity flow and have a low flow rate, they will have specific elevation and grade requirements.

6-601.3.3 LAYING PIPE

Culvert pipe joints must be placed in conformance with the plans and specifications. Typically, the direction of joint laps is placed so that the bell or grooved end of concrete pipe or the outside laps of metal or plastic pipe are placed in the upstream direction. Placing the joints in this position improves the water tightness of the joint. Check that joints are properly sealed or banded, and snug. Verify that joints are grouted, where required. Any holes in the pipe material that were used for lifting must be plugged in an acceptable manner per the specifications. The inspector must check in-place pipe for damage before backfilling and again before accepting the work. The inspector should also confirm that any damage to coating or lining is properly repaired.

6-601.3.4 BACKFILL

The material around and above the pipe and the manner in which it is placed and compacted influences the culvert's ability to perform as designed and to achieve its design life. In general, the greater the compaction of the backfill under the haunches and along the sides of the pipe, the less the pipe will deform under load. Consistent and uniform compaction reduces settlement. Settlement of the backfill can result in an increased transfer of embankment load onto the pipe. Increasing loading of the pipe could deform the pipe, which weakens the pipe and causes separation of the pipe joints.

For these reasons, the backfill or embankment material adjacent to the pipe should be material free from large rocks and lumps, containing sufficient fines so it compacts to a relatively impervious mass. It must be compacted to a density and width not less than that required by the specifications. Care must be taken to obtain proper compaction under the haunches of the pipe and to place and compact the backfill uniformly on both sides of the culvert. Firm support must be obtained. Over-tamping of the haunches can cause the pipe to lift out of position. Proper backfilling can prevent culvert pipe failures. Backfilling in strict accordance with the specifications is required for the pipe to perform as designed. Refer to Section 6-207, Backfill for additional information.

Figure 6-601.5. Pipe Backfill.

The inspector verifies that the backfill material is placed and fully compacted in lifts of the required thickness. This operation must be performed equally and simultaneously on both sides of the pipe. The area under the haunches of the pipe is critical during the backfilling and compaction operation. Refer to Figure 6-601.5. Note that the required compaction must be obtained prior to placing successive lifts. Observe the operation to confirm that the compaction method does not cause pipe damage or displacement. The inspector should request compaction testing whenever the contractor's compaction methods change or appear inadequate.

The construction method of the embankment around and above the culvert largely affects the load that will be imposed on a culvert pipe. The plans show the maximum fill height allowed over various sizes and types of pipe. Equipment is not permitted to operate across the culvert until the embankment has been constructed to a safe minimum depth above the culvert, typically two feet. Concrete headwalls should be constructed as soon as the embankment is constructed to the height of the headwall so the ends of the culvert are protected during storms.

6-601.3.5 PIPE JACKING

Pipe jacking is a technique for installing underground pipelines and culverts, usually concrete pipes, by jacking, or pushing, pipes through the ground. Pipes can be jacked with little or no surface disruption. For large diameter pipes, excavation takes place as the leading edge of the pipe is pushed through the ground.

To install a pipeline using this technique, construct jacking pits at the beginning and ending points. The dimension and construction of a jacking pit depends on the equipment selected by the contractor.

A thrust wall is constructed to provide a support against which to jack. High-pressure hydraulic jacks provide the forces required for jacking concrete pipes. The ram diameter and stroke of the jack may vary according to a contractor's technique. To ensure that the jacking forces are distributed around the circumference of a pipe being jacked, a thrust ring is used based on the number of jacks being used. The jacks are interconnected hydraulically to ensure that the thrust from each is the same. The number of jacks used may vary because of the pipe size, the strength of the jacking pipes, the length to be installed, and the anticipated frictional resistance.

During the jacking operation, the pipe may veer off-line. The contractor should monitor the pipe alignment. Check the roadway surface for signs of upheaval or failure, and require immediate corrective action. When the plans and specifications designate jacking, proposed alternative methods require written approval by the Resident Engineer in coordination with the Design Division Hydraulics Section.

6-601.4 MEASUREMENT AND PAYMENT

Pipe used for culverts and other drainage improvements are typically manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If end treatments are to be constructed with the culvert, consult the specifications for measurement and payment for the end treatment. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-603 REINFORCED CONCRETE PIPE

6-603.1 GENERAL

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to reinforced concrete pipe. The guidelines in this section clarify the installation of reinforced concrete pipe. Reinforced concrete pipe may have circular or elliptical cross sections. The plans and specifications will specify the type of reinforced concrete pipe. When nonreinforced concrete pipe is specified, follow the guidelines for reinforced concrete pipe.

Following are the basic shapes of reinforced concrete pipe joints:

- Modified tongue and groove
- Tongue and groove
- Bell and spigot

Generally, use a rubber gasket for sealing concrete surfaces with opposing shoulders on both ends, such as the bell and spigot and the modified tongue and groove joints. Use preformed flexible joint sealants or mortar joints where lesser joint performance is required or where the product shape dictates the type of seal. Joints using flexible sealants typically perform as a soil-tight system unless the specifications describe higher performance expectations.

6-603.2 BEFORE CONSTRUCTION

Review the following guidelines before installing reinforced concrete pipe:

- At the contractor's option and expense, the contractor can use pipe that exceeds specified strength requirements.
- Inspect the pipe for damage. Minor hairline cracks and chips are not reasons to reject the pipe. However, the following problems are unacceptable:
    - Pipe with cracks through the wall
    - Exposed reinforcing steel
    - Damaged bells, spigots, or joint grooves
- Monitor the contractor's method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments according to the plans and specifications. Before the contractor installs pipe, the inspector determines the acceptability of excavations and any required bedding. For pipes with bell ends, confirm that the excavation and bedding uniformly support the pipe.

- For elliptical pipe, the top of the pipe must be marked.
- Store rubber gaskets in a cool place away from sunlight. If lubrication is required before installation, the contractor must follow the manufacturer's instructions.
- Before using joint mortar, the mortar aggregate must be approved.
- Ensure that certification of casting yard complies with specifications.

6-603.3 DURING CONSTRUCTION

The inspector should be familiar with the following guidelines before installing reinforced concrete pipe:

- Confirm that pipe of the specified size, type, and class is installed at the proper locations.
- Observe that pipes are placed with belled ends upstream. Where possible, lay pipes from lower to higher elevations. Laying pipe from the downstream end facilitates tight joints, particularly on steep grades. When extending an existing pipe downstream, the new pipe can be placed beginning at the existing pipe, continuing downstream, or beginning downstream and connecting at the existing pipe with a special connecting structure.
- When a section of pipe is placed, verify that the pipe elevation and alignment conforms to the plans.
- Ensure that joints have smooth, uniform interior surfaces. Unless otherwise required, joints must be sealed completely with mortar, rubber gaskets, resilient materials, or liquid sealing materials. Reject gaskets that have cracks or splits.
- Before the contractor places the backfill, confirm that lift holes are plugged.
- Use mortar within 30 minutes after adding water.
- Refer to Section 6-207 Backfill for additional guidance on backfill.
- Complete backfill while the mortar in joints is still plastic. However, after the mortar sets, backfill is prohibited until 16 hours after mortaring the joints and the mortar is cured in accordance with the specifications.
- Water cannot contact the interior of the pipeline until seals containing portland cement have aged 24 hours.
- Require backfilling in a manner that will not damage seals.
- For siphons and pressure pipes, perform hydrostatic testing required by the specifications before backfilling. Repair all leaks and other defects. If the pipe sweats but no flow develops, repair is not needed.
- Require minimum cover for construction loads, as shown in the plans and specifications.

- Protect pipes from damage during construction operations.
- Do not permit the pipe to be dropped onto the bedding to consolidate and mold the bedding. This is commonly called “battering” and is not allowed because of the potential to damage the pipe.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris.

6-603.4 MEASUREMENT AND PAYMENT

Reinforced concrete pipe is manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If culvert end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual.*

6-604 CORRUGATED METAL PIPE AND METAL ARCH PIPE

6-604.1 GENERAL

The discussion of pipe culverts in Section 6-601, Pipe Culverts – General, applies to corrugated metal pipe and metal arch pipe. The guidelines in this section clarify the installation of corrugated metal pipe and metal arch pipe. Corrugated metal pipe and metal arch pipe may have circular or near-circular cross sections. The plans and specifications will specify the type of corrugated metal pipe and metal arch pipe. When using slotted corrugated pipe to allow surface drainage to enter the pipe, install it flush with the top of dense-grade pavement before placing the open-graded surface.

6-604.2 BEFORE CONSTRUCTION

The inspector should review the following guidelines before installation of corrugated metal pipe:

- Inspect the pipe for damage. Damaged corrugated metal pipe should not be incorporated into the work.
- Monitor the contractor’s method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments in accordance with the plans and specifications. Before the contractor installs pipe, determine the acceptability of excavations and any required bedding.
- If rubber gaskets are used, verify that the contractor stores the gaskets in a cool place away from sunlight.

6-604.3 DURING CONSTRUCTION

Be familiar with the following guidelines relating to installing corrugated pipe:

- Confirm that pipe of the specified size, type, and class is installed at the proper locations.
- Where possible, lay pipes from lower to higher elevations. Laying pipe from the downstream end facilitates tight joints, particularly on steep grades. When extending an existing pipe downstream, the new pipe is connected to the existing pipe, continuing downstream.
- When placing a section of pipe, verify that the elevation and alignment of the pipe conforms to the survey crew's stakeout.
- Corrugated metal pipe sections are joined with a coupler that is firmly bolted in place.
- Refer to Section 6-207, Backfill, for additional guidance on backfill.
- Require backfilling in a manner that will not displace joints.
- When used as siphons, corrugated metal pipe seams are soldered and couplings incorporate a rubber or other approved gasket material. Fill the siphon pipe with water and repair leaks before backfilling.
- Require minimum cover before any loads are placed on the pipe.
- Protect pipes from damage during construction operations.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris. Verify that the pipe has not been deformed.

6-604.4 MEASUREMENT AND PAYMENT

Corrugated metal pipe and metal arch pipe are manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If culvert end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-605 PLASTIC PIPE

6-605.1 GENERAL

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to plastic pipe. The guidelines in this section clarify the installation of plastic pipe. Plastic pipe can have a solid wall or it can be perforated to allow water to enter or exit the pipe. The plans and specifications will specify the type of plastic pipe.

6-605.2 BEFORE CONSTRUCTION

Review the following guidelines before installation of plastic pipe:

- Inspect the pipe for damage. Do not incorporate damaged plastic pipe into the work.
- Review manufacturer's recommendations on exposure of pipe to the elements.
- Monitor the contractor's method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments in accordance with the plans and specifications. Before the contractor installs pipe, determine the acceptability of excavations and any required bedding.

6-605.3 DURING CONSTRUCTION

Be familiar with the following guidelines before installation of plastic pipe:

- Verify that pipe of the specified size, type, and class is installed at the proper locations.
- Lay pipes from lower to higher elevations.
- When a section of pipe is placed, observe that the elevation and alignment of the pipe conforms to the survey crew's stakeout.
- Refer to Section 6-207, Backfill, for additional guidance on backfill.
- Require backfilling in a manner that will not displace plastic pipe or cause the pipe to float.
- Require minimum covers, as required by the manufacturer or as shown in the plans and specifications.
- Protect pipes from damage during construction operations.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris, and undamaged.

6-605.4 MEASUREMENT AND PAYMENT

The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If plastic pipe end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-606 STRUCTURAL PLATE CULVERTS

6-606.1 GENERAL

Figure 6-606.1. Structural Plate Culvert.

When the size and shape requirements of a culvert exceed the capabilities of corrugated metal pipe, structural plate culverts can be used. Structural plate culverts are manufactured and transported to the jobsite where the components are assembled to construct the culvert. Structural plate culverts are fabricated based on the requirements of the plans and specifications.

The contractor develops shop drawings based on the requirements of the plans and specifications. The contractor submits the shop drawings to the Resident Engineer. The Resident Engineer submits the shop drawings to the Structures Division for review and approval. Based on the approved shop drawings, the structural plate culvert is manufactured. The manufacturer provides assembly instructions showing the position of each plate and assembly sequence. The inspector should be familiar with the plans and specifications relating to the structural plate culvert. Verify that anchorage assemblies are installed according to the plans and the manufacturer's recommendations. The discussion of pipe culverts in Section 6-601, Pipe Culverts – General, and in Section 6-604, Corrugated Metal Pipe and Metal Arch Pipe, also apply to structural plate culverts.

6-606.2 MEASUREMENT AND PAYMENT

The length of structural plate culvert measured for payment is the average of the top and bottom centerline lengths. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-607 UNDERDRAINS

6-607.1 GENERAL

Underdrains are pipes that intercept underground flow and seepage to drain the roadway structural section. The most common use of underdrains is to intercept subsurface water moving toward the roadway. A system of interconnected underdrains can be used to remove the groundwater when drainage of a large area is necessary. Typically, a system of interconnected underdrains may include a drain backfill with a geotextile fabric to prevent sediment from entering the underdrains. Cleanouts are constructed at regular intervals and other locations, such as junctions. Cleanouts provide access to the underdrains for maintenance.

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts, and related sections pertaining to the specific pipe material apply to underdrains.

6-607.2 MEASUREMENT AND PAYMENT

Pipe connector pieces, such as bends, wyes, and tees, are measured as pipe along centerlines and included in the quantity of underdrain pipe length. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-608 DOWNDRAINS

6-608.1 GENERAL

Downdrains are drainage systems that convey water down roadway slopes in a manner that prevents slope erosion. Downdrains are constructed to allow drainage from fill embankments, benches in cut sections, and other steep or long slopes. Downdrains are often placed near bridges to remove runoff from the roadway before reaching the structure. A downdrain system consists of a catch basin (embankment protector), downdrain pipe and anchors, end section, and riprap. Downdrain placement is important to ensure that drainage is collected and passed down the slope. Metal corrugated pipe and plastic pipe are the most commonly used downdrain pipes. Downdrain pipes are constructed so that the outlet end of the pipe extends to or beyond the toe of the slope to prevent erosion. Observe that anchorage assemblies are installed according to the plans and the manufacturer's recommendations. The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to downdrain pipes. Consult the plans and specifications regarding the type of inlet and outlet structure for each downdrain.

6-608.2 MEASUREMENT AND PAYMENT

The length of downdrain pipe measured for payment is the total length placed. Structure excavation, backfill, and riprap are not measured for payment in downdrain systems, but are included in the cost of other items. Pipe connector pieces are not directly paid for, but are included in the quantity of underdrain pipe length. Anchor assemblies are paid individually. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-609 CATCH BASINS, MANHOLES, AND INLETS

6-609.1 GENERAL

Catch basins, manholes, and inlets are structures that connect to pipes and culverts. Section 609 of the specifications describes the requirements of materials and construction. Unless otherwise specified in the plans or specifications catch basins, manholes, and inlets may be precast or cast-in-place. The traffic control requirements of the project influence the structure type selection, construction materials, and construction method. For example, if disruption of traffic must be kept to a minimum, pre-cast structures and quick-setting concrete could be used to reduce construction time and allow traffic to return to the roadway.

6-609.2 BEFORE CONSTRUCTION

Before starting work on drainage structures, review the plans and specifications. Verify existing drainage conditions, and check that the structures are staked at the proper location and elevation. Consider the following:

- Review safety requirements for trenching operations and confined space entry. Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.
- Conduct periodic field inspections at the precast yard to verify that structures are constructed as detailed in the plans. Upon delivery of precast structures, verify receipt of proper material certifications. Check the type and dimensions of precast items for conformance. Where applicable, check the spacing of stair rungs for compliance. Pay particular attention to defects and damage that may have occurred during shipping.
- Where cast-in-place structures are used, check forms and reinforcing steel for proper condition and dimension.
- Verify the contractor has provided all survey tie records, including permanent reference ties, to all covers to be adjusted and submits the documentation to the Resident Engineer before paving or making any adjustments.
- Clearly mark frames and matching lids as matched pairs to ensure that each lid is placed on its matching frame.

6-609.3 DURING CONSTRUCTION

Consider the following during construction of catch basins, manholes, and inlets:

- Verify receipt of proper certificates of compliance.
- Check pipe invert and flow-line elevations.
- Provide a smooth flow line between manholes and pipes. Check that a watertight union with pipes is achieved. Where precast sections are used, check that clean joints are constructed. Verify the proper use of concrete adjustment rings and mortar to make field adjustments. Verify that special coatings that may be required by the specifications are applied.
- Check for proper dimension, formwork, concrete placement, and curing.
- Check grates for acceptability with respect to type, dimension, orientation, and galvanization. Grates and their matching frame must be delivered to the project together.
- Check the type, label, dimension, and utility company marking of manhole covers for compliance with specifications. Where located within pavements, check the slope and elevation of covers.
- When adjusting existing covers:
    - Verify adjustments are made by one of the methods described in the specifications.
    - Confirm that frames and lids are installed as matched pairs.
    - Verify that the material around the structure has been compacted prior to placing concrete for collars
    - Replacement collars must be the same diameter as the original collar. If a smaller diameter collar is used, the structural section must be replaced. The patched roadway structural section must match the thickness of the adjacent section, prior to placement of the smaller diameter collar.
- Review the specifications for mortar or grout requirements. Verify that any needed mortar repairs and grouting around pipe and grade rings are properly performed.
- Verify concrete and reinforcement in the manhole collars comply with plans and specifications.
- Concrete patching material must be approved for use.
- Obtain local agency or utility company acceptance after covers are adjusted.

6-609.4 MEASUREMENT AND PAYMENT

Because third parties may reimburse NDOT for the costs of manholes or manhole adjustments, accurately document the ownership of the manholes in the appropriate field book. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-610 RIPRAP

6-610.1 GENERAL

Figure 6-610.1. Riprap.

Erodible slopes within the right-of-way are typically treated with an erosion control measure. A common type of erosion control is riprap. Riprap is the careful placement of relatively large stone on the erodible slope. Riprap is also used at culvert inlets and outlets to protect natural ground from erosion and as a means for dissipating energy from flowing water. Because conditions that require riprap are variable, different types or classes of riprap are required. The classes of riprap are described in the specifications. For additional erosion control protection, riprap may be grouted.

6-610.2 BEFORE CONSTRUCTION

Before construction begins, consider the following guidelines:

- Review the plans and specifications with respect to the location, limits, and type of material required. Pay particular attention to the nominal size and material requirements of the stone, and placement depth.
- Review the requirements for riprap with respect to nominal size, shape, specific gravity, gradation, abrasion resistance. To reduce the likelihood of riprap stones moving under flowing water, specific gravity of the riprap is specified. The inspector should confirm the specific gravity of the riprap to be used by verifying that the source of the riprap has been approved. Visually observe the required material samples from the material source and jobsite for compliance with specification requirements. Where the material is suspect, request lab results for verification or require the contractor to provide the necessary equipment for gradation testing.
- Verify the acceptability of the slope after it is prepared, including the bedding for riprap if required. Check the excavation for the toe or cut-off wall, where required, to confirm that it conforms to the lines designated in the plans.

6-610.3 DURING CONSTRUCTION

The stone for riprap is generally placed and spread using a combination of mechanical and hand methods. Before the riprap is placed, observe the placement of bedding material to confirm that the bedding is placed as stated in the plans and specifications. The contractor should place riprap so that it is tight, stable, and closely conforms to the details shown in the plans. Verify the depth of the riprap. Regardless of the contractor's placement method, the final surface should appear relatively smooth with interlocking faces of adjacent stones. Riprap is typically placed in a single layer by a means that does not cause segregation.

6-610.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-611 CONCRETE SLOPE PAVING

6-611.1 GENERAL

Concrete slope paving is used primarily for erosion control and is typically used on slopes around major structures. Concrete slope paving is typically a Class A or a Class AA portland cement concrete with fiber reinforcement. Section 501, Portland Cement Concrete, of the specifications describes the concrete requirements. Guidance on concrete inspection is provided in Section 6-501, Portland Cement Concrete.

6-611.2 BEFORE CONSTRUCTION

Before concrete slope paving begins, consider the following guidelines:

- Review the plans and specifications. Pay particular attention to the location, limits, depth, and type of slope paving required.
- Review Section 6-501, Portland Cement Concrete.
- The contractor must have an approved mix design for concrete used in the slope paving. The concrete materials, including reinforcing fibers and color pigmentation, are described in the plans and specifications. Check the required materials for compliance, including required material certifications.
- Confirm that the area to receive slope paving is properly graded, compacted, and free of unsuitable materials. Check the toe or cut-off wall excavation for conformance to plans and specifications. Figure 6-611.1 shows a slope paving cut-off wall excavation. Where unsuitable soil material is encountered, it may be necessary to replace the material. The grading of the slope may need to be adjusted in the field to match the ditch line or other boundaries. If the grade of the slope paving is adjusted in the field, the adjustment must be to flatten the grade, not to make the grade steeper.

Figure 6-611.1. Slope Paving Cut-Off Wall Excavation.

6-611.3 DURING CONSTRUCTION

Review the plans and specifications to confirm that the contractor mixes and places concrete as required. Where forms and reinforcement are required, check the acceptability of forms and the placement of reinforcement. Verify that header boards are anchored. Monitor the depth of paving for compliance, and confirm that expansion joint materials, where required, are placed at the proper thickness and location.

Concrete consolidation is more effective with manual consolidation techniques, such as using a hand-tamping tool, rather than with mechanical internal vibrators, which may cause the wet concrete to flow out of the forms. Concrete slope paving is placed, starting at the bottom, moving up the slope. Verify compliance with requirements for slope paving during inclement weather, curing method and material, surface moisture, and curing period. The surface to receive concrete slope paving must be pre-wetted before placing concrete to reduce moisture loss in the concrete.

6-611.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-612 COATINGS

6-612.1 GENERAL

This section relates to graffiti resistant coatings applied to surfaces. Graffiti resistant coatings are proprietary. Therefore, follow the manufacturer's instructions. Before beginning application of the coating, the inspector should become familiar with the specifications and manufacturer's recommendations.

6-612.2 BEFORE CONSTRUCTION

Consider the following:

- The Resident Engineer should verify with the District Engineer the limits of the coating to be applied.
- Understand the specifications and manufacturer's recommendations related to coatings.
- When applying coatings to new concrete surfaces, confirm that the concrete has cured for at least 30 days, or as recommend by the manufacturer.
- When applying coatings to stained or painted surfaces, diligently follow the manufacturer's recommendations. Special consideration may be needed for freshly stained or painted surfaces.
- Be aware that graffiti-resistant coatings include several components that must work together as specified by the manufacturer. Therefore, the success of the coating depends strongly on proper surface preparation and application, including appropriate cure times of the individual component materials.
- Confirm that the technical representative for the manufacturer has been notified of the application schedule.

6-612.3 DURING CONSTRUCTION

Be familiar with the following:

- Confirm that the manufacturer's technical representative is on-site and has verified that the application process complies with the manufacturer's recommendations.
- Observe that the surface to receive the graffiti-resistant coating is prepared consistent with the manufacturer's recommendations.
- Document the surface preparation with sufficient detail to provide information if the coating does not perform as anticipated.
- Monitor the application of the graffiti-resistant coating, noting the application rate and the cure time between coats.

6-612.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-613 CONCRETE CURBS, GUTTERS, AND SIDEWALKS

6-613.1 GENERAL

This section covers concrete curbs, gutters, and sidewalks. Concrete curbs, gutters, and sidewalks are constructed on a solid foundation, typically base course material, which has been graded and compacted. Curb and gutter systems must be constructed so that water will not pond on the roadway or flow randomly over fill slopes. For additional information, refer to the following sections: Section 6-501, Portland Cement Concrete, Section 6-501, Concrete Structures, and Section 6-505, Reinforcing Steel.

Curbs and gutters have two purposes: first as a gutter to direct drainage from the roadway, and second for safety, to keep motorists on the roadway. A gutter guides water from rain and melted snow and ice into the storm drains, so that it does not accumulate on the surface. A curb channels the movement of traffic and redirects vehicles. Since curbs, gutters, and sidewalks add to the cost of a road, they are generally limited to urban areas, and they are rarely built in rural areas except where certain drainage conditions make them necessary.

6-613.2 BEFORE CONSTRUCTION

Before the contractor constructs curbs, gutters, and sidewalks, the inspector should do the following:

- Review the plans and specifications for details about the project's concrete curbs, gutters, and sidewalks, and compare these details with conditions in the field.
- If the Resident Engineer decides that curbs, gutters, or sidewalks are required, in addition to those shown on the plans, the Resident Engineer should consult with the District Engineer and the Design Division. When adding curbs, gutters, or sidewalks, the Resident Engineer should confirm the following:
    - Conformance to the current policy of replacing existing facilities.
    - Compliance with requirements of the Americans with Disabilities Act (ADA).
    - Compliance with agreements.
    - Placement that provides proper drainage.
- Discuss the construction operation with the contractor. Determine whether the contractor has considered the public's convenience. The contractor must accommodate vehicle and pedestrian traffic in conformance with the specifications. Advise the contractor of any necessary modifications to the operation.
- Make a general check of the layout as staked, including the location of gutter depressions, curb ramps (wheelchair ramps), and driveways. Also, review the survey stakeout for accuracy.
- Mark and measure sections identified for removal before removal operations begin. Coordinate with the contractor regarding removing sections to the nearest existing joint.

- Review the location and construction details of curb ramps that are designated in the plans. Pay particular attention to the slope and surface finishing requirements of curb ramps. A textured surface finish or detectable warning devices are used, and field adjustments may be needed to meet slope requirements. Confirm that adjustments comply with ADA requirements.
- Review the locations of drainage structures to confirm that no new drainage structures are aligned with curb ramps.
- Verify that there is an approved concrete mix design for the curbs, gutters, and sidewalks.
- Examine the base material to verify the following:
  - The base has been constructed to the proper elevation and cross section.
  - The foundation has been watered and compacted.
  - The appropriate density tests have been taken and meet the minimum density requirements.
  - The base is wet immediately before placing concrete.
- Check that the contractor has adequate materials on hand to cure and, as needed, protect the concrete during inclement weather.
- Verify the contractor has implemented appropriate measures for washing out concrete mixer trucks.
- Confirm that gutters will drain. When new curbs or gutters are to join existing facilities, confirm that the survey crew has checked the existing elevations against the planned grades.

6-613.3 DURING CONSTRUCTION

Once work begins, take these steps:

- Examine the forms to verify the following:
  - Forms are placed to the lines and grades staked by the survey crew.
  - The forms are smooth on the side next to the concrete.
  - Forms have a true, smooth upper edge.
  - Forms are full depth.
  - Forms are rigid enough to withstand the pressure of fresh concrete without distortion. Replace forms that will not produce an end product within specified tolerances.
  - Forms are coated with form oil as specified.
- Confirm the contractor adjusts the forms to remove any unsightly changes in vertical or horizontal alignment. Adjustment from staked grades is sometimes necessary near joints with existing curbs or sidewalks.

- Pay particular attention to how forms are set with respect to locations of drop inlets, curb ramps, and driveways; make adjustments where needed.
- Finished appearance is important and is noticeable by the public. Do not directly use existing edges of pavement and sidewalks, or existing pavement surfaces to establish a grade line for curbs.
- Where reinforcing steel is required, check spacing, clearance, and supports for acceptability.
- Confirm that joints are scored as specified.
- If the plans and specifications require adhesive to bond the concrete to the pavement surface, verify that the contractor cleans the pavement as specified and uses the required adhesive.
- Inspect the placement of weakened plane and expansion joints to confirm that they are constructed as specified.
- Refer to Section 6-501, Portland Cement Concrete, for inspection requirements related to concrete placement.
- Observe concrete as it is placed. In the daily construction report, record the reasons for rejecting any concrete and the approximate amount rejected. Confirm that the contractor does not allow concrete to segregate while being placed and consolidated in the forms. Stop the operation if the concrete requires patching with grout or mortar. Inform the contractor to take corrective measures when concrete placement does not meet the requirements of the specifications.
- When corrective measures are necessary, advise the contractor and Resident Engineer, being specific as possible, and document the discussion in the daily construction report.
- Check that transverse expansion joints are located and constructed in conformance to the specifications. Joint types and locations should match those in adjacent concrete. Verify that edging is performed where required.
- Before the forms are removed, confirm that the contractor uses the required trowel to finish the concrete surface as specified.
- Prohibit excessive finishing and addition of water. Confirm that the finishing meets specifications, and measure the finished product to verify it conforms to the required tolerances.
- Verify that concrete cures for the specified curing period. Verify an approved curing compound is applied to exposed concrete surfaces and that the rate and time of application is acceptable. Confirm that the contactor complies with the provisions for concrete protection during cold weather.
- Do not begin form removal and backfill until the concrete is strong enough to prevent damage. Confirm that the edges are adequately shouldered. Watch for damage to the concrete during the backfill operation.
- Verify that the contractor does not place concrete on frozen or ice-coated material and protects the concrete after placement according to the specifications.

Construct curbs and gutters using either forms or equipment, such as a curb and gutter extrusion machine. The inspector must verify that the machine is configured to produce the required cross section. Typically, the extrusion machine uses a guide wire to control the vertical and horizontal alignment. The survey crew should check the guide wires to verify the correct vertical and horizontal alignment before beginning the concrete placement.

Extrusion machines typically require clearance to operate the equipment. The amount of space depends on the type of equipment used by the contractor. Discuss these details with the contractor. Because the concrete is supported for a relatively short time, a low slump concrete is used to retain the desired shape. The extrusion machine should produce a consistent and uniform concrete surface with no major defects. Curing and protection requirements of the concrete remain the same as when forms are used. All exposed surfaces must be cured.

6-613.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-614 PAINTING

6-614.1 GENERAL

This section addresses the painting requirements for steel and concrete structures. Section 714 of the specifications covers specific paint specifications for different surfaces. Paint removal, disposal, and painting requirements are changing because of environmental and personnel safety concerns. The Resident Engineer and crew should thoroughly review the specifications for each project.

6-614.2 BEFORE CONSTRUCTION

Specifications require that the Resident Engineer approve prepared paints. While certificates of compliance are most often required for paint, the Materials Sampling and Testing Checklist issued by the Materials Division provides direction for the specific project.

For structural steel members, an inspector from the Structures Division Nondestructive Testing Section will monitor painting operations on the project and at the fabrication facilities. Painting must be performed under clean, dry conditions. Confirm that the contractor provides adequate protection from paint drift or overspray. Traffic, personnel, and other items that may be damaged by the paint require protection. The contractor may have to tent the structure or portions of the structure or provide traffic detours to provide adequate protection. Moisture on the surface will be trapped by the paint and prevent bonding. Moisture or dust in the air will cause a speckled or blotchy appearance on the painted surface. Cold weather also inhibits bonding of the paint to the steel. Painting should not be conducted on surfaces that are below 32°F. Inspect the surface to be painted to verify it is prepared as described in the specifications and is free of any foreign matter.

Paint systems must be applied in accordance with the paint manufacturer's recommendations utilizing proper mechanical mixers, thinners, pressures, paint guns, nozzles, and safety equipment. Review with the contractor the procedure, system, and safety clothing to be used. The Structures Division Nondestructive Testing inspector discusses with the contractor the surface preparation and paint application process to be used. Painting of structural steel requires that painters and sandblasters be qualified by experience and demonstrated abilities. The Resident Engineer may withdraw the qualification at anytime the performance of the painter, sandblaster, or their equipment is in question.

When painting concrete, the concrete surface must be cured and dried for a minimum of seven days before paint is applied. Painting operations must follow the manufacturer's recommendations.

6-614.3 DURING CONSTRUCTION

When the paint arrives at the jobsite, the inspector must check that the paint formula and system complies with the specifications. If the contractor desires to paint during inclement weather, the Resident Engineer should make certain that the contractor provides suitable enclosures to protect the work. The contractor receives no additional compensation for enclosures to protect the work. A clean surface is one of the most important aspects of a successful painting operation. Refer to the specifications for painted surface requirements.

When paint removal is required, review the specifications to determine submittal requirements. Typically, the contractor is required to submit a paint removal plan that incorporates environmental considerations. The Resident Engineer submits the plan to the Structures Division for review and approval.

The Structures Division Nondestructive Testing Section inspector performs on-site painting inspection of steel girders. The inspector confirms that each coat of paint is of the proper thickness. To verify the proper thickness of paint on the surface, the inspector checks the dry film thickness of the paint using a gauge or meter. The inspector should choose checkpoints that are representative of the painted surface and document the locations of the paint thickness checks. Frequently check difficult to reach areas for coverage.

6-614.4 MEASUREMENT AND PAYMENT

Painting is not paid for directly, unless otherwise provided in the specifications. The cost of painting is included in the cost of other items of work. The inspector verifies and documents the activity, date, and location of the work.

6-618 GUARDRAIL

6-618.1 GENERAL

Guardrail is installed to prevent errant vehicles from leaving the roadway and impacting fixed objects, steep side slopes, and opposing traffic. Different types of guardrail designs exist to address specific conditions.

6-618.2 BEFORE CONSTRUCTION

The Resident Engineer should refer to the current version of the AASHTO *Roadside Design Manual* when reviewing planned guardrail installations. Give attention to the stakeout and construction of required embankments for flared guardrail end sections. After the survey crew stakes the guardrail, the Resident Engineer should review the survey layout. The Resident Engineer should request a guardrail review from the Standards and Manual Supervisor in the Specifications Section of Roadway Design, if the planned guardrail installation appears deficient.

The inspector should consider the following guidelines before installing guardrail:

- Review the plans and specifications.
- Check the type of guardrail system for conformance, including rail sections, hardware, and posts. The specifications require shop drawings to be submitted for guardrail terminals.
- Verify survey stakeout.
- Check lateral offset, longitudinal length, termini location, post spacing, rail curvature, and parabolic flares.
- Confirm planned guardrail locations are consistent with current field conditions.
- Confirm that the embankments for flared guardrail end sections are staked.
- Guardrail identified for removal, removal and replacement, or remove and reset should be measured for payment before guardrail removal begins.
- Verify receipt of proper certificates of compliance.
- Check post layout for conflicts with utilities and drainage structures.

6-618.3 DURING CONSTRUCTION

Consider the following guidelines during the construction of guardrail:

- Unless designated otherwise, drive guardrail posts in place, or set them in dug holes. Check post spacing, elevation, depth, and alignment regularly. Where posts are driven, watch for irregular movement or heaving of the soil, possibly indicating an underground obstruction. Check driven posts for damage such as distortion or splintering.
- Where posts are set in pilot holes, watch for over drilling and require backfilling and compaction as needed to adjust depth and provide a firm foundation. After setting, place and compact backfill material in layers around posts. Compact backfill with an appropriate tool but do not displace the post from correct alignment. Check that all posts are set firm and plumb and that they are within tolerance of the required alignment and elevation.
- Where wood posts are cut in the field, verify that the exposed surface is treated as specified. Post lengths must conform to the plans and specifications for the type and location of installation.
- If posts are installed in loose soil or within two feet of the top of a slope, use longer posts. If unsure about the post length, consult the Resident Engineer and the Standards and Manual Supervisor in the Design Division Specifications Section.
- Verify that connections to bridge railings, retaining walls, abutments, or other flat surfaces comply with plans and specifications.
- Check for correct construction of the embankment for flared guardrail end sections.
- Check that all fittings and metal plates are securely placed in the correct position. Check that rail sections are lapped so that the exposed ends will not face approaching traffic and are smooth and continuous.
- Check bolts for tightness and threaded rods for proper trimming. Make sure bolts are long enough and nuts are threaded completely onto the bolt. One or two threads are insufficient.
- Check for conformance in the rail height and rail face with respect to lateral offset and alignment and inform the contractor of any needed adjustment.
- Pay particular attention to the construction details for end treatments, median terminals, and rail transitions such as post type, post length, post spacing, number of rail sections, lapping direction, splices, method of connecting, fastener type, and reflector tab location. Specialized hardware and designs are commonly used at these locations and require close inspection before acceptance. The inspector should refer to the manufacturer's installation instructions for specialized hardware.
- When the roadway remains open to traffic, the installation of rail sections immediately follows the installation of guardrail posts, unless other protection is provided for in the plans and specifications. At the end of the workday, check to confirm that the termini of exposed rail sections are treated with temporary end treatments such as a temporary impact attenuator.
- Install cable clips in the proper direction and tighten them to the required torque.

- Immediately before placing concrete, verify that holes for concrete anchors and footings are excavated to the dimensions shown on the plans and on the manufacturer's drawings.
- Verify that anchor cables are tight enough to prevent any obvious slack in the cable once the footing concrete has cured for the required period.
- Check that plantmix bituminous dikes are positioned under the guardrail as shown on the plans.
- Check that the construction of flares conforms to the plans.
- Verify that installed guardrail is visually uniform, horizontally and vertically. Require the contractor to adjust posts and rail if necessary.
- Verify each pay item for each guardrail installation.
- Keep accurate records and make sufficient measurements to support both partial and final payment.

At the completion of any project that installs or removes guardrail, the inspector must accurately complete the guardrail inventory sheet. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a guardrail inventory sheet and a manual describing how to complete the inventory sheet. The completed guardrail inventory sheet is sent to the Standards and Manual Supervisor in the Specifications Section of Roadway Design. The guardrail inventory sheet is used to evaluate and address federal safety requirements.

6-618.4 MEASUREMENT AND PAYMENT

The limits of measurement for payment are shown in the plans. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-623 SIGNALS, LIGHTING AND INTELLIGENT TRAFFIC SYSTEMS

6-623.1 GENERAL

Traffic signals, street lighting, illuminated signs, and Intelligent Traffic Systems are all part of roadway electrical systems. Intelligent Traffic Systems (ITS) is a general term that includes items such as changeable message signs, communication systems, and traffic monitoring systems. Typically, electrical systems along local roadways, including traffic signals at highway ramp junctions, are maintained by the local agency and built to the local agency's specifications. Electrical systems along highways are constructed to NDOT specifications and maintained by NDOT or the local agency. The technology and materials associated with electrical systems continually evolve. The evolution of the technology for these systems creates advances in equipment. Although equipment advances are common, the basic construction features typically remain the same.

Electrical systems are typically installed in urban areas, although lighting and ITS systems are also common in rural areas. The basic components of electrical systems consist of electrical service, controller, wiring, conduit, and signal/lighting/ITS components. The electrical service is the point at which an electrical utility company furnishes or provides electrical power to a user, typically with a meter to record electrical power usage. A controller is the equipment, similar to a computer, that controls and manages the components of the electrical system. Controllers are typically located in metal cabinets on the project, near the electrical system that they control. Wiring and conductors convey electrical power to the electrical components, including the electrical service. Conduits are plastic or metal pipes in which wiring is placed. Conduits allow for the installation or replacement of wiring underground without trenching after the initial installation. All electrical systems must meet certain standards and codes as detailed in the plans and specifications.

6-623.2 BEFORE CONSTRUCTION

The inspector's work on roadway electrical systems should begin before the contractor arrives at the jobsite. The inspector needs to become familiar with the project; existing conditions should be thoroughly documented to help settle disputes during construction, quality of materials should be verified before use, and the construction schedule should be reviewed to confirm that it is appropriate for the work to be performed. Completing the following tasks before construction begins will help with this process:

- Thoroughly review the project plans and specifications to confirm compliance with regulations and codes and pay close attention to all project notes. Record on the plans any unusual items covered in the specifications but not directly called out on the plans.
- If electrical systems not maintained by NDOT are constructed or modified, contact the local agency that performs the maintenance.
- Check the condition of any existing electrical equipment that is indicated on the plans to remain in place, to be salvaged, or to be relocated; take photographs to document the condition of these items before the contractor arrives at the jobsite.
- Confirm that electrical equipment and materials submittals have been provided by the contractor, and approved by the Resident Engineer. The specifications require equipment submittals for all equipment and materials to be used on an electrical system.
- The inspector should keep a copy of the contractor's submittal to confirm that the proper products are used. As materials are delivered to the jobsite, verify that they match the description on the approved submittal. If the contractor wants to substitute a specified product with a different product of equal quality and suitability that is not listed in the Qualified Products List, a request for substitution must be made in writing. The Resident Engineer approves or denies the substitute. Refer to Section 3-403.3.1.5, Qualified Products List, for additional information.
- If the plans and specifications call for any agency-furnished equipment such as traffic signal controllers and cabinets, confirm with the furnishing agency that these materials will be available when needed, that provisions have been made for testing if necessary, and that all parties have been properly contacted to control the pickup and delivery of these items.

- Review the contractor's schedule of operations and confirm that arrangements are being made to maintain existing electrical systems, or that temporary electrical systems will be provided in accordance with the plans and specifications.
- Certain job-specific electrical equipment such as poles and controllers often require substantial lead-time due to fabrication of specialized materials. Confirm with the contractor that lead-time for the electrical equipment is accounted for in the schedule of operations; partial payment will not be given for these materials until they are delivered to the jobsite. If the specifications allow for suspension of working days due to material lead time, the contractor should still be required to perform underground work such as conduit, pull box, and foundation installations before allowing any suspension of working days.
- Walk the project with the contractor to determine the locations where cranes, pile-driving equipment, or other equipment may be needed, and advise the utility company representatives of overhead clearances necessary to accomplish the work. Also, if overhead wires for temporary lighting or signals will encroach on private property, refer the situation to the Right-of-Way Division.
- Contact the project manager and district utility coordinator to discuss the status of electrical and utility agreements for the project. If an electrical or telephone service connection is needed, the district utility coordinator should submit an application to the utility company. Confirm that this is being provided early enough for the utility company to plan their work in an orderly manner.

6-623.3 DURING CONSTRUCTION

Before installing any underground equipment, the contractor must contact the appropriate underground utility locating service. The Resident Engineer should not allow the contractor to perform any excavations until all underground utilities have been located.

Only journeyman electricians or electrical apprentices directly supervised by a journeyman electrician may perform electrical work or install electrical material. All work performed on traffic signals must be performed or be directly supervised by a journeyman electrician certified as International Municipal Signal Association (IMSA) Level II or higher.

Existing electrical systems should remain in satisfactory operation during construction, except when shutdowns are permitted by the specifications. The contractor may need to provide a temporary system in order to maintain satisfactory operation during construction. Coordinate with the local agency for the operation of the signal system during construction. Any existing facilities damaged by the contactor's operations must be promptly repaired or replaced in accordance with the specifications.

Throughout construction, it is important that the contractor provide adequate warnings and safeguards in the form of signs, lights, and barricades. All temporary traffic control devices used must be in good condition and conform to the latest version of the "Manual on Uniform Traffic Control Devices" (MUTCD) and the NDOT Standard Plans. Any excavated foundation holes, where pedestrians may walk, must be covered with adequately braced plywood or an equivalent.

Underground work such as the installation of conduit and concrete foundations should be inspected while the work is actually being performed, since these items cannot be inspected once the work is complete. If any unexpected underground utilities are encountered while performing underground work, a representative of the utility owner should be contacted immediately.

All electrical equipment and installations must be properly grounded according to the bonding and grounding techniques explained in the plans and specifications. Electrical systems should be tested for system voltages, insulation resistance, ground continuity, and current before final inspection. If detector loops are being installed on the project, they should be tested before and after they are permanently secured in the pavement. The plans and specifications fully explain the testing techniques and acceptable tolerances. The tests should be performed by the contractor, in the presence of the inspector, and documented. Any items that fail to test satisfactorily should be repaired or replaced.

Changes made during construction are recorded using NDOT form 040-056, "Daily Construction Report," and on the as-built plans. Specific details of the changes made should be recorded. Significant changes require a change order.

The specifications will describe the specific components of electrical systems that require inspection during construction.

6-623.3.1 CONDUIT

Conduit is an integral part of all electrical systems as it provides for the installation of the wiring that powers the electrical equipment. The two different types of conduit used for underground installation on electrical systems include metallic (steel) conduit and non-metallic (plastic) conduit. An initial inspection of the conduit should be performed prior to conduit installation to confirm that the conduit is in good condition and that it is of the schedule and size specified in the plans and specifications. Non-metallic conduit used in electrical systems should be gray in color unless otherwise indicated in the plans and specifications. Conduit should also have the manufacturer's name, trade size, and schedule imprinted on the outside. Should the contractor want to use a different conduit size and schedule not conforming to the plans and specifications, it must be approved by the Resident Engineer. Conduit should also be inspected for cracks, dents, excessive weathering, or signs of having been damaged. Any conduit that does not appear to be in acceptable condition must be rejected.

For placing electrical conduit underground, the typical methods of installation are trenching and boring. The contractor can typically choose which method of installation to use, as long as it is in conformance with the plans and specifications. As conduit is being installed, the inspector should monitor the following:

- Verify that conduit is placed at the proper depth, and the trench is properly bedded, backfilled, and compacted in accordance with the plans and specifications. On new construction, all trenching for conduit located under paved surfaces should be placed prior to construction of the base course and pavement
- For clarity, conduit runs as shown on the plans, are schematic. Actual installation of the conduit should be as straight a line as possible between pull boxes or other terminations. Changes made to conduit routing during construction should be reflected on the as-built plans
- When conduit is properly screwed together, all threads should be covered by the coupling, and the ends of the conduit should be butted tightly together. If threads are exposed, generally either the connection is not tight or the threads are crossed in the coupling
- Rigid metallic conduit, when used underground, must be wrapped in accordance with the specifications to protect it from corrosion

- When a conduit run containing signal cables is over 50 feet in length, all bends (sweeps) must be factory-coated PVC rigid metallic conduit. The friction created by the cable being pulled through a sweep on a long run, may 'burn' through the side of a PVC sweep, creating a hole in the conduit
- The total degree of bends (sweeps) used on a conduit run cannot exceed 360°. For example, a conduit run with 90° sweeps can only have four sweeps
- Field bends should be made only with approved tools, and conduit should never be bent to a radius smaller than the minimum bend radius specified by the conduit manufacturer.
- Conduits should be capped to prevent contamination such as dirt, debris, rodents, and water from entering them until the wiring is installed. After the wiring is installed, the ends of the conduit should be plugged with an approved duct seal to prevent contaminants from entering the conduit
- Conduit used on a pole as a riser for power service must conform to the specifications and the power company's standards
- Allow only the number and sizes of cables/conductors in a conduit that is shown in the plans. The size of the conduit specified is based on the fill, or amount of space taken up by the wiring. The National Electrical Code (NEC) limits the number of conductors that are allowed to be installed in a single conduit. If approved, at the contractor's expense, the contractor may use a larger size conduit than specified on the plans, as long as the same size and type is used for the entire length of the conduit run
- Verify that all conduit runs are complete and that all appurtenances such as pull boxes, poles, and controller boxes are connected by conduit runs. Conduits that terminate in pull boxes with multiple runs should be permanently labeled or otherwise identified to determine where they run

For conduit that is to be installed in or on a structure, the inspector should consider the following:

- Refer to the bridge plans for conduit installation details
- Expansion fittings are provided when a conduit passes through an expansion joint on a structure
- Conduit that is hung on structures must have hangers that conform to the specifications, and should be painted the same color as the structure and run straight to provide a suitable appearance

6-623.3.2 PULL BOXES

Pull boxes, vaults, or junction boxes are installed at conduit termination points, and facilitate wire pulling and splicing. The term vault is used for a large pull box and the term junction box is used for a pull box that is located in or on a structure. The size, type, and installation methods for pull boxes will be indicated on the plans and in the specifications. Typically, pull boxes used on NDOT projects are required to be traffic rated with metal lids. Initial inspections of the pull boxes should be performed prior to installation, and any pull boxes that are chipped, cracked, or have more than minor surface blemishes should be rejected. As pull boxes are being installed, the inspector should consider the following:

- Pull boxes should generally be placed at intervals as shown on the plans. The contractor may install additional pull boxes or junction boxes to facilitate operations however, it will be at the contractor's expense
- Pull boxes are typically installed on a minimum of 6-inches of drain rock or as shown on the plans. Additional drain rock may be required around and under the pull box to prevent the soil from eroding around the pull box
- The tops of pull boxes should be set flush with the final grade and slope; whether in pavement, sidewalks, landscaped areas, or in the roadway shoulder
- Verify that steel pull box lids are grounded
- On unpaved slopes, check that pull boxes are kept out of depressions so as not to collect water
- Pull boxes should not be placed in pedestrian ramps
- Pull boxes placed in structures must be constructed and placed in accordance with the plans and specifications. If the formed type of pull box is to be used, confirm that the contractor places properly dimensioned wooden pull box templates at the correct locations and the conduit is stubbed into the pull box before concrete is placed for the structure
- Verify that pull boxes placed on or adjacent to a structure are placed away from where expansion joints will be located

Following construction, a final check of pull boxes should be performed to verify pull box lids are properly fastened, all metal pull box lids are properly grounded, and all lids are properly marked with embossed lettering identifying what the pull box is being used for. Refer to the specifications for additional information on requirements for pull box lid markings.

6-623.3.3 WIRING

Wiring is used in electrical systems to convey electrical power to the system components. The wiring for electrical systems generally consists of conductors and cables. A conductor is a single wire, and a cable is a group of two or more insulated conductors wrapped in a common sheath. Wires are sized based on the standard American Wire Gauge (AWG) system which uses numbers to indicate the size of the wire; in general, the smaller the number, the larger the wire diameter. Since wiring is typically installed underground in conduit, it is important to perform a preliminary check of the wiring prior to installation to make sure the insulation is not damaged. Wiring with damaged insulation must be rejected. During installation of the wiring in conduit, the inspector should consider the following:

- The wiring being installed should match the size and type being called for in the plans and specifications. The symbols for wire sizes, insulation types, and temperature and voltage ratings are imprinted on the insulation of single conductors or the non-metallic sheath of multi-conductor cables
- In general, wiring that is installed in conduit should be pulled through the conduit by hand. Pulling wire by mechanical means may damage the conductors, the insulation, or the conduit. If the specifications permit power pulling of larger conductors or cables, a tension measuring device should be used in accordance with the manufacturer's recommendations
- All traffic signal conductors must be run continuously from terminal to terminal with no splices. (Terminals are the devices located on the poles and in the controller that are designed specifically for joining electrical circuits together)
- When a single conduit or pull box has multiple circuits passing through it, each circuit should be labeled. All traffic signal conductors and cables must be labeled and color coded in accordance with the specifications. Labels should be banded to the conductors or cables with labels specifically designed for wiring
- When possible, high voltage wiring and low voltage wiring should be placed in separate conduit

As the contractor installs the wiring, wire splices will sometimes be necessary. The plans and specifications give specific guidance on what types of wires can be spliced, appropriate splicing methods, and where splicing is allowed. As splicing requirements may be different for different types of wiring, it is important to thoroughly review the plans and specifications to become familiar with these requirements. In general, splices are typically allowed only in pull boxes, junction boxes, or at the bases of lighting standards. Also, splicing is often not allowed on certain types of wiring such as signal interconnect cable and detector loop cable.

6-623.3.4 SERVICE ENCLOSURES

Service enclosures are the cabinets that house the circuit breakers and electrical service equipment. There are two separate sections in a typical service enclosure, a line side and a load side. The line side is the section where the serving utility brings in the wires from the service point. The load side is the section that houses the circuit breakers and where the wires go out to power the electrical equipment.

Service enclosures are typically either pedestal mounted or surface mounted on a pole or cabinet. Pedestal mounted service enclosures are mounted on concrete pads, which can either be cast-in-place or precast. The cabinet is bolted into place on the pedestal and properly sealed in accordance with the specifications to prevent seepage of water into the cabinet. If the service enclosure is mounted on a pole or cabinet, it should be securely fastened in accordance with the plans and specifications. Service enclosures should be placed in a location where utility access can be provided and oriented such that the meter can easily be read. The service address should be embossed onto a metal plate and permanently attached to the front of the enclosure.

Make sure the service cabinet is the type specified in the plans and specifications. The circuit breakers should have their ratings imprinted on them and a nameplate identifying what the circuit breaker controls. A nameplate should be placed adjacent to each circuit breaker. Confirm that these circuit breaker ratings match what is called out for in the plans and specifications. The cabinets should also be inspected for dents or chipped paint. Minor dings or paint chips can be field repaired, but cabinets with more than minor damage must be replaced.

Some service enclosures will also house transformers, which are devices that are used to boost or drop voltage. If a transformer is to be installed in an enclosure, it will be called out for in the plans and specifications. Because transformers generate a certain amount of heat, the enclosure housing the transformer usually needs to be vented and may require a fan. Make sure the venting and screening is accounted for and in accordance with the plans and specifications. Also, check that the transformer is securely fastened and wired in accordance with the plans and specifications.

6-623.3.5 CONTROLLERS AND CONTROLLER CABINETS

Controllers are the equipment that control and manage the components of an electrical system and are typically located in metal cabinets on the project, near the electrical system that they control. Controllers are necessary at all traffic signals, and are needed to operate many ITS components such as changeable message signs, traffic monitoring stations, and closed-circuit television (CCTV) cameras. If a controller is necessary, the type of controller and cabinet to be installed will be called out for in the plans and specifications. The inspector should confirm that the controller and cabinet being installed are in good condition, are of the type that is specified, and include all equipment called out for in the plans and specifications.

The concrete base for the controller cabinet, conduits, and grounding systems is installed before the cabinet. The cabinets are supplied with a gasket that is placed between the clean concrete foundation and the cabinet. The cabinet must be bolted into place using the anchor bolts that are an integral part of the foundation, and properly sealed to prevent seepage of water into the cabinet. The door of the cabinet should be able to open fully without hitting any obstructions, and the cabinet should be oriented in the proper direction. Typically, the cabinet is oriented so that when a technician is working on the controller, the technician can see the system that it controls. Do not allow any electronic equipment, including the controller, to be placed inside the cabinet until the cabinet has been securely bolted into place on the foundation.

A wiring diagram should be provided with each cabinet. Confirm that the power input wiring, signal head (lights) output power wiring, detector wiring, and pedestrian push button wiring are connected to the labeled terminals in accordance with the wiring diagram furnished with the cabinet, and that all wiring is properly labeled in accordance with the plans and specifications. Any stranded conductors smaller than No. 14 should have crimp-on spade terminals installed on them to facilitate attaching them to the terminals. If any modifications are made to a signal system, the cabinet wiring diagram must be modified accordingly. Only certified IMSA Level II personnel should attempt to rewire any portion of the cabinet, or make modifications to any part of a signal system. Verify that the contractor provides documents for all modifications and the reasons for the modifications.

When completed, the cabinet and wiring should be neatly organized. All the wiring should be neatly and firmly bundled together, either laced, bound, or tie-wrapped, and out of the way so that the wire bundles don't inadvertently come into contact with various components, such as the test switches mounted on the inside of the door. The wiring bundles should be arranged so that technicians cannot easily hook them or disturb them when opening the door.

6-623.3.6 POLES

Poles are used on electrical projects for traffic signals, lighting, overhead sign structures, and intelligent traffic systems. In general, all poles and anchor bolts should be inspected prior to installation to confirm that they are of the correct type and are in good condition. The type of pole to be installed at each location will be detailed in the plans. Poles or pole arms with dents should be rejected, and any damaged galvanizing or paint should be properly repaired in accordance with the specifications.

Prior to installation, each pole location should be staked and the locations should be approved by the inspector. As signal pole locations are often dependant upon pedestrian ramp and sidewalk placement, the locations of these items should be staked as well to facilitate pole location approval. Should any underground or overhead utilities prevent the placement of a pole at its specified location, the Safety/Traffic Division should be contacted to provide an alternate location. When laying out pole locations for traffic signals, verify that no obstructions exist that will prevent vehicular or pedestrian traffic from seeing vehicular or pedestrian signal faces, or that will prevent pedestrians from accessing push buttons. Poles with push buttons must be located so that the button is ADA accessible and in accordance with the most recent editions of the MUTCD and the NDOT Standard Plans.

All poles must be mounted on properly prepared foundations with properly sized anchor bolts and be individually grounded in accordance with the plans and specifications. The finished pole foundations should not be placed in depressed areas and anchor bolts should be embedded to the proper depth. Poles should be mounted to the anchor bolts, plumbed, and the nuts should be properly tightened in accordance with the specifications. When the plans call for the installation of a lighting standard with a safety base, check that the safety base is properly installed by the contractor. Specific safety base installation and torque requirements are explained in detail in the plans and specifications. Installing the safety base in accordance with torque requirements is critical for the safety base to perform as designed.

Concrete for pole foundations is often placed without forms against the excavation. The resulting rough block of concrete is functionally satisfactory, however, confirm that the contractor forms and finishes the exposed part of the footing and that all exposed forms are stripped after the concrete is at full strength. Verify that the foundation excavation is of the proper size and depth as detailed in the plans and specifications, and confirm that the specified concrete is used.

Mast arms on poles for traffic signals and lighting must be bolted to the flanges and installed in accordance with the specifications. Traffic signal mast arms will require tenons, which are steel tubes to which the signal heads are attached. The contractor may be required to field weld the tenons to the mast arms in order to properly align the signal heads with the travel lanes. All field welds need to be certified welds, performed in accordance with the specifications. After welding, metal surfaces must be repainted or galvanized in accordance with the specifications. Signal poles and mast arms are designed to withstand not only the dead loads that result from traffic signal heads and signs, but also from live loads caused by winds and truck gusting. The loads on the arms and poles must not exceed the loads for which they were designed. Do not allow any additional equipment or signs to be placed on the poles or mast arms, and do not allow the installation of a longer signal arm on an existing pole without approval from the Safety/Traffic Division

6-623.3.7 VEHICLE AND PEDESTRIAN SIGNAL HEADS

Vehicle and pedestrian signal heads are installed at traffic signals to control vehicle and pedestrian movements. Signal heads generally consist of indication lenses installed in a main housing; a back plate and visors are also usually required to be attached to the housing. All signal heads should conform to the plans and specifications and should be inspected for damage to the housings and lenses prior to and after construction. Minor paint scrapes or blemishes may be touched up in the field, but any housings or lenses with cracks must be rejected.

Signal heads are designated in the project plans under “pole schedule” by a standard code. For instance, a 1W3C head is a typical one way, three-color head. Vehicle and pedestrian signal heads should be installed at the locations shown on the plans and oriented towards the movement they are designed to control. Vehicle signal heads must be properly aligned with the travel lanes and leveled. The type of mounting for vehicle and pedestrian signal heads can also be found in the signal summary sheet under “Pole Schedule”. There are three basic types of mounts: mast arm mounted heads, bracket or side mounted heads, and post-top mounted heads. Details of the various mounts can be found in the plans. Make sure the contractor places them in accordance with the plans.

Signal heads are wired from the head to the terminal block on the pole with single conductors. All wiring should be performed neatly and labeled in accordance with the plans and specifications.

6-623.3.8 VEHICLE AND PEDESTRIAN DETECTION

The standard types of vehicle and pedestrian detection consists of loop detectors, video detection, preemption, and pedestrian push buttons. Vehicle and pedestrian detection is an area where evolving technology creates advances in equipment. Because of this, the plans and specifications for each project should be thoroughly reviewed to confirm that the detection equipment being provided is of the correct type, and is properly installed.

6-623.3.8.1 LOOP DETECTORS

Loop detectors are installed by sawcutting slots into the pavement, wrapping a cable in the slots, and filling the slots with an approved loop sealant. The loop wires are run from the loop to the pull box, where they are spliced to a loop cable, and the loop cable runs from the loop wires to the controller cabinet. Typically, splicing of the loop cable is not allowed. Proper detector loop installation techniques and details are shown and explained in further detail in the plans and specifications. Proper installation and labeling of individual loop wires is essential, as improperly installed detector loops will cause ongoing problems with vehicle detection and can result in malfunctioning signal systems. Maintenance and replacement of improperly installed detector loops is time consuming and expensive. .

When inspecting loop detector installations, check that the overall loop layout and proposed loop type match the plan details. Loops should not be placed across cracks or joints in the pavement and should be at least 2 feet from the lane lines. Generally, loops should be centered in the travel lane unless the plans show otherwise. Placing loops across cracks can result in early loop failure, and placing them too close to a lane line may cause vehicles in the opposing lane to be detected. If no alternative location can be provided for loop wires and they must cross a joint or crack in the pavement, a flexible slip joint should be provided in accordance with the plans and specifications. If a manhole or water valve is located where a loop detector is to be installed, the loop detector must be modified; the Safety/Traffic Division should be contacted for a design change.

Sawcuts should be inspected to verify that the cut is de-burred, cleaned out, and blown dry prior to installation of the loop wires. The contractor performs testing on detector loops as required by the plans and specifications before and after they are permanently secured in the pavement. Test results should be documented by the inspector and submitted to the Resident Engineer.

The loop wires should have identification bands placed on them and be properly labeled in the pull box, and the loop cables should be properly labeled in the controller cabinet. If loops are installed for future use, the ends of the wires must be taped and waterproofed in the pull box, and the wires should be labeled.

6-623.3.8.2 VIDEO DETECTION

Video detection is a system that uses video cameras instead of loops for detecting vehicles. Cameras are typically mounted on poles or mast arms and pointed towards the approach that they will detect. The method used to mount the cameras should be in accordance with the plans and specifications, or the manufacturer's recommendations. The symbol shown on the plans does not necessarily indicate the proper mounting location. There are many different types of video detection systems available, and the system used needs to be compatible with the controller. Because of this, it is important to check that all components of the video detection system comply with the specifications.

Field wiring for the video cameras is relatively easy, consisting of a coaxial cable and power wiring run from the camera to the controller. Wiring should be done neatly and labeled properly. Wireless video detection systems are also available. If a wireless system is to be used on the project, it will be specified in the plans and specifications. .

6-623.3.8.3 PREEMPTION

Preemption is a type of vehicle detection that recognizes certain types of vehicles as they approach and assigns their movement priority at a traffic signal. Preemption is typically installed at traffic signals for emergency vehicles, but it can also be used for transit and for rail vehicles. Emergency vehicle and transit preemption equipment, if applicable, consists of detectors that are mounted on signal arms or luminaire arms and a phase selector that is mounted in the controller cabinet. The locations of the preemption detectors and mounting details will be shown on the plans. Check that the proposed detector location is within the line of sight of an approaching vehicle from the direction that it controls. If the line of sight to the detector is impeded due to curvature of the roadway, landscaping, or any other fixed object, contact the Safety/Traffic Division to provide an alternate location. Make sure the equipment is the type specified in the plans and specifications and is properly mounted. Special cable is typically used to connect the preemption detectors to the phase selectors in the cabinet, splicing of this cable between the detectors and phase selectors should not be allowed. .

For railroad preemption, the railroad company provides the operator of the traffic signal system with a railroad preemption circuit that is connected to the controller. Wire will be run through conduit from the traffic signal controller to a pull box located at the railroad right-of-way that will be connected to the railroad's circuit. Railroad preemption at a traffic signal must be coordinated with the railroad and the coordination is typically handled through the Right-of-Way Division Utilities Section. If railroad preemption is applicable for a project, the inspector needs to confirm that the conduits, pull boxes, and wiring are installed in accordance with plans and specifications.

6-623.3.8.4 PEDESTRIAN PUSH BUTTONS

Pedestrian push buttons are used to detect pedestrians at traffic signals. A standard pedestrian push button assembly consists of a base, sign panel and push button. The push button assemblies will typically be mounted on a traffic signal pole or on a smaller pole called a pedestrian push button post. The mounting height, location, and accessibility of pedestrian pushbuttons must comply with the most recent editions of the Americans with Disabilities Act (ADA), the *Manual on Uniform Traffic Control Devices,* and the NDOT Standard Plans. If a proposed pedestrian push button location is not accessible, the Safety/Traffic Division should be contacted to provide an alternate location. The push buttons should be securely mounted to the pole at the correct height and in the correct quadrant, as shown in the plans. Make sure the arrow on the sign panel points in the correct direction.

6-623.3.9 LUMINAIRES

Luminaires are used on electrical projects for the lighting of roadways and overhead signs. Luminaires for overhead signs are mounted on the supporting framework in front of the sign, mounting details for these lights can be found in the plans. Luminaires for roadway lighting can be mounted on a pole or on a structure. The plans and specifications will show mounting details and show the locations of all luminaires on the project. The inspector needs to check that all luminaires match the type and wattage called for in the approved equipment submittals and are properly mounted and oriented in the correct direction so that the light distribution lights the roadway as designed. For luminaires mounted on poles, the pole should be plumbed and the anchor bolts should be tightened before the tilt angle on the luminaire is set. Structure and wall mounted luminaires should be oriented and installed per the manufacture's specifications.

6-623.3.10 INTELLIGENT TRAFFIC SYSTEMS (ITS)

While many ITS components are commonly used electrical items, other ITS components may require highly specialized equipment. The plans and specifications should be thoroughly reviewed for all projects with ITS equipment to confirm that the equipment being installed meets the requirements of the project. There may also be test procedures and knowledge of operational parameters that require specialized expertise to be provided by the equipment suppliers, installers, or manufacturers. Any specialized tests and procedures should be observed and documented by the inspector.

6-623.3.11 UTILITY COORDINATION

Utility coordination will typically be required on electrical projects to obtain electrical and/or telephone service points. Prior to construction, contact the Safety/Traffic Division and district utility coordinator to discuss the status of electrical and utility agreements for the project. If an electrical or telephone service connection needs to be obtained, the district utility coordinator should submit an application to the utility company. Once the meter pedestal is installed and ready for inspection, the district utility coordinator should be notified to perform a final inspection. The district utility coordinator will work with the Resident Engineer and the utility company for the final meter installation and activation.

6-623.3.12 TESTING

Before completion and acceptance of electrical work, testing must be completed in accordance with the plans and specifications. All electrical systems should be tested for system voltages, insulation resistance, ground continuity, and current before final inspection. If detector loops are being installed on the project, they should be tested before and after they are permanently secured in the pavement. Testing techniques and acceptable tolerances are explained in detail in the plans and specifications. The tests should be performed by the contractor, in the presence of the inspector, and documented by the inspector. Test results should be submitted to the Resident Engineer. Any items which fail to test satisfactorily should be repaired or replaced.

6-623.3.13 TRAFFIC SIGNAL TURN-ON

Prior to the turn on of a new traffic signal system, the following should be performed:

- Until signals are placed in operation, the signal heads are to be turned away from traffic and/or completely covered with an approved method
- Before a new traffic signal is opened to traffic, do a final check to verify all traffic control devices are in place and working properly
- Check that the contractor has properly installed all signing and striping items
- Give two weeks notice of the proposed turn-on of a signal system to the District traffic engineer, public information, local jurisdiction, local maintaining agency, local fire and police departments, and schools
- If timing information is required and not provided by the local agency, contact the Safety/Traffic Division

6-623.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. Typically, measurement and payment of the wiring and conduit is paid for by the linear foot, and most other items are paid for by each. Items such as pole and cabinet foundations are included in the price of the item to be installed. On new installations, the payment for traffic signal controller cabinet will include a fully equipped cabinet, except for preemption and video detection equipment, which will be included in the payment for those items. The payment for electrical service cabinet also includes a fully equipped cabinet.

6-624 ACCOMMODATIONS FOR PUBLIC TRAFFIC

6-624.1 GENERAL

This section provides guidance on worker protection and the safe passage of public traffic through and around construction with as little inconvenience and delay as possible. Refer to the current version of the *Manual on Uniform Traffic Control Devices (MUTCD)* and the plans for details on signs, lights, and traffic control devices used on construction projects. An electronic version of the MUTCD is found at the following web site: http://mutcd.fhwa.dot.gov/kno-2003r1.htm .

A traffic control plan addresses management of public traffic in and around a construction project. When NDOT prepares the traffic control plan, the designer, in consultation with the District, Construction Division, and Safety/Traffic Division, develops a plan to accommodate public traffic during construction. If the plans and specifications require the contractor to prepare the traffic control plan, the contractor, in consultation with the Resident Engineer, develops a plan to accommodate public traffic during construction, as required in Section 625 of the specifications. The purpose of the plan is to provide safe passage of traffic as well as to create and maintain safe work areas for construction personnel. When the plan is prepared by NDOT, it is based on a logical sequence of operations. When submitted by the contractor, the plan is based on the contractor's scheduled construction operations.

Traffic control plans have the following basic objectives:

- Protect the traveling public
- Protect construction workers
- Reduce traffic delays in work zones
- Channelize traffic
- Provide directional information to drivers
- Provide an acceptable level of service during construction operations
- Provide for pedestrian and bicycle traffic

Because NDOT places importance on traffic flow and safety in work zones, it has developed Policy 07-02 on Work Zone Safety and Mobility, and the *Work Zone Safety and Mobility Implementation Guide*. The traffic control plan may be included in the plans and specifications, or the specifications may require the contractor to prepare traffic control plans.

Traffic control plans developed by the contractor are reviewed and either accepted or rejected by the Resident Engineer. The Resident Engineer works with the contractor and project stakeholders in reviewing the contractor's traffic control plans. The Resident Engineer confirms that the contractor's traffic control plans comply with Policy 07-02, and the plans and specifications. The Resident Engineer may confer with the District Engineer or the Safety/Traffic Division for assistance.

The Resident Engineer may propose changes to traffic control plans included in the plans or developed by the contractor. Typically, changes to traffic control plans are considered when field conditions are different from those contained in the plans. The traffic control plan must be appropriate for expected conditions during construction. If the traffic control plan is included in the project plans and specifications, the traffic control may require modification to address the contractor's proposed operations. The Resident Engineer documents the proposed traffic control changes and submits them to the District Engineer and the Safety/Traffic Division for review and approval.

6-624.2 BEFORE CONSTRUCTION

The Resident Engineer should perform the following duties:

- Compare the project traffic control plan to jobsite conditions. Note any unusual local traffic movements and the movements of emergency vehicles. Discuss the traffic control plan at the preconstruction conference.
- Review the specifications for operations limitations as related to traffic control.
- Review proposed changes to traffic control plans with the Safety/Traffic Division and the District traffic engineer.

6-624.3 DURING CONSTRUCTION

During construction, the Resident Engineer assigns an inspector to monitor and document traffic control activities. The inspector must be certified by the American Traffic Safety Services Association (ATSSA) as a traffic control supervisor. The inspector should consider the following:

- Observe installation of specified signs and traffic control devices. Signs, barricades, drums, cones, and flagger paddles must meet specified retro-reflectivity requirements described in Section 625 of the specifications.
- To document the markings, devices, and signs that exist during the project, maintain a detailed record of the placement and spacing of signs and other traffic control devices on the inspector's daily inspection report.
- On the back of each sign, print the assigned installation number, contract number, date of installation, and inspector initials. Also enter this number in the appropriate field book.
- Regularly drive through the project and review the traffic control installed to confirm continued conformance with the traffic control plan. Monitor the effectiveness of the traffic control while driving through the project. Discuss ideas for improving the traffic control with the Resident Engineer. Note deficiencies and immediately notify the contractor to take corrective action.
- Regularly monitor the retro-reflectivity of signs, barricades, drums, cones, and flagger paddles. The contractor may be required to clean or replace devices with unacceptable retro-reflectivity.

- The contractor's traffic control supervisor must submit the original and copies of completed NDOT form 040-056B, "Work Zone Traffic Control Checklist," as required by the specifications. If documentation is not provided by the contractor, the Resident Engineer may withhold payment to the contractor for the Traffic Control Supervisor bid item.
- Verify flaggers are at designated locations and that they meet the requirements of the specifications. Flaggers must have certifications in their possession. Flagger qualification is obtained through the following approved instructional courses: NDOT in-house flagger training, University of Nevada, RenoT2 program, American Traffic Signing and Safety Association (ATSSA), and National Safety Council.
- Record work hours for all flaggers on the project using NDOT form 040-036, "Flagging Hours," for proper payment.
- When unpredictable situations occur, a formally approved traffic control plan is not required, but written documentation is required to record actions taken and directions given.
- If the contractor's operations interfere with or cause potential safety problems with vehicular or pedestrian traffic, notify the contractor to correct the deficiency immediately. If the notification to the contractor is verbal, document the notification in writing to the contractor.
- Because the safety of the traveling public is of the utmost concern, NDOT maintenance forces may need to correct traffic control deficiencies when the contractor is physically unable or refuses to act. The Resident Engineer may terminate the contractor's work operations if the contractor fails to perform. Keep the Resident Engineer informed of traffic control deficiencies. If danger persists, take immediate action.

To reduce the impacts to existing traffic, NDOT may require the contractor to conduct construction activities when traffic volumes are low. These low volume periods typically occur at night. Although nighttime construction can reduce traffic impacts in the work zone, it can also create situations that require diligent attention to worker and motorist safety.

The contractor's traffic control supervisor is responsible for initiating, installing, and maintaining all traffic control devices. A uniformed traffic control officer is required when a signalized intersection is interrupted for construction activities. Uniformed traffic control officers are city, county, or state police officers. The specifications will state if a uniformed traffic control officer is required.

The effectiveness of handling traffic through night construction depends upon the plans and upon the details of the contractor's operations. Consider the following during nighttime operations:

- Light the immediate work area and flagger stations with floodlights, taking care to not blind drivers.
- Require workers to wear bright colored clothing with reflective material that conforms to the specifications.
- Ensure that signs, barricades, and traffic control devices are clean and have proper retro-reflectivity.

- Confine the work area to the shortest practical distance.
- Verify the contractor's operation plan provides sufficient room for construction vehicle access with the least impact to traffic.
- Either through illumination or suitable marking, all construction equipment should be visible to traffic.

In the event of an accident within the work zone, the traffic control inspector must document the traffic control devices in use at the time of the accident on NDOT form 040-056, "Daily Construction Report." Photos are useful additions to written records. For information on other required accident documentation, refer to Section 3-404, Safety, of this *Construction Manual*.

Although a traffic control plan reflects the contractor's operations and traffic conditions during construction, setting up the various elements of the plan at the appropriate time is also important. The traffic control measures must address current activities and conditions. For example, a flagger may or may not be present. If the flagger is not present, "Flagger Ahead" signs should not be visible to traffic. Traffic control measures create driver expectation of upcoming conditions. When traffic control measures do not accurately reflect upcoming conditions, drivers tend to disregard signage and other traffic control devices.

Timely publicity can significantly improve traffic behavior on a construction project. A motorist who is forewarned of construction conditions will be more tolerant of delay and inconvenience and probably will be more alert and responsive to construction zone traffic control. The Resident Engineer must verify that information on project road closures, new road openings, traffic rerouting, and changes in traffic conditions is made available before such changes.

6-624.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-625 CONSTRUCTION SIGNS

6-625.1 GENERAL

Construction signs are a part of accommodating public traffic through a construction project. The project plans and specifications address requirements for construction signing, temporary traffic control devices, and traffic control plans. General guidance relating to construction signs is included in Section 6-624, Accommodations for Public Traffic.

When the specifications require the contractor to develop a traffic control plan, the Resident Engineer reviews and either accepts or rejects the contractor's traffic control plan. The contractor must submit a traffic control plan that complies with the specifications at least seven days before the preconstruction conference. The Resident Engineer works with the contractor and project stakeholders in reviewing the contractor's traffic control plans. The Resident Engineer confirms that the contractor's traffic control plans comply with Policy 07-02, and the plans and specifications. The Resident Engineer may confer with the District Engineer or the Safety/Traffic Division for assistance.

The Resident Engineer may propose changes to the contractor's traffic control plan. Typically, changes to traffic control plans are considered when field conditions are different from those contained in the plans. The traffic control plan must be appropriate for conditions that will be encountered during construction.

6-625.2 MEASUREMENT AND PAYMENT

Traffic control devices such as signs, barricades, cones, and drums are paid as rental items. As a traffic control device is installed, the sign installation is noted and it is measured for payment. The rental payment for each specific device is for the duration of the project. No additional compensation is paid if the same device is used at a different location. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-632 PERMANENT PAINTED PAVEMENT MARKINGS

6-632.1 GENERAL

This work consists of applying permanent painted traffic stripes or pavement markings to the roadway surface. Pavement striping or markings materials can be any of the following:

- Epoxy paint
- Waterborne paint
- Thermoplastic
- Polyurea paint

The plans and specifications will describe the striping and markings locations and types.

6-632.2 BEFORE CONSTRUCTION

Before work begins, the Resident Engineer should discuss the pavement markings with the NDOT District maintenance striping superintendent or supervisor. Determine if any striping or marking concerns require attention. In addition, the Resident Engineer should take the following preliminary steps:

- Discuss pavement marking materials and placement operations with the contractor.
- Review striping and marking plans, details, and any special requirements.
- Review existing field conditions. The Resident Engineer consults with the Safety/Traffic Division and the District Traffic Engineer if any changes to the plans appear to be necessary.
- Obtain material certificates of compliance before or when the material is delivered to the project. Examine the material as it arrives on the project. Look for clearly labeled containers. Verify the delivered material is the type specified to be applied.
- Obtain required samples as specified in Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.

- Inspect the contractor's equipment for specification compliance. Examine the contractor's methods for checking spread rates of paint and glass beads, application temperatures of paint material, and maximum temperatures of paint.
- Verify that the survey crew has coordinated with the contractor to establish an appropriate pilot line for proper application of pavement striping and markings.
- If installing pavement markings, verify that the contractor's stencils will produce correctly dimensioned pavement markings.

6-632.3 DURING CONSTRUCTION

During the work, do the following:

- Require that paint and thermoplastic material be placed within the specified temperature range. Thermoplastic material heated to excessive temperatures can flash and splatter when exposed to air. Check the accuracy of temperature gauges mounted on heating equipment. Employees working around thermoplastic material should wear suitable personal safety equipment, long-sleeved shirts, and eye protection.
- Verify that paint and other pavement marking material temperatures are within the limits contained in the specifications.
- Before applying pavement marking material, check and document the pavement temperature, atmospheric temperature, and expected weather conditions. Never apply materials when rain, fog, or condensation could damage the freshly painted surface.
- Before applying pavement markings, check the condition of the pavement. The pavement must be dry and clean as specified.
- Apply pavement markings within the specified time limits after completing the pavement surfacing.
- Check traffic stripes for the correct width, lengths of gaps and stripes, alignment, and direction of application.
- Check that the applied paint material complies with thickness requirements. Check the paint thickness before application of glass beads and record it on NDOT form 040-021 "Striping Paint Thickness Report."
- Check application rates for glass beads and paint. Inspect the stripes to verify that glass beads are spread uniformly and are properly embedded.
- Check thermoplastic markings for workmanship as the markings are applied. Do not permit bumps resulting from overlaps in extruded materials.
- Take samples, when necessary, in accordance with the sampling frequency Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*.

- After application, look for any damage to striping or marking. Document any deficiencies, and notify the contractor of any required corrective action.
- Conduct and document an immediate night inspection to verify the retro- reflectivity of the installed material. One to two weeks after installation, monitor the contractor checking the retro-reflectivity of the installed material with a reflectometer listed on QPL. Checking the retro-reflectivity is required for final acceptance and is reported on NDOT form 040-041, "Retroreflectivity Measurements". If the retro-reflectivity fails to meet specifications, notify the Resident Engineer who will confer with the Materials Division and the Construction Division Quality Assurance Section to determine if corrective actions are necessary.

6-632.4 MEASUREMENT AND PAYMENT

Measure the striping and markings as described in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Solid double lines are considered a single line when measured for payment. Gaps in the broken or dotted lines are included in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-633 PAVEMENT MARKERS

6-633.1 GENERAL

This work consists of applying raised or recessed pavement markers to the roadway surface. Recessed pavement markers may be used in areas subjected to snow. Raised pavement markers are typically used in areas that are not subject to snow removal operations. The plans and specifications will describe the locations and type of pavement markers to be installed.

6-633.2 BEFORE CONSTRUCTION

Before work begins, take the following steps:

- Review striping plans, details, and any special requirements.
- Review existing field conditions. Consult the District Traffic Engineer and Safety/Traffic Division with any potential changes.
- Verify that the survey crew has coordinated with the contractor to ensure an appropriate pilot line is established for proper application of pavement markers.
- Review the contractor's proposed method of controlling traffic and verify that all the specified components of any required traffic control are in place.
- Verify the receipt of specified material certifications before installing markers. Confirm that markers and adhesive are on NDOT's approved Qualified Product List.
- Take samples, when necessary, in accordance with the sampling frequency Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.

6-633.3 DURING CONSTRUCTION

During the work, do the following:

- Before placing pavement markers, confirm that new pavement has cured for the specified time.
- Before applying adhesives, check that the pavement is clean and the surface is dry.
- Determine that the patterns and types of pavement markers are placed correctly in accordance with the typical details on the plans.
- After placement, determine that the pavement markers are not on longitudinal or transverse joints and that they are fully supported with adhesive.
- Also after placement, look for any missing or damaged pavement markers and document any deficiencies.
- Conduct and document an immediate night inspection to verify the retro-reflectivity of the installed material. Notify the contractor immediately with any problems.
- When installing temporary markers, the contractor must replace lost or damaged markers daily.

6-633.4 MEASUREMENT AND PAYMENT

Pavement markers are paid by the marker for the types installed. Record counts for payment in the appropriate field book. When placing large quantities of pavement markers, the inspector may count the markers by keeping track of the number of boxes of markers used. Check this number against the estimated number of markers to be placed. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-634 PAVEMENT MARKING FILM

6-634.1 GENERAL

This work consists of applying pavement marking film to the roadway surface. The plans and specifications will describe the locations and type of pavement marking film to be installed. Pavement marking film should be inlaid in the fresh open-graded surface during final rolling of the mat, before the surface temperature on the mat falls below 160°F. Coordination between the paving crew and the pavement marking crew is critical to proper installation of marking film. An additional roller may be necessary to properly install marking film. For final acceptance the inspector must perform an adhesion test in accordance with the specifications. The test results are recorded on NDOT form 040-047, “Pavement Marking Film Adhesion Test”.

Pavement marking film has similar requirements to painted pavement markings. Therefore, refer to Section 6-632, Permanent Painted Pavement Markings, for installation, and measurement and payment guidance.

6-635 TEMPORARY PAVEMENT STRIPING TAPE

6-635.1 GENERAL

This work consists of applying temporary pavement striping tape. The plans and specifications will describe the locations and type of temporary striping tape to be installed. Temporary striping tape must be completed before opening the roadway to traffic. The contractor must maintain temporary striping tape without additional compensation.

6-635.2 BEFORE CONSTRUCTION

Before work begins, take the following preliminary steps:

- Discuss pavement marking materials and placement operations with the contractor.
- Review traffic control sheets for temporary striping details.
- Review existing field conditions. Consult with the District Traffic Engineer and the Safety/Traffic Division if any changes appear to be necessary.
- Obtain material certificates of compliance before or during material delivery. Examine the material as it arrives on the project. Verify the delivered material is the type specified to be applied.
- Verify that the survey crew has coordinated with the contractor to ensure an appropriate pilot line is established for proper application of temporary pavement striping.

6-635.3 DURING CONSTRUCTION

During the work, do the following:

- Determine that temporary striping tape will be correctly located.
- Before applying striping, check the condition of the pavement. Ensure the pavement is dry and clean as specified.
- Observe and document the installation. Notify the contractor immediately to correct any deficiencies.
- After construction, remove all temporary pavement striping tape.

6-635.4 MEASUREMENT AND PAYMENT

Measure the striping and markings according to the units and manner specified in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Include gaps in the broken or dotted lines in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. The contractor is required to maintain and remove temporary pavement striping tape without additional compensation; therefore, only the initial installation is measured for payment. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-636 TEMPORARY PAINTED PAVEMENT MARKING

6-636.1 GENERAL

This work consists of applying temporary painted pavement striping and marking. The plans and specifications will describe the locations and type of temporary pavement striping to be installed.

Temporary striping must be completed before opening the roadway to traffic. For temporary striping paint to adhere to the pavement surface the air temperatures must be at least 45°F and the surface temperature must be above 32°F. The contractor must maintain temporary pavement striping without additional compensation.

Temporary painted pavement marking has similar application requirements to temporary pavement striping tape. Refer to Section 6-635, Temporary Pavement Striping Tape, for installation guidance.

6-636.2 MEASUREMENT AND PAYMENT

Measure the striping and markings according to the units and manner specified in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Include gaps in the broken or dotted lines in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. The contractor is required to maintain temporary painted pavement markings; therefore, only the initial installation is measured for payment. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-637 POLLUTION CONTROL

6-637.1 GENERAL

Pollution control consists of the construction, installation, maintenance, and removal of temporary pollution and erosion control measures. This work prevents or minimizes air pollution, erosion, sedimentation, and pollution of water and wetlands that can occur during a construction project.

During the design phase, a project is evaluated to determine whether a storm water permit is required. If a storm water permit is not required, Section 637 of the project specifications will identify the project as “No Impact.” A “No Impact” project has no storm water pollution requirements. For all other projects, the contractor is required to use temporary pollution control measures during construction.

Temporary pollution control measures used to reduce water pollution and erosion are called "Best Management Practices." Temporary pollution control and erosion control work must conform to the requirements of NDOT's *Construction Site Best Management Practices (BMPs) Manual*. The contractor and the Resident Engineer have the following responsibilities relating to temporary pollution control:

- Contractor responsibilities:
  - Contact the Nevada Department of Environmental Protection (NDEP) at least seven days before the Pre-Construction Conference to obtain appropriate permits
  - Prepare a Storm Water Pollution Prevention Plan (SWPPP) containing Best Management Practices that conform with NDOT's *Construction Site Best Management Practices (BMPs) Manual* before submitting the Notice of Intent (NOI) to NDEP
  - File a NOI with NDEP at least two days before starting work
  - Provide copies of the SWPPP and environmental permits to the Resident Engineer before beginning work
  - Photograph existing vegetation in areas that will be disturbed
  - Submit applications for Temporary Working in Waterways/Discharge Permit to NDEP
  - Photograph installed BMPs within two weeks of completion
  - Designate an individual as the Water Pollution Control Manager (WPCM)
- Resident Engineer responsibilities:
  - Photograph existing vegetation in areas that the contractor will disturb
  - Inspect BMP installations weekly and document on NDOT form 040-054, "Weekly NDOT Construction Site Discharge Inspection Checklist"
  - If deficiencies are noted, monitor the situation daily to confirm compliance within seven days

The Best Management Practices in the NDOT *Construction Site Best Management Practices Manual* are minimum requirements that the contractor implements on construction projects. As necessary, the contractor may implement other best management practices in addition to the minimum required by the NDOT *Construction Site Best Management Practices Manual*.

When temporary pollution control measures are required, the Resident Engineer must perform weekly inspections. Under the following situations, weekly inspections are not required:

- Frozen ground conditions are expected to continue for at least one month
- Land disturbance activities have been suspended
- Beginning and ending dates of the waiver period are documented in the contractor's SWPPP

The Resident Engineer documents observations using NDOT form 040-054. The form is first completed on the date that the contractor begins work on the project, and is completed weekly until the conditions of the storm water permit are fulfilled. If inspections are suspended, the Resident Engineer completes NDOT form 040-054, noting that inspections are suspended and reasons for the suspension.

The contractor must construct and maintain erosion and sedimentation control measures in accordance with the Best Management Practices designated in the contractor's Storm Water Pollution Prevention Plan (SWPPP) for the project. The NDOT *Construction Site Best Management Practices Manual* contains additional information. Section 3-405, Environmental, of this *Construction Manual* also contains additional information.

6-637.2 BEFORE CONSTRUCTION

Before the contractor begins pollution control work, the Resident Engineer should consider the following guidelines:

- Review the contractor's schedule to identify construction activities that require placement of temporary and permanent erosion control measures.
- Review the contractor's approved SWPPP to identify the types and locations of the Best Management Practices (BMPs) that the contractor proposes to use.
- At the Pre-Construction Conference, discuss environmentally sensitive areas and other areas to be preserved as described in the plans and specifications. These areas should be clearly marked and communicated to the contractor.

6-637.3 DURING CONSTRUCTION

During pollution control work, the inspector does the following:

- Observe installation of the BMPs and verify that the installation conforms to the contractor's approved SWPPP.
- Inspect the installed BMPs and verify that each is performing in the intended manner.
- Complete NDOT form 040-054, "Weekly NDOT Construction Site Discharge Inspection Checklist." Note that the form must be completed weekly. A contractor's representative must sign the form before it is submitted to the Resident Engineer.
- Inspections may be suspended under the following conditions:
    - Frozen ground conditions are expected to continue for at least one month
    - Land disturbance activities have been suspended
    - Beginning and ending dates of the waiver period are documented in the contractor's SWPPP
- Temporary erosion and sediment control features that have served their useful purpose must be removed by the contractor, unless directed otherwise by the Resident Engineer.
- The Resident Engineer must continue inspections until the National Pollutant Discharge Elimination System permit is closed and the contractor removes the Best Management Practices.

After the contractor completes all items of work, the contractor requests to be relieved of maintenance. When the contractor is granted relief of maintenance, NDOT maintenance forces become responsible for maintaining the BMPs. Before the Resident Engineer grants relief of maintenance, the following actions and items must be completed for BMPs remaining in place:

- Coordinate with the Environmental Services Division and the NDOT Maintenance Manager for the project location to review BMPs that will be left in place
- Obtain a report from the Environmental Services Division that identifies the approximate time when acceptable stabilization will occur
- Provide the Maintenance Manager with copies of the most current inspection reports (form 040-054) for all BMPs remaining in place
- Confirm that BMPs that will remain in place are in an acceptable condition
- Provide a current copy of the contractor's SWPPP to the Maintenance Manager

With projects that have a bid item for plant establishment, the contractor is not relieved of maintaining the BMPs related to plant establishment until all plant establishment requirements are met.

6-637.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-640 RETAINING WALLS (MSE WALLS)

6-640.1 GENERAL

A retaining wall is a structure that holds back soil or rock. In roadway construction, retaining walls are used along cuts or fills where space is inadequate for construction of cut slopes or embankment slopes. Bridge abutments and foundation walls, which support earth fills, are also designed as retaining walls. Retaining walls are typically used in the following situations:

- New or widened roadways in developed areas
- New or widened roadways in mountains or near steep slopes
- Bridge abutments, wing walls, and bridge embankments
- Slope stabilization
- Protection against falling rock
- Depressed roadway sections

Figure 6-640.1. Typical MSE Wall.

Retaining walls prevent downslope movement or erosion and provide support for vertical or near-vertical grade changes. Retaining walls are generally made of masonry, stone, brick, concrete, steel, or timber.

A common type of retaining wall is the MSE wall (Mechanically Stabilized Earth). MSE walls utilize metallic (strip, bar mat, or wire mesh) or polymer (strip, grid, or sheet) reinforcement embedded in soil during backfilling of the MSE wall. The reinforcement is connected to precast MSE facing panels or modular blocks to create a reinforced soil mass. The backfill soil and reinforcement act together to restrain the soil. Figure 6-640.1 shows a typical MSE wall.

MSE wall systems are available in a variety of patented configurations. MSE wall systems consist of precast facing panels, wall panel spacers, and soil reinforcement. Because MSE wall systems are patented processes, the contractor designs the MSE wall system based on the design constraints contained in the plans and specifications. MSE walls approved for installation are listed on the QPL. The contractor is required to submit MSE wall shop drawings for review and approval.

MSE wall installation typically includes the following:

- Prepare the base material. This includes excavating to the MSE wall foundation grade, removing and replacing any unsuitable soil, and compacting the foundation soil.
- Construct a concrete leveling pad for MSE wall facing panels. Occasionally, a gravel pad is substituted for a concrete leveling pad.
- Place the first row of MSE wall facing panels on leveling pad. The first tier of precast facing panels is braced to maintain alignment and stability.
- Place and compact MSE backfill, and embankment if called for in the plans, up to the first layer of reinforcement.

- Place the second row of MSE wall facing panels.
- Layout and install soil reinforcement.
- Place and compact backfill over soil reinforcement.
- Repeat placement of wall panels, soil reinforcement, and backfill to final wall height.
- Construct traffic barriers, copings, or other appurtenances to the wall.

6-640.2 BEFORE CONSTRUCTION

Because the contractor designs the MSE wall system based on the design constraints contained in the plans and specifications, the contractor must submit plans, calculations, and construction manuals to the Resident Engineer. The specifications describe contractor submittal requirements. The Resident Engineer reviews the contractor's submittal for completeness and, if the submittal is sufficient, forwards the submittal to the Structures Division, which consults with the Materials Division for review and approval.

Before work begins, take the following steps:

- Review plans, specifications, and the project geotechnical reports as they relate to MSE wall construction.
- Review contractor's approved method of construction, plans, and manuals.
- Verify that panels and soil reinforcement material delivered to the projects are in acceptable condition and stored appropriately.
- Check with the survey crew to verify that the layout is in the correct location.
- Verify the contractor has located all utilities within the work area.

6-640.3 DURING CONSTRUCTION

During the work, do the following:

- Verify that the site is excavated to the proper elevation, all unsuitable material is removed and replaced, and the foundation soil is properly compacted. Confirm that the soil types and groundwater conditions encountered at the MSE wall locations match the conditions established in the geotechnical report for MSE wall design. If significant differences are noted, notify the Resident Engineer and the contractor immediately.
- Check the survey crew's stakeout. Determine that adequate survey control is established.
- Monitor MSE wall construction to verify that it conforms to the contractor's approved construction plans and manuals, and the specifications.
- When drainage structures are specified, verify that the structures are correctly located and constructed according to the plans and specifications.

- Observe and document the installation of facing panels, verifying the correct spacing and batter (vertical angle); where connectors are required, verify that connectors are installed correctly and not in contact with non-galvanized reinforcing steel. If any deficiencies are noted, notify the Resident Engineer and the contractor immediately for corrections.
- Confirm that the testers perform tests on the backfill in accordance with Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.
- Monitor placement of backfill material and soil reinforcement, and compaction of backfill material, until the top of the wall is reached.
- Verify that the traffic barrier, coping, or other appurtenances to the wall are properly installed on the top of the wall.

Figure 6-640.2 MSE Wall Installation.

Figure 6-640.3 Soil Reinforcement Connected to MSE Wall Facing Panel.

Figure 6-640.4 MSE Wall Facing Panel.

Figures 6-640.2, 6-640.3, and 6-640.4 show elements of MSE wall installation, including placement of facing panels, stepped foundation excavation, soil reinforcement, and temporary wall bracing.

6-640.4 MEASUREMENT AND PAYMENT

Because MSE wall systems, including soil reinforcement, are patented processes, the quantities incorporated into the work may vary from planned quantities. Quantities for payment are limited by the specifications. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-643 GROUND ANCHORS

6-643.1 GENERAL

Ground anchors are steel tendons, such as bars or cables, that are grouted in holes drilled into soil. The ground anchors transmit tensile loads into the ground, using the strength of the soil to restrain or anchor other structural elements, such as retaining walls.

Each ground anchor is installed into a pre-drilled hole and then grouted into place. Grouted ground anchors, also called tiebacks, are usually installed at a slight downward inclination. Refer to Figure 6-643.1 for a cross-sectional view of a ground anchor.

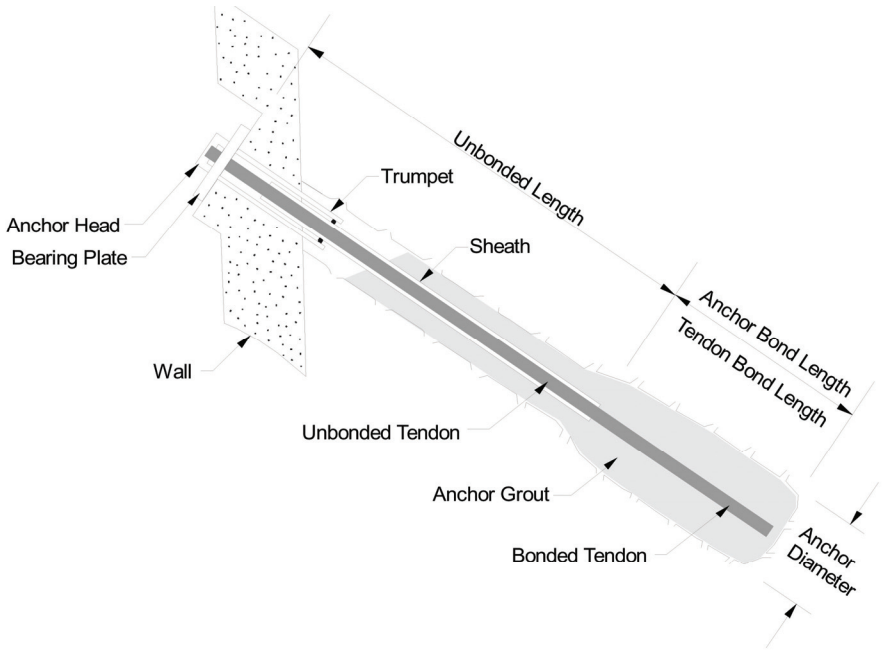

Figure 6-643.1. Ground Anchor Cross-Sectional View.

Many similarities exist with the installation of ground anchors and soil nails. Refer to Section 6-644, Soil Nail Retaining Walls. The significant difference between ground anchors and soil nails is that ground anchors are post-tensioned after construction of the retaining wall. Because of the similarities of installation methods, review Section 6-644, Soil Nail Retaining Walls, for general guidance on installation. Review Section 643, Ground Anchors, of the specifications for post-tensioning and other detailed requirements.

6-643.2 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-644 SOIL NAIL RETAINING WALLS

6-644.1 GENERAL

Soil nailing is a technique for reinforcing soil slopes, excavations, or retaining walls by inserting relatively slender steel reinforcing bars. The bars are usually installed into pre-drilled holes and then grouted into place or drilled and grouted simultaneously. Soil nails are usually installed at a slight downward inclination. Refer to Figure 6-644.1 for a cross-sectional view of a soil nail wall. The soil is stabilized by installing threaded steel bars into the slope as construction proceeds from top down. Installing and grouting these bars creates a stable mass of soil.

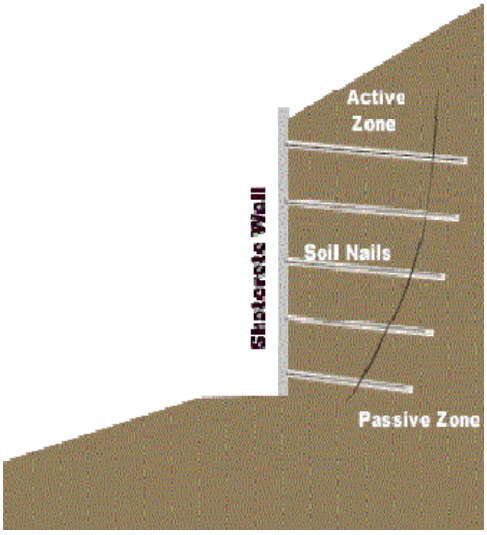

Figure 6-644.1. Soil Nail Wall.

Soil nail wall construction is sensitive to ground conditions, construction methods, equipment, and excavation sequencing. For soil nail walls to be economical, construct them in ground that can stand unsupported on a vertical or steeply cut slope of 3 to 6 feet for at least one to two days, and that can maintain an open drilled hole for at least several hours.

After soil nails are installed, the face of the slope is typically covered with shotcrete, which is reinforced using woven mesh. Following are common soil nail wall applications:

- Temporary and permanent walls for excavations.
- Cut slope retention for roadway widening and depressed roadways.
- Bridge abutments – addition of traffic lanes by removing end slopes from in front of existing bridge abutments.
- Slope stabilization.
- Repair or reconstruction of existing structures.

Following is the construction sequence for soil nail wall construction:

- Excavate a vertical cut to the elevation of the soil nails.
- Drill the hole for the nail.
- Install and grout the soil nail.
- Place drain strips and weep holes (if required), mesh reinforcing, the initial shotcrete layer, and install the bearing plates and nuts.
- Repeat process to final grade.
- Place the final facing (for permanent walls).

6-644.2 BEFORE CONSTRUCTION

The contractor must be pre-qualified to perform soil nail wall construction and must provide a construction plan to perform the work specified. The contractor submits the qualifications and construction plan before beginning the soil nail work. The Resident Engineer reviews the submittal for completeness, and if the submittal is sufficient, forwards it to the Materials Division for review and approval.

Before work begins, take the following preliminary steps:

- Review plans and specifications as they relate to soil nail wall construction.
- Review the contractor's approved soil nail wall construction plan.
- Attend the mandatory pre-construction meeting.
- Verify the contractor has located all utilities within the work area.
- Observe and document the pre-construction condition of the work area. Photo images provide indisputable supporting documentation.
- Coordinate with the Structures Division Nondestructive Testing Section for inspection of soil nail walls.

Before soil nailing begins, complete a verification testing program. The verification program tests the installation methods and verifies that the soil performs as anticipated. Nails used in the verification testing are sacrificial and are not incorporated as production soil nails. Bare nails may be used for the verification testing nails.

6-644.3 DURING CONSTRUCTION

During the work, do the following:

- Check the layout of the soil nails. Determine that adequate survey control is established.
- Monitor the work and confirm that it conforms to the specifications and the contractor's approved construction plan.
- Observe and document the installation. Notify the contractor immediately for correction of any noted deficiencies.
- Monitor the soil nail wall for movement and for signs of failure. If downward excavation uncovers unanticipated material, the contractor may need to change the construction plan or safety provisions. Notify the Resident Engineer of observations.
- If excavation exposes unstable areas, suspend work until the contractor develops approved corrective measures.
- Obtain the specified contractor records that document the soil nail wall construction.
- Assist the Structures Division Nondestructive Testing Section with inspection of soil nails.

6-644.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-646 WATERPROOFING, DAMPPROOFING AND CRACK SEALING

6-646.1 GENERAL

Waterproofing consists of sealing concrete surfaces to prevent the passage of water. Waterproofing materials include membranes with applications of waterproofing asphalt, and polymer concrete. For bridge decks, overlaying the deck with a thin layer of polymer concrete is the most common method of waterproofing a bridge deck. Polymer concrete is described in Section 6-496, Bridge Deck Seal Concrete. When membranes and asphalt are used to waterproof a bridge deck, a bituminous pavement is placed on the waterproof membrane. Waterproofing of other types of concrete surfaces, besides bridge decks, is accomplished with spray-on sealant chemicals.

Dampproofing consists of treating concrete surfaces to retard the passage or absorption of water or water vapor. Concrete surfaces, such as retaining walls, are dampproofed to protect the concrete from nuisance water that may discolor or otherwise detract from the appearance of the concrete. Typically, concrete is dampproofed by applying waterproofing asphalt.

Crack sealing consists of sealing random cracks in structures to prevent water penetration. Random cracks are sealed using chemical sealants. Concrete elements that may be sealed include bridge decks or other component parts of the bridge, such as footings, columns, or pier caps. The spray-on chemical silane is used to seal concrete cracks. Silane is typically used to seal concrete surfaces that are not bridge decks. For bridge decks, methacrylate is commonly used as the chemical sealant. While silane is sprayed onto the concrete, methacrylate, which is more viscous, is flooded onto the bridge deck. Guidance on using methacrylate is described in Section 6-496 Bridge Deck Seal Concrete. The specifications will describe the type of waterproofing, dampproofing, or crack sealing material to be used on the project.

6-646.2 SAFETY

Chemical sealants require special handling and safety procedures. All personnel working, handling, or transporting the materials, as well as inspectors and material testers, must be familiar with safety procedures for handling and applying the chemicals. Because of the volatile nature of the chemicals used, strict adherence to handling and safety procedures is required to avoid violent chemical reactions.

The inspector should carefully review and understand the Material Safety Data Sheets (MSDS) that the contractor provides. If chemicals are not shipped, handled, and combined precisely as required by the MSDS and the specifications, the combined chemicals, including chemical vapors, can cause an explosion.

6-646.3 BEFORE CONSTRUCTION

Before the waterproofing, dampproofing, or sealing treatment is applied, consider the following guidelines:

- Review the plans and specifications, paying particular attention to the limits of treatment, type of treatment designated, required deck preparation, traffic control requirements, sampling and testing requirements, and the method and sequence of operation.
- Check the materials delivered to the site to verify they conform to the type designated for the project. Obtain applicable certificates of compliance. Verify compliance with project requirements.
- Be familiar with application requirements such as weather limitations, surface moisture, and surface and ambient temperatures. Pay particular attention to required drying periods of the sealant.
- Before application of the sealant, check that the age of the concrete complies with specification requirements.
- Confirm that the concrete surface has been prepared as required by the specifications. Pay particular attention to the limits of cleaning for the bridge deck, approach slabs, height of curb above asphalt overlay, height of bridge rail above deck, and sidewalks. Also, pay attention to the cleaning sequence, timing, and methods. Where waterproofing membrane is specified, verify that rough surface areas that could puncture or create air pockets in the membrane have been corrected.

6-646.4 DURING CONSTRUCTION

During the application of waterproofing, dampproofing, or sealing treatment, consider the following guidelines:

- When a primer is specified, observe the application, making sure that the limits and application rate conform to the plans and specifications.
- Monitor the membrane placement. Verify that the membrane is placed at the appropriate time after the primer is applied. Check the limits of placement. The contractor must place the membrane with an overlap at the seams so that a shingling effect is achieved that directs runoff toward curbs and drains. The placed membrane must not have wrinkles and air bubbles. If placement is unacceptable, the contractor must repair the defects. Near joints and drain pipes, pay particular attention to placement and priming requirements.
- Where protective covering is designated over the membrane, do not permit more membrane to be placed than can be properly covered in the same work day. Pay particular attention to the limits of covering and the required treatment of overlaps and joints.
- If traffic will use the chemically sealed surface, sand is applied to increase the skid resistance of the riding surface. The specifications describe the type of sand and application requirements.
- The contractor must follow the manufacturer's safety recommendations when applying chemical sealers. The technical representative from the manufacturer is required to be on the project.
- The contractor must correct defective work as soon as practical..

6-646.5 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-660 PNEUMATICALLY PLACED CONCRETE MORTAR

6-660.1 GENERAL

Pneumatically placed concrete is mortar or concrete that is applied under pressure through a hose. Pneumatically placed concrete mortar is also called shotcrete. Shotcrete is pneumatically projected at high velocity onto a surface. Placement and compaction occurs at the same time due to the force with which it is projected from the nozzle. Shotcrete can be applied or impacted onto a variety of types or shapes of surfaces, including vertical or overhead areas.

Shotcrete is used for lining ditches and channels, slope paving, temporary wall facings, and other similar features. When used as a ditch lining or slope paving, shotcrete stops soil from eroding. As a temporary wall facing, shotcrete also restrains the soil during the process of constructing retaining walls that require soil to be excavated from the top to the bottom.

When shotcrete is used as a temporary wall facing, it is used in conjunction with ground anchors or soil nails, providing a system that stabilizes a slope prior to constructing a permanent retaining wall. For details relating to ground anchors and soil nails, refer to Section 6-643, Ground Anchors, and Section 6-644, Soil Nail Retaining Walls. The sequence of construction operations when using shotcrete as a temporary wall facing begins at the top of the slope being excavated and proceeds downward. For example, if a slope is to be excavated in thirds, the top third is excavated first, then soil nails or ground anchors are installed, and then shotcrete is applied to the slope face. The process progresses downward to the middle third, then to the bottom third. After the bottom third is completed, construction of the permanent retaining wall begins. The excavation dimensions are detailed in the plans and specifications, and must be constructed in conformance with the approved construction plan for soil nails or ground anchors submitted by the contractor.

Shotcrete used with soil nail walls has specific requirements relating to contractor qualifications and material submittals. Because of the stricter requirements of shotcrete used with soil nail walls, this section focuses on shotcrete used in soil nail walls. For other applications in which shotcrete has no structural function, the plans and specifications should provide sufficient direction.

6-660.2 BEFORE CONSTRUCTION

Before shotcrete is applied, the contractor must provide required submittals including qualifications of the person applying the shotcrete, as described in the specifications. The Resident Engineer reviews the submittal for completeness. Shop drawings and contractor qualifications are submitted to the Structures Division for review and approval. The Resident Engineer submits the shotcrete mix design to the Materials Division for review and approval. After the contractor has provided the required submittals, a mandatory pre-construction meeting is held prior to the start of the shotcrete operation. Attendees of the pre-construction meeting typically include representatives from the contractor, soil nail subcontractor, shotcrete subcontractor, and NDOT representatives.

Before the shotcrete work begins, the inspector takes the following preliminary steps:

- Review plans and specifications as they relate to temporary wall construction.
- Confirm that the required submittals have been reviewed and approved.
- Attend the mandatory pre-construction meeting conducted by the Resident Engineer.
- Confirm that the proposed mix design is approved and method of placement is acceptable, including the qualifications of the person applying the shotcrete.
- Confirm soil nails and ground anchors have been successfully proof tested. If proof testing has not been completed, coordinate with the Structures Division Nondestructive Testing Section to complete the required proof testing.
- Confirm that the pre-construction test panels have been tested and accepted before beginning the shotcrete operation.

6-660.3 DURING CONSTRUCTION

Before the shotcrete operation begins, inspect the excavation face, observing that the face is free of loose debris. The face of the excavation should be free of irregularities that could cause quantity overruns. Monitor placement of drainage elements, such as geocomposite drainage strips. Geocomposite drainage strips must be connected to drainage holes, commonly called weep holes, and be secured to prevent movement during shotcrete placement. Confirm that weep holes are located above the finish grade, thereby providing unobstructed drainage. Shotcrete wall facings are reinforced with welded wire fabric or mesh, or reinforcing steel. Before shotcrete placement, inspect reinforcement to verify conformance to the plans and specifications.

During the shotcrete placement, do the following:

- Monitor the work; verify it conforms to the specifications, the contractor's approved construction plan, and approved shop drawings.
- Observe and document the installation. If any deficiencies are noted, notify the Resident Engineer and the contractor immediately for corrections.
- If groundwater is encountered causing displacement of the applied shotcrete, suspend work until the contractor develops approved corrective measures.
- Shotcrete placement should be suspended during inclement weather, such as rain and wind, unless the contractor provides approved protection methods.
- Before the initial set of shotcrete, confirm that the contractor installs the bearing plate and nut to each nail head in accordance with the specifications.
- Verify proper controls are in place to monitor the thickness of the applied shotcrete. Incorrect shotcrete thickness can negatively affect permanent retaining wall construction.

The inspector observes the contractor obtaining core samples of the placed shotcrete, collects the contractor's samples, and transmits the samples to the Materials Division for compressive strength testing. Samples are taken in accordance with ASTM C171. Core holes are filled according to the specifications. Cores are sent to the Materials Division for testing as described in the specifications.

6-660.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

GLOSSARY

- Aggregate – Rocky material used as base course for roadway. Can be one of several types or classes, depending on where and how it will be used.
- Aggregate size – For aggregate testing, this is the smallest sieve that will pass at least 90 percent of the sample.
- As-built drawings – Notations that describe revisions to original project plans. Also called record drawings.
- Backfill – Granular material used in excavations for bridges, retaining walls, headwalls, culverts, and other structures.
- Base course – Roadway layer. Can be either the bottom or middle layer between the original ground and the surfacing. Consists of gravel and sand or mixed with asphalt.
- Benchmark – A stable, physical point that establishes vertical control during surveying. Examples of benchmarks are a length of reinforcing steel driven into the ground or a railroad spike driven into a utility pole, with the elevation of the point written on a witness stake. Usually required near major structures, special construction areas, or where terrain is rugged and preliminary benchmarks are difficult to reach.
- Bituminous material – Asphalt.
- BLM – United States Bureau of Land Management
- BMP – Best Management Practices relating to temporary pollution control and erosion control measures.
- Borrow – Material excavated from one area that will be used in another area.
- Centerline – The center of the road, which is shown on the plans and established in the field by the project survey crew.
- Clearing and grubbing – Cleaning a site to prepare it for construction. Involves removing debris, structures, shrubbery, trees, obstructions, and objectionable and unsuitable materials. May also involve handling and disposing non-hazardous and hazardous waste materials.
- Cold milling – Technique for removing asphalt or concrete pavement that may include base and sub-base material. Also called rotomilling.
- Compacting – Tightly compressing material for stability and strength.
- Control points – Semi-permanent survey markers set prior to construction that provide the basis of subsequent construction surveying or staking. Also known as reference points.
- Control sheets – Provide information about a construction location, such as control points.
- Courses – Layers of a roadway, such as, base or surfacing.
- Crack and seat – Roadway rehabilitation process that demolishes concrete pavement into pieces approximately 20 inches in size, then stabilizes the pieces by rolling or vibrating. Usually done with a guillotine-type hammer.

- Culvert – A type of drain used to pass runoff or other drainage under a roadway. Can be constructed of materials such as concrete, steel, or plastic. Common types of culverts include reinforced concrete pipe, corrugated metal pipe, metal arch pipe, and plastic pipe. Culvert ends may include end sections, headwalls, manholes, drop inlets, or riprap basins.
- Deposit – Source for aggregate, sometimes called an aggregate pit.
- Downdrains – Downdrains are drainage pipes that convey water down roadway slopes in a manner that prevents slope erosion. They allow drainage from fill embankments, benches in cut sections, and other steep or long slopes.
- Eastings – Survey identifiers in the east-west direction that measure an east-west direction from a defined location.
- Edge lines – Lines that mark the edges of a travelway.
- Excavate – Remove material.
- FHWA – United States Federal Highway Administration, a division of the Department of Transportation
- Field books – Books used to record survey and construction activities. Types of field books include compaction, sieve, concrete, and testing.
- Foundation fill – Replacement material for excavated material. Used to replace unsuitable material and establish a stable foundation for culverts, bridges, and other structures.
- Global Positioning System (GPS) – Surveying tool preferred because of its mobility and efficiency—only one or two people are required to perform the survey. The technology uses satellites, resulting in an extensive survey coverage area.
- Grade – Incline, slant, or slope of a roadway.
- Grade stake – See Redhead.
- Grooving – A method of finishing Portland Cement Concrete Pavement.
- Guinea – A small wooden stake used to show the contractor where survey information was taken and to identify where construction begins. They can also be used to reestablish catch points if slope stakes are accidentally removed or destroyed.
- Lanyard – Rope suitable for supporting one person. One harness end is fastened to a safety belt or harness and the other end is secured to a substantial object or a safety line.
- Lifeline – Rope, suitable for supporting one person, to which a lanyard or safety belt or harness is attached.
- Location Project Number (LPN) – The LPN identifies a specific geographical area – or control points – that the Location Division has surveyed.
- Material site – Source for aggregate.
- Means and methods – The means is the way the contractor physically controls the work and the method is the plan for how to control it.

- Monuments/markers – Used in surveying to identify property boundaries or to mark a specific survey area.
- MSHA – United States Mine Safety and Health Administration.
- Network – A chart of the critical path schedule.
- NAQTC – Nevada Alliance for Quality Transportation Construction
- NGS – United States National Geodetic Survey
- Northings – Survey identifiers in the north-south direction that measure a north-south direction from a defined location.
- Nuclear density gauge – Instrument for measuring the density of roadway material, such as base or asphalt pavement. Requires training and certification to operate, store, or transport.
- Occupational dose – Amount of radiation received by an individual during the performance of his duties. The dose is indicated by the Thermal Luminescent Dosimeter or Optically Stimulated Luminescent badges.
- Optically Stimulated Luminescent (OSL) badges – A badge that monitors occupational dose of radiation.
- OSHA – United States Occupational Safety and Health Administration.
- PDDM – NDOT Project Design Development Manual, sometimes referred to as Design Manual.
- Phenolphthalein solution – Chemical solution used to check uniformity of cement distribution in soil or aggregate.
- Pipe jacking – A technique for installing underground pipelines and culverts, usually concrete pipes, by jacking, or pushing, pipes through the ground.
- Pit – Source for aggregate.
- Plantmix – Mixing method that uses a mixing plant to combine aggregate, Portland cement, and water, or aggregate and asphalt. The material is then transported to the roadway for placement.
- Portland cement concrete – Mixture of aggregate, water, and Portland cement.
- Portland cement concrete pavement (PCCP) – Portland cement concrete that is used as a roadway paving surface.
- Portland cement treated base – Base material in which Portland cement is added for increased strength.
- Protective blanket – Type of erosion control that involves an asphaltic cover, which serves as a blanket to allow establishment of vegetation.
- Pugmill – Type of mixer, consisting of revolving blades, fins, or paddles on a shaft.
- Record drawings – Drawings that contain notations, which describe revisions to original project plans. Also called as-built drawings.

- Redhead/grade stake – Stakes placed so that the top of the stake indicates the elevation of the finished aggregate base.
- Reference points – – Semi-permanent survey markers that provide the basis of subsequent construction surveying or staking. Also known as control points.
- Riprap – A type of erosion control. Riprap is the careful placement of relatively large stone on the erodible slope. It is also used at culvert inlets and outlets to protect soil from erosion and to dissipate energy from flowing water.
- Roadmix – Mixing method that combines cement, aggregate, and water on the roadway instead of at a central mixing plant.
- Rock slides – Movement of rocks down a slope. Groundwater seldom primarily causes these movements.
- Rolling pattern – Pattern used by the roller during placement of roadway base or surfacing. Rolling establishes stability, permeability, and uniform thickness.
- Rotomilling – See Cold milling.
- Rubblizing – Demolition process that produces concrete pieces smaller than 12 inches, then stabilizes the pieces by rolling or vibrating. Usually done with either a resonant breaker or a multi-head breaker with drop hammers.
- Safety Belt – Device, usually worn around the waist and attached to a lanyard, lifeline, or structure, to prevent a worker from falling.
- Sawcuts – A narrow cut into pavement that reduces internal stresses. Sawcuts are typically protected with a seal that keeps out debris.
- Scarify – To break up and loosen the surface of a field or a road.
- Screed – Part of an asphalt paver that strikes off excess paving material and partially compacts it.
- Seeding – Type of erosion control that involves mulching or seeding and jute matting, which hastens and encourage abundant vegetative root growth, which binds the soil particles together.
- Shoring – Temporary bracing that provides strength and stability during trenching operations or construction of structures.
- Shouldering material – Graded material placed and compacted against the edge of a plantmix bituminous surface or Portland cement concrete pavement.
- Shrink factor – The difference in material volume before and after compaction.
- Slides – See rock slides, slipout, and slump slides.
- Slipout – Landslide that occurs at or below roadway grade in embankments.
- Slope scaling – Process of removing rock and soil to construct a slope. This task requires experienced personnel.
- Slope stakes – Stakes that mark the original ground locations where the toe of a fill slope and the top of a cut slope begins.

- Slump slides – Slides that occur when a large mass of soil moves with relatively little deformation along an internal slip surface. Slump slides usually contain seepage or saturated material.
- Soil nailing – Technique for reinforcing soil slopes, excavations, or retaining walls with relatively slender steel reinforcing bars inserted at a downward inclination into the slope, excavation, or wall, and then grouted within the hole.
- Spalling – Flaking or weathering of concrete or masonry block in which chips or larger pieces of material break away.
- Special Provisions – Project-specific specifications that add, delete, or otherwise revise standard specifications.
- Split sample – Material sample that is divided into smaller and equal sizes or amounts.
- Stakes (staking/stakeout) – Stakes are wooden sticks or slats that mark survey points on a construction project. Stakes are also made of alternative materials, such as metal or plastic. The staking process (or "stakeout") usually occurs before clearing and grubbing.
- Standard Specifications – Written directions for the administration, materials, and construction of a project.
- Stockpile – Supply of material, such as gravel.
- Striping – Pavement marking that delineates certain areas of pavement, such as traffic lanes and crosswalks.
- Subgrade – Original ground on which construction takes place.
- Surfacing course – The top layer of a roadway.
- Survey crew – Group of engineering technicians that performs construction staking on a project.
- Swell factor – The difference in material volume before and after excavation from a compacted state
- Thermal Luminescent Dosimeter (TLD) badge – Monitors occupational dose of radiation.
- Tining – A method of finishing portland cement concrete pavement that creates small grooves and ridges in the finished surface.
- Total Station – A surveying instrument that measures angles, electronically measures distances, and provides the ability of robotic survey, in which the user remotely operates the instrument from the area to be staked.
- Trenching – Construction activity in which a trench, such as for a pipe, is dug.
- Underdrains – Pipes that intercept underground flow and seepage to drain the roadway below the surface. They are commonly used to intercept subsurface water moving toward the roadway.
- USC & GS – United States Coast and Geodetic Surveys
- USGLO – United States General Land Office
- USGS - United States Geological Survey

- WAQTC – Western Alliance for Quality Transportation Construction.
- Windrow – Soil, gravel, or similar material shaped into a row or berm.
- Wire line – Technique that involves placing a wire along the roadway, used for determining roadway grade when placing aggregate or paving material.
- Witness stakes – Stakes that provide information about adjacent surveyed points. Used during surveying.

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