

Chapter 26

**NON-DESTRUCTIVE TESTING
(NDT)**

NDOT STRUCTURES MANUAL

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Chapter 26

NON-DESTRUCTIVE TESTING (NDT)

26.1 NDT SQUAD

26.1.1 Responsibilities

26.1.1.1 General

The Non-Destructive Testing (NDT) Squad is in the Inventory/Inspection Section within the Structures Division. In general, the Squad provides all in-house NDT services required by NDOT for a variety of applications. The following Sections summarize these services.

26.1.1.2 Construction Support

The NDT Squad performs the following activities in support of the NDOT Construction Program:

- quality assurance of shop fabrication for structural steel and precast, prestressed concrete;
- inspections for field welding, erection, post-tensioning and grouting operations;
- QA for field verification and production testing of soil nails;
- QA for field testing and loading of tie-backs; and
- bridge deck evaluation.

See [Section 26.2](#) for more discussion.

26.1.1.3 Existing Structures

The NDT Squad performs non-destructive testing to evaluate the condition of existing structures in support of the following:

- the Nevada Bridge Inspection Program, and
- bridge rehabilitation projects.

In addition, the NDT Squad can perform certain maintenance repairs on existing bridges (e.g., grinding and/or drilling of fatigue cracks). See [Section 26.3](#) for more discussion.

26.1.2 Qualifications of NDT Personnel

In general, all NDOT personnel performing non-destructive testing must meet the requirements of NDOT/ASNT CP-011-2005 "NDOT Standard for Qualification and Certification of Non-Destructive Testing Personnel." [Section 28.2.2](#) discusses the positions and responsibilities of NDT Squad personnel specifically for the Nevada Bridge Inspection Program.

26.2 CONSTRUCTION SUPPORT

26.2.1 Quality Assurance (QA) of Shop Steel Fabrication

The NDT Squad provides a continuous audit of the contractor's procedures during shop fabrication. Guidance on Quality Assurance policies and procedures for steel-bridge components can be found in AASHTO/NSBA Steel Bridge Collaboration S4.1-2002 "Steel Bridge Fabrication QC/QA Guide Specification."

26.2.1.1 Preparation

The following procedures will apply to steel shop fabrication inspection:

1. Prior to fabrication, the following shall have been received, reviewed and approved:
 - Shop drawings,
 - Welding procedures and welder qualifications,
 - AISC Certifications,
 - *Fabricators Quality Control Manual*,
 - Request to perform radiographic testing after normal work hours,
 - Notice of beginning of work,
 - Heat cambering and straightening procedure, and
 - Fracture Control Plan, if fabricating fracture critical members.

26.2.1.2 Pre-Operation Activities and Checks

The NDT Inspector will:

1. Meet with the QC and shop supervisor and discuss QC/QA shop protocol and fabrication protocol in general. Discuss additional requirements if fabricating fracture critical members.
2. Review all Material Certifications and record on appropriate NDOT form. Visually inspect material for any deficiencies.
3. Record all Heat Numbers for the structural steel used in individual girders and verify with Mill Certifications. Verify that all components are stamped with heat numbers for traceability.
4. Prior to welding, inspect welding machines for proper operation and record results. Check electrode oven and wire and flux storage area.
5. Prior to welding, randomly verify joint fit-up and verify that the configuration for full-penetration welds and web-to-flange fillet weld complies with drawings and Welding Procedure.

26.2.1.3 Welding and Painting Operations

The NDT Inspector will:

1. During welding, verify that welder is qualified to make specific weld(s). Monitor preheat, interpass temperature and travel speed.
2. Inspect all finished welds visually and record results on appropriate NDOT form.
3. Witness all QC Non-Destructive Testing of weldments. Obtain a copy of the QC test report in a timely manner and record results on appropriate NDOT form. QC personnel shall perform all NDT in accordance with the *Standard Specifications for Road and Bridge Construction*, Section 506, latest addition of AWS D1.5 and QC NDT Procedure.
4. Perform the required QA Non-Destructive Testing per the *Standard Specifications for Road and Bridge Construction*, Section 506, latest addition of AWS D1.5 and Special Provisions. Record all results on appropriate NDOT form and report results to fabricator's QC personnel.
5. Repair all welds in accordance with approved weld procedure and re-inspect repaired welds. Obtain QC test report and record results on appropriate NDOT form. If welds are fracture critical, verify that additional requirements are met.
6. Upon completion of welding, verify that flange tilt, web flatness and sweep complies with the latest addition of AWS D1.5. Record results on appropriate NDOT form.
7. During shop assembly, verify that camber and stiffener locations comply with shop drawings and AWS D1.5. Record results on appropriate NDOT form. Note: If heating is required for cambering, verify that the temperature of base metal is appropriate, and that blocking is in accordance with the Heat Straightening and Cambering Procedure.
8. Verify that shop and field high-strength bolts comply with the *Standard Specifications for Road and Bridge Construction*, Section 506.03.07 and Special Provisions. Record test results on appropriate NDOT form. Reseal field bolt containers and identify each container.
9. Prior to painting, verify that all welds and base metal repairs have been made and accepted.
10. Verify that painting complies with *Standard Specifications for Road and Bridge Construction*, Section 614, manufacturer's recommendations and Special Provisions for paint system. Verify dry-film thickness on each coat, cure time and finished product. Make necessary repairs. Record dry-film thickness, surface finish, humidity, ambient air and surface temperature results for each girder on appropriate NDOT form.
11. Verify that all welding, dimensional tolerances, bolting and painting complies with *Standard Specifications for Road and Bridge Construction*, Special Provisions and shop drawings. Verify that all non-conformances have been corrected. Ensure that all NDT results, dimensional measurements, bolting tests and paint measurements are recorded on the appropriate Final NDOT Inspection Report.
12. Upon compliance with items mentioned in #11 above, release girders for shipment using appropriate Inspection Shipping List Form.

26.2.2 Post-Tensioning Inspections

NDT Squad members and bridge designers should be familiar with the following procedures applicable to post-tensioning inspections. The objective of post-tensioning inspections is to ensure conformance to the design requirements.

26.2.2.1 Preparation

Before the start of any post-tensioning operation, it is the responsibility of the NDT Inspector to:

- review the *NDOT Standard Specifications* and Special Provisions, specifically Section 503;
- review the approved shop drawings to obtain the jacking forces, stressing sequence and elongation requirements;
- review grouting plan if prepackaged grout will be used;
- meet with bridge design personnel to discuss the stressing operation and to obtain pertinent information (e.g., the number of strands that can be lost prior to the replacement of a tendon and by how many kips to reduce the force if this occurs);
- discuss safety procedures needed for working around post-tensioning and grouting operations;
- check grout certifications; and
- ensure that all strands have been tested and reels checked by NDOT.

26.2.2.2 Materials

The NDT Inspector should have the following items upon arrival at the job site:

- electric hydraulic pressure cell,
- indicator readout unit,
- approved shop drawings,
- diary,
- *NDOT Standard Specifications* and Special Provisions,
- jack calibration charts,
- post-tensioning field worksheet (see [Figure 26.2-A](#)),
- approved grouting procedure,
- grout cone,
- strand-testing results,
- detensioning procedures, and
- Tendon Grout Acceptance Checklist.

26.2.2.3 Resident Engineer Discussions

Upon arrival at the job site, the NDT Inspector should meet with the Resident Engineer to discuss the following:

- if the requirements on the age of the concrete and the compressive strength have been met;
- when placement of strands begin and corrosion inhibitor requirement (when necessary, a certification is required); and
- whether ducts have passed the required pressure tests.

The NDT Inspector shall also meet with the subcontractor's Stressing Foreman to discuss or obtain the following:

- work schedule,
- a copy of the calibration charts for the gauge and ram to be used,
- stressing procedure,
- grouting operations plan, and
- confirm required backup equipment is on-site.

26.2.2.4 Pre-Operation Checks

Before the start of the stressing operation, it is the responsibility of the Inspector to check the following:

- All ducts have the required number of strands.
- All strands have wedges on them.
- The ram and jack for the Identification Number are available (to ensure they match the calibration charts submitted).
- Grout inlets and outlets are functioning properly and tagged.
- The ram, hoses and stressing equipment are in good operating condition.

26.2.2.5 Stressing Operation

During the stressing operation, it is the responsibility of the NDT Inspector to perform the following:

- Calibrate the readout unit and pressure cell before incorporating it into the stressing system.
- Calculate jacking forces using current ram calibration charts and compare calculations with stressing supervisor's calculations.
- Ensure that all stressing personnel are aware of the area where the tendons must be painted for elongation and slippage.

- When the stressing begins, the tendon is first pulled to 20% of the total jacking force and a mark made either on the tendon itself or the ram. The jacking end of the tendon is also painted to check for wedge slippage. The tendon is then stressed until the total jacking force is reached; the gauge pressure is then recorded. At this time, the previously made mark is measured from the face of the jack. The measured value is compared to 80% of the total calculated elongation. After this has been recorded, the jack is backed off to the 20% point and another measurement is taken. The difference between this measurement and the last one will be the anchor set. Record the measured anchor set. After the jack has been backed off completely and before it is removed, the paint marks at the stressing end should be checked to ensure that none of the wedges have slipped. After stressing is completed, both ends of the tendons should be checked to ensure that all wedges are seated and there has been no slippage.
- Perform an in-place Modulus of Elasticity Test and Friction Test if elongations do not meet expected values.
- Flame cutting of strand in upper tendons before completion of all stressing is not permitted. The NDT Inspector shall monitor the sawing to see that abrasive methods are used and no damage occurs to the unstressed strand.

26.2.2.6 Grouting Operation

During the grouting operation, it is the responsibility of the NDT Inspector to ensure the following:

- All equipment meets the requirements of the approved Grouting Operations Plan including the grout mixer, grout storage hopper, grout pump and standby flushing equipment.
- Grouting technicians have the required training and documentation.
- A joint meeting has been held with the contractor, grouting technician and NDOT personnel to discuss testing, corrective procedures and other relevant issues.
- Conduct a Tendon Grout Trial Batch Test.
- Conduct a duct pressure test.
- Grout is prepackaged and conforms to the requirements for a Class C grout, as defined by the Post-Tensioning Institute (PTI) Specification for Grouting of Post-Tensioned Structures.
- The grout must be continually agitated during pumping.
- The grouting mixture must be checked using a flow cone. The flow cone is plumbed and filled with a known quantity of grout and the time required to empty the cone is dependent upon the type of grout; see specifications for efflux time requirements.
- The grouting equipment must be capable of pumping at a pressure of at least 150 psi but not more than 250 psi.

26.2.2.7 Potential Issues

The NDT Inspector should be aware of the following potential issues:

1. Variations in Elongation. The measured elongation should not vary by more than 5% from the calculated value. If the measured elongation is not close to the calculated value, the method of measurement should be closely watched. Ensure that 20% of the final tendon stress is being used for the initial stress. Ensure that the contractor is accurately marking and measuring the elongations, and all wedges are properly installed. If problems continue, contact the Structures Division.
2. Strand Breakage. If a strand breaks, immediately stop the stressing operation and record the force in the tendon. The Structures Division will recommend a new jacking force or will recommend the complete removal of the tendon. Ensure that the stress limits were not exceeded. Check the actual stresses in the strand and compare with the stress limits prior to seating, immediately after seating, and at the end of the seating loss zone. For example:
 - 10-strand, 1/2-in diameter tendon stressed to $0.75f_{pu}$
 - $P_j = (0.75)(270 \text{ ksi})(10 \text{ strands})(0.153 \text{ in}^2) = 309.8 \text{ kips}$
 - Assume one strand breaks when the jacking force is 305 kips
 - Stress in remaining 9 strands = $(305 \text{ kips})/((0.153 \text{ in}^2)(9 \text{ strands})) = 221.5 \text{ ksi}$
 - Stress limit = $0.9f_{py} = 0.9(0.9f_{pu}) = (0.9)(0.9)(270 \text{ ksi}) = 218.7 \text{ ksi}$
 - Entire tendon must be rejected because the stress in the remaining 9 strands is greater than the stress limit.
3. Wedge Slippage. If wedges are slipping during the stressing operation, the stressing operation should be stopped. The contractor shall correct the slippage before continuing. Some slippage is acceptable at low levels of force. If slippage occurs at a high force, the Structures Division should be contacted.
4. Equipment. If the contractor's equipment does not perform in a satisfactory working manner (pump surges, leaky lines, faulty gauges, etc.), the stressing operation shall be stopped and not continued until the contractor has fixed or replaced the faulty equipment.

Note: Check other critical stress limits also.

26.2.2.8 Record Keeping

The NDT Inspector shall maintain the following records for post tensioning:

1. Daily Diary. The NDT Inspector should keep accurate records on the number of strands stressed or grouted that day. Any item discussed with the Resident Engineer or Stressing Foreman shall be noted plus any problem area that may arise.
2. Post-Tensioning. Post-tensioning report forms shall be completed daily.

3. Final Report. It is the responsibility of the Inspector to submit a final report on all post-tensioning.

26.2.3 Precast/Prestressed Concrete Girder Fabrication

26.2.3.1 Preparation

The NDT Inspector is responsible for the following:

1. Prior to fabrication, the following items are submitted and approved:
 - shop drawings,
 - mix design,
 - curing method,
 - PCI Certification,
 - *Fabricators Quality Control Manual*, and
 - current ram calibration certifications.
2. Holding a Pre-fabrication Meeting to discuss fabrication procedures, QC testing, stressing and curing procedures.
3. Reviewing all material certifications and strand test results from NDOT.

26.2.3.2 Pre-Operation Checks

The NDT Inspector is responsible for the following:

1. Verifying that forms are free of rust and dents and are in good shape and clean.
2. Verifying that strand placement complies with the *Standard Specifications for Road and Bridge Construction*, Section 503, Special Provisions and shop drawings.
3. Tracking heat/reel numbers for each girder. Rejecting any strand that does not comply with the above-mentioned specifications.
4. Verifying that the stressing operation complies with the *Standard Specifications for Road and Bridge Construction*, Section 503, Special Provisions and shop drawings.

26.2.3.3 Prestressing Operations

The NDT Inspector is responsible for the following:

1. Monitoring stressing operation using a calibrated hydraulic pressure cell with a strain gage indicator. Recording stressing results on appropriate NDOT form.
2. Verifying that reinforcing steel, inserts and bearing placement complies with shop drawings.
3. Recording inspection results on daily construction reports. Making any operational repairs or adjustments to comply with drawings.

4. Verifying that concrete complies with mix design and that concrete testing is conducted in compliance with specifications.
5. Verifying that concrete curing complies with the *Standard Specifications for Road and Bridge Construction*, Section 503 and Special Provisions. Recording all concrete test results, curing temperatures and deficiencies on appropriate NDOT form.
6. Verifying that concrete transfer strength has been achieved prior to release of strand (cut-down).
7. Verifying condition of girder after forms are removed. Documenting any defects for repairs on appropriate NDOT form.
8. Verifying that dimensional tolerances comply with the *Standard Specifications for Road and Bridge Construction*, Section 503, and Special Provisions. Recording deficiencies on appropriate NDOT form.
9. Reviewing all test data, dimensional checks and non-conformance reports for final compliance to the *Standard Specifications for Road and Bridge Construction*, Section 503, Special Provisions and shop drawings. Releasing girders for shipping if girders meet above-mentioned specifications and drawings.

26.3 EXISTING STRUCTURES

The NDT Squad will perform the following tests and work on existing structures, as needed, in support of the Nevada Bridge Inspection Program or to assist the bridge designer in identifying any necessary work for a proposed bridge rehabilitation project.

26.3.1 Testing Methods for Cracking in Metals

The extent and size of cracks should be established to determine the appropriate remedial action, if visual inspection by the bridge inspector reveals cracking in steel components. The following are the most common test methods performed by the NDT Squad to locate cracks in steel components and measure their extent and size:

1. Dye-Penetrant Testing (PT). The surface of the steel is cleaned, then painted with a red dye. The dye is allowed time to “dwell” on the area and then is wiped off. If a crack is present, the dye penetrates the crack through capillary action. A white developer is the painted on the cleaned steel and any cracks are indicated where the red dye “bleeds” from the crack.
2. Magnetic-Particle Testing (MT). The surface of the steel is cleaned and sprinkled with fine iron filings while a strong magnetic field is induced in the steel. A crack causes an interruption in the lines of magnetic flux, allowing them to “leak” from the metal, thereby attracting the metal filings, which form a trace along the line of the crack.
3. Ultrasonic Testing (UT). Testing devices that use high-frequency sound waves to detect cracks, discontinuities and flaws in materials. The accuracy of UT depends upon the expertise of the individual conducting the test and interpreting the results.
4. Eddy Current Testing (ET). Eddy Current testing uses a phenomenon called electromagnetic induction to detect flaws in conductive materials. This form of testing detects flux leakage emanating from a discontinuity in metal when an eddy current is passed through the material. Eddy Current testing can detect very small cracks in or near the surface of the material, the surfaces need minimal preparation, and physically complex geometries can be quickly investigated.

All tests must be conducted by, at a minimum, a Level II ASNT certified technician. For more information, see *Detection and Repair of Fatigue Damage in Welded Highway Bridges*, NCHRP Report 206, July 1979.

26.3.2 Fatigue-Damage Retrofits

When cracking is discovered during in-service inspections, the NDT Squad may retrofit minor cracking. The retrofits consist mainly of grinding or drilling holes (see [Chapter 22](#) for more details on these retrofit procedures, especially [Section 22.7.2.1](#)). When lead-based paint is encountered during a retrofit, the NDT Inspector shall adhere to the following procedures.

26.3.2.1 Policy/Procedure Statement for Fatigue Crack Repair Involving Lead-Based Paint

Fatigue damage may be found in steel members during bridge inspections. Often, fatigue cracks are found that are small in size and of such a nature that they may be easily removed or

stabilized by grinding or drilling methods. NDOT bridge inspection or NDT personnel, while still on-site, may retrofit this type of fatigue damage during the bridge inspection. Retrofittable fatigue damage may exist in bridges with coating systems containing lead or other heavy metals. The mechanical action of grinding or drilling may cause particles of lead-based paint or coating to become airborne. Accordingly, work in this environment must comply with the OSHA Lead Construction Standard (1926.62), in addition to all applicable NDOT Transportation Policies and safety procedures. This policy/procedure covers both the safety and technical aspects of work involving minor fatigue damage retrofit with paint systems containing inorganic lead.

26.3.2.2 Applicable Safety Standards and Transportation Policies

The following standards, policies and procedures shall be followed when working in environments in which lead-based coating materials are removed:

- OSHA 29CFR1926.62 “Lead in Construction”
- OSHA 29CFR1910.134 “Respiratory Protection”
- OSHA 29CFR1926.59 “Hazard Communication”
- OSHA 29CFR1910.1000 “Air Contaminants”
- OSHA 29CFR1910.146 “Permit-required Confined Spaces”
- *NDOT Employee Safety Manual*
- NDOT Policies and Procedures Manual TP 1-6-26, “Respiratory Protection”
- NDOT Policies and Procedures Manual TP 1-6-28, “Confined Spaces”
- NDOT Policies and Procedures Manual TP 1-7-2, “Chemical Hazard Communication”

26.3.2.3 Required Training and Testing

Prior to performing any work that may fall under this policy, all affected employees must have completed the following training and testing:

- NDOT Respiratory Protection Program Training.
- Respirator Fit-Testing.
- Biennial physical exam, in accordance with NDOT Medical Surveillance Program.
- Lead awareness training, as per CFR1926.59 (h) “Employee Information and Training,” CFR1926.62(1) “Employee Information and Training” and CFR1910.52(1) “Employee Information and Training.”
- Baseline blood sampling and analysis for blood lead (PbB).
- Confined Space Awareness Training, as outlined in NDOT TP 1-6-28.

26.3.2.4 Required Personal Protective Equipment (PPE)

The following PPE must be worn at all times during fatigue damage retrofit work involving coatings containing lead or other heavy metals:

- Half or full-face respirators with organic vapor, acid gas and HEPA filter cartridges.
- Disposable over-garments, including hooded-coveralls, booties and gloves. Garbage bags will be on-site for collection of used garments for proper disposal.
- Safety goggles or face shields (if full-face respirators are not used).
- Work shoes or boots (no tennis shoes).
- In lieu of wearing gloves, hands must be washed with soap and water immediately after completing the procedure, or wiped with towelettes until soap and water are available. At no time shall food be consumed or tobacco, gum or cosmetics be used unless hands are washed with soap and water.

26.3.2.5 Confined Space Work

Any retrofit that must be performed within a confined space (e.g., a steel tub girder) as defined in the OSHA regulations must be conducted in accordance with NDOT Policies and Procedures Manual TP 1-6-28, "Confined Spaces." The introduction of any chemical or material (e.g, Carbomastic 15 Low Odor epoxy mastic) into a confined space that may create a hazard must be reviewed by the on-site NDOT supervisor or engineer before any employee is allowed to enter. Additional equipment, including but not limited to communications equipment, air sampling monitors, safety harnesses and tethers, may be required. The on-site supervisor or engineer will ensure that the proper procedures are observed when confined spaces must be entered.

26.3.2.6 Inspection/Retrofit Equipment

Equipment to be used to perform retrofits of fatigue damage typically consists of the following:

- "Peel-Away" brand lead-based-paint remover and neutralizer, or equivalent;
- HEPA vacuum-blast abrasive paint removal system;
- "Hougen Rotabroach" magnetic drill, or equivalent;
- die grinder or hand held flat grinder;
- hand scrapers;
- non-destructive testing equipment including, but not limited to, Magnetic Particle, Ultrasonic and/or Liquid (Dye) Penetrant equipment; and
- conventional hand tools, as commonly used in bridge inspection.

26.3.2.7 Engineering Controls

The use of "Peel-Away" brand lead-based-paint remover and/or the HEPA vacuum-blast abrasive paint removal system shall be used whenever possible to minimize the release of airborne lead or other heavy metal particles into the environment or the breathing zone of employees.

26.3.2.8 Contractor Safety (Multi-Employer Worksite)

On-site personnel that are not NDOT Structures Division Bridge Inspection/NDT Squad employees must not be allowed to be exposed to airborne lead or other heavy metals unless:

- they comply with all aspects of this program, and
- they are approved to enter the work zone by the on-site NDOT supervisor or engineer.

26.3.2.9 Retrofit Procedures

The following procedures shall be used when completing retrofits of minor fatigue damage when coatings containing lead or other heavy metals are present:

26.3.2.9.1 Preparation

1. Prior to the start of any retrofit work, a member of the work group or other on-site person who meets the qualification of a competent person [as per CFR 1926.32(f)], and qualified person [as per 1926.32(m)], shall identify any material hazard present. This shall involve a review of the bridge plans and a review of all painting materials listed in the original construction documents.
2. Consultation with a Certified Industrial Hygienist (CIH) will occur on an as-needed basis and may include evaluation of work-space atmospheric concentrations of lead or other heavy metals, including air sampling in the employee's Personal Breathing Zone. The NDOT Environmental Services Division will provide sampling and testing of coatings on an as-needed basis and maintain analytical data on bridges tested.
3. Prior to the start of work, Material Safety Data Sheets (MSDS) for any products to be used in the repair procedure shall be made available to, and reviewed by, all parties involved in the repair effort. MSDS shall also be available on-site.
4. Adequate traffic control and access to the work site shall be provided by NDOT District personnel, as per Part 6 of the *Manual on Uniform Traffic Control Devices* (MUTCD).
5. Personnel performing the retrofits must have completed all applicable testing and training and must wear all required PPE, as outlined above.

26.3.2.9.2 Coating Removal

1. Areas of fatigue damage shall be identified and surface contaminants (e.g., dirt, cobwebs) removed.
2. When a lead-based-paint removal paste is used, the product shall be applied to the member following the manufacturer's directions. The product shall be applied at the tip(s) of each crack, if drilling methods will be used, or to the entire length of each crack, if grinding methods will be used. If multiple cracks will be repaired, paint remover should be applied to all cracks before subsequent repair work is completed, to allow time for the remover to work (dwell time). Following an adequate dwell period, the loosened coating/paint remover paste residue shall be carefully scraped away and collected in approved sampling containers for delivery, using chain-of-custody procedures, to a State

of Nevada certified laboratory for analysis to evaluate disposal options. Remove paint down to bare metal.

3. If HEPA vacuum blast equipment is used, the manufacturer's directions should be followed that result in coating removal down to bare metal in the areas surrounding either the tip(s) of each crack if drilling methods will be used, or the entire length of each crack if grinding methods will be used. All abrasive/paint residues from the operation shall be collected in approved sampling containers for delivery, using chain-of-custody procedures, to a State of Nevada certified laboratory for analysis to evaluate disposal options.

26.3.2.9.3 *Crack Examination*

1. Once the surface coating has been removed, the tip(s) of each crack shall be identified using NDT methods including, but not limited to, Magnetic Particle Testing (MT), Ultrasonic Testing (UT) or Dye Penetrant Testing (PT). See [Section 26.3.1](#). Personnel conducting the NDT testing shall be qualified to perform such tests.
2. Once the NDT test has been performed, the NDT inspector and/or the engineer on-site shall identify the tip(s) of each crack.

26.3.2.9.4 *Drilling Procedures*

1. If crack stabilization by the hole-drilling method is selected, a ¼-in diameter pilot hole shall first be drilled at the tip of each crack. This hole serves to center the cutter used by the magnetic drill.
2. Using the magnetic drill, drill a hole completely through the damaged member, which intercepts the crack tip. Situate the hole such that one-half of the diameter of the cutter extends past the detectable tip of the crack to cover undetectable crack propagation. Use dry lubricant on the cutter where practical. Cutter size to be used may vary between ½-in and 1-in diameter, depending upon the size of the crack, location and stress level.
3. When multiple, closely spaced cracks exist, position pilot holes to intercept multiple crack tips, as directed by the engineer or NDT Inspector.
4. All drilled holes that overlap or exhibit less than ¼ in of material between the edges of adjacent holes shall be elongated by grinding, as directed by the engineer or NDT Inspector.
5. Collect drilling chips, clean each drill hole, and remove all traces of cutter lubricant adjacent to the drill hole(s).
6. Examine drill core(s) and interior of each drill hole, using appropriate NDT and visual methods, to ensure that each crack tip was properly intercepted. Improperly positioned holes may need to be slightly enlarged to properly intercept the crack tip, as directed by the engineer or NDT inspector.
7. Properly placed holes shall be polished with emery cloth, removing all gouges, nicks and burrs.

8. Satisfactory retrofit holes not receiving high-strength bolts shall be coated using Carbomastic 15 Low Odor epoxy mastic or equivalent.
9. Fill drill holes with high-strength bolts conforming to ASTM A325 when space permits. The bolt's clamping force induces a compressive stress in the area of the drill hole that resists further crack growth. The diameter of the fasteners should be 1/16 in smaller than the diameter of the drill hole. Tighten bolts using the "turn-of-the-nut" method. Fasteners shall be coated with Carbomastic 15 Low Odor epoxy mastic, or equivalent, following installation.

26.3.2.9.5 *Grinding Procedures*

1. If grinding retrofits are specified, a die grinder or hand-held flat grinder shall be used to remove all visible portions of the crack.
2. The individual performing the grinding procedure has the greatest potential for exposure. All other personnel should remain at least 6 ft away.
3. Upon completion of the grinding, the recess shall be examined, using appropriate NDT and visual methods, to ensure that all traces of the crack were completely removed.
4. After the crack has been completely removed, the recess shall be polished with emery cloth, removing all gouges, nicks and burrs.
5. Satisfactory repairs shall be coated using Carbomastic 15 Low Odor epoxy mastic or equivalent.

26.3.3 **Concrete Bridge Deck Condition Surveys**

The NDT Squad conducts the following concrete bridge deck condition tests:

- Delamination Sounding (see [Section 22.4.2.3](#))
- Chloride Analysis (see [Section 22.4.2.4](#))
- Pachometer Readings (see [Section 22.4.2.5](#))
- Ground Penetrating Radar (see [Section 22.4.2.6](#))
- Coring (see [Section 22.4.2.8](#))

Each condition test method is discussed in the referenced section, including a test description (with any ASTM or other specification reference), the test purpose, when to use the test and an analysis of the test results.