State DOT: Minnesota

State Report Questions on NDT Testing

1. What NDT testing methods for concrete materials, concrete pavements, and overlays are you trying?
   - **Probing**
     - MnDOT started requiring documentation of Contractor Probing in 2010 in addition to coring. We have reduced our coring requirements by 50%.

2301.3.N Thickness Requirements

Provide pavement with a finished pavement thickness as shown on the Plans or as modified, in writing, by the Engineer.

N.1 Procedure

Construct pavement to the thickness shown on the plans. On each Project and on each roadbed of a divided highway, evaluate pavement thickness in accordance with the following:

(1) Contractor Quality Control Probing (QCP),
(2) Probe Verification Core (PVC), and
(3) Quality Acceptance Core (QAC).

The Department defines plan thickness lot (PTL) as concrete pavement of the same thickness added together lineally. Establish a separate PTL for each concrete plan thickness on the Project.

The Department defines a sublot as the rate at which an individual measurement is taken over a given length. The Department considers a sublot as one lane wide, measured in accordance with the following:

(1) From the pavement edge to the adjacent longitudinal joint,
(2) From one longitudinal joint to the next, or
(3) In the absence of a longitudinal joint, between pavement edges.
(4) Each ramp and loop 18ft (5.5 m) wide or less is considered a single lane.

The Engineer will divide the PTL into sublots of 4,000 lineal lane ft [3,300 lineal lane m] to determine the QCP, PVC, and QAC locations. The Engineer will add partial sublots less than 2,000 ft [1,650m] to the previous lot. The Engineer will consider partial sublots equal to or greater than 2,000 lineal lane ft [1,650 lineal lane m] as individual sublots. If the PTL for the entire Project is less than 4,000 lineal lane ft [3,300 lineal lane m] the Engineer will consider the PTL as an individual sublot.

The Engineer will identify the QCP, PVC, and QAC thickness measurement locations in accordance with the following:

(1) Determine the longitudinal locations using random numbers multiplied by length of the sublot.

(2) Determine the transverse offset locations using a random number multiplied by the width of the traffic lane, ramp, or loop at the determined longitudinal location.

(3) Adjust the location to ensure the Contractor takes no measurements within 1 ft [0.3 m] of the pavement edge and takes no measurements within 2 ft [0.60 m] of any transverse or longitudinal joint or other obstructions.

N.2 Contractor Quality Control Probing (QCP)

Measure the pavement thickness of freshly finished concrete pavement at a rate of at least four QCP measurements per sublot. Notify the Engineer before performing probing thickness measurements in the plastic concrete so they may inspect or observe the Contractor's QCP tests during the paving operations.

Provide daily summary reports listing the results of the day's QCP thickness measurements and additional probing results to the Engineer.

N.3 Contractor QCP Probing Equipment and Probing Method

Provide the following equipment as approved by the Engineer to perform QCP probing:

(1) Probing rod meeting the following characteristics and requirements:
- *(1.1) Non-flexing,*
- *(1.2) Length capable of completely penetrating the pavement for measuring,*
- *(1.3) Utilizes a circular or square top plate,*
- *(1.4) Contains a centrally located hole in the top plate with a diameter allowing for easy maneuvering along the length of the probing rod, and*
- *(1.5) Fitted with a locking device fixing the angle between the top plate and the probing rod at 90 degrees when locked.*

(2) Base plate meeting the following characteristics and requirements:
- *(2.1) 10.5 in [267 mm] square 26 gage galvanized steel plates or 11.8 in [295 mm] diameter 28 gage high strength steel circular plates or,*
- *(2.2) Rigid when in place, allowing the probing rod to be pushed against it without flexing, and*

(3) Work bridge meeting the following characteristics and requirements:
- *(3.1) Spans the full width of the freshly laid concrete,*
- *(3.2) Supports a person, and*
- *(3.3) Height above the concrete allows for the use of the probing device.*

(4) Tape measure accurate to nearest ⅛ in [even mm] and with a length capable of measuring the depth of penetration of the probing device into the plastic concrete pavement.

Perform probing in accordance with the following:

(1) Place the base plates at the randomly selected locations and anchor the plates to prevent movement during concrete placement. Mark the locations of the base plates to ensure ease of locating the plates after the paver has passed,

(2) Position the bridge at the selected locations to reach and locate each point,

(3) Assemble the probing device. Keeping the probing rod perpendicular to the pavement surface, insert the rod into the plastic concrete until the rod strikes the base plate,

(4) Slide the top plate down the probing rod until it contacts the pavement surface, then lock to the probing rod,

(5) Withdraw the probing device, and

(6) Measure the length of the probing rod inserted into the plastic concrete from the underside of the top plate to the end of the probing rod. Record this measurement to the nearest ⅛ in [even mm].

N.4 Quality Acceptance Testing – Coring

The Engineer will measure the pavement thickness of concrete for each sublot in accordance with the following:

(1) Probe Verification Core (PVC), and

(2) Quality Acceptance Core (QAC).

The Engineer will mark one of every four QCP measurement locations per sublot for a PVC. The Engineer will mark one QAC per sublot. The Contractor will core at the designated PVC and QAC locations.

N.5 PVC and QAC Coring Method

(1) Begin coring on concrete older than 7 days, when the control beams attain a flexural strength in accordance with Table 2301-1, or when the control cylinders attain a compressive strength of 3,000 psi [20.6 MPa]. Use 3U18 concrete or another concrete mix approved by the Engineer to fill the core holes within 72 h of coring at no additional cost to the Department. Provide traffic control for coring;

(2) Cut 4 in [100 mm] nominal diameter cores at marked locations. Lay the cores next to the holes in a curing condition. Protect the cores. Do not submit cores out of round, not perpendicular, or containing ridges;

(3) The Engineer will field measure the core thickness to the nearest ⅛ in [even mm], verify (Field ID Number) the cores, and record the field measurement on MnDOT Form 24327, "Field Core Report" or a computerized spreadsheet available on the MnDOT Concrete Engineering website;

(4) Pick up the cores, accompanied by the Engineer. Store the cores in a water tank heated from 60° F to 80° F [15° C to 25° C] at the Department field office. The Engineer will not require the storage of cores in a curing condition for concrete older than 28 days;

(5) The Engineer will transport the cores in a curing condition, unless older than 28 days, to the MnDOT Office of Materials and Road Research; and

(6) The MnDOT Office of Materials and Road Research will determine the pavement thickness by measuring the length of the PVC and QAC cores in accordance with the procedure on file at the MnDOT Office of Materials and Road Research. Following this procedure, the MnDOT Office of Materials and Road Research will use nine probes interconnected in a hydraulic linkage to obtain the average length of the core in one operation. The MnDOT Office of Materials and Road Research will record the core length to the nearest 0.05 in [1 mm].

N.6 Non-conforming thickness

The Department will base acceptance of the pavement thickness and price adjustment for deficient thickness on the combination of both lab measured PVC and QAC coring.

The Department defines the tolerance limit for pavement thickness as the plan thickness lot (PTL) minus ½ in [13 mm]. If the QCP measurement shows a thickness deficiency greater than PTL minus ½ in [13 mm], take a core at the location of the deficient QCP. If any core thickness measurement (PVC or QAC) shows a thickness deficiency greater than PTL minus ½ in [13 mm], consider the pavement defective and take exploratory cores as directed by the Engineer.

The Department defines the defective pavement area as the entire area surrounding the deficient core within a traffic lane and between acceptable cores. The Department considers the pavement acceptable in the remaining areas as the increment where the cores show a thickness deficiency no greater than PTL minus ½ in [13 mm].

Take the first exploratory cores at any location within 10 ft [5 m] on each side of the deficient thickness location and at the same distance from the pavement centerline. Take an additional exploratory core in the adjacent traffic lane if the concrete was placed in the same operation. If the length of each of the first exploratory cores is at least equal to the PTL minus ½ in [13 mm], the Engineer will not require additional cores from this location. If any cores do not fall within the PTL minus ½ in [13 mm], take additional exploratory cores at 25 ft [10 m] intervals and at the same distance from the pavement centerline in the same lane as the original thickness measurement, as directed by the Engineer. Perform coring in the direction of the deficiency until obtaining a core with a length at least equal to the PTL minus ½ in [13 mm]. The Engineer will use exploratory cores to determine the extent of deficient pavement thickness for adjusting the unit bid price or requiring pavement removal and replacement.

For cores showing a pavement thickness greater than the PTL minus ½ in [13 mm] to 1 in [25 mm], the Contractor may choose one of the following:

(1) Remove and replace the defective pavement area, or
(2) Leave the pavement in place with a monetary deduction of $20 per sq. yd [$25 per sq. m] for the defective pavement area, as approved by the Engineer.

For cores showing a pavement thickness greater than PTL minus 1 in [25 mm], the Engineer, in conjunction with the Concrete Engineer, will determine whether the Contractor will remove and replace concrete pavement or leave the pavement in place at no cost to the Department and apply a monetary deduction of $20 per sq. yd [$25 per sq. m] for the defective pavement area in accordance with 1503.

The Engineer will use the PVC and QAC cores to determine the final average plan thickness lot (PTL), except for the following:

(1) If exploratory cores are taken to identify the defective pavement area, substitute the two outside exploratory cores that are within PTL minus ½ in [13 mm] for the deficient PVC or QAC.

(2) If the length of a PVC or QAC exceeds the by PTL plus 0.30 in [8 mm], the Engineer will limit the core length to the PTL plus 0.30 in [8 mm].

The Engineer will consider the pavement thickness as conforming provided the deficiency of the final average PTL does not exceed PTL minus 0.10 in [3 mm]. If the final average PTL is deficient by more than the PTL minus 0.10 in [3 mm], the Department will pay for the pavement in the PTL at the Contract unit price less the following monetary deductions in accordance with 1503 and Table 2301-14, excluding areas of defective pavement.

Table 2301-14
Deductions for Thickness Deficiencies

Thickness Deficiency Exceeding Permissible Deviations, in [mm]	***Adjusted unit bid price per sq. yd [sq. m] of Payment***
0.00 – ≤ 0.10 [≤ 3]	*None (tolerance)*
0.10 – ≤ 0.20 [3 – ≤ 5]	*$0.20 [$0.25]*
0.20 – ≤ 0.30 [5 – ≤ 8]	*$0.40 [$0.50]*
0.30 – ≤ 0.40 [8 – ≤ 10]	*$0.70 [$0.90]*
0.40 – ≤ 0.50 [10 – ≤ 13]	*$1.00 [$1.25]*
*0.50 – ≤ 1.00 [13 – ≤ 25]**	*$20.00 [$25.00]*
* *Perform exploratory coring as required by the Engineer.*	

After Department thickness verification, the Department will test all of the cores for compressive strength at 60 days of age. The Department will test three of the cores from the entire Project for rapid chloride permeability (RCP) in lieu of compressive strength testing for information only.

- **<u>MIT-SCAN-T2</u>**
  - MnDOT used this for implementing a Contractor Probing Requirement on concrete pavements. At this time we do not yet use it for acceptance of concrete thickness. Because of this device, we require a Contractor to provide a metal plate that is recognized by the MIT-SCAN T2 for all probing locations.
  - In addition, we are now requiring the Contractor to provide a MIT-SCAN T2 device to use as a QC tool to quickly check if tie bars and dowel bars are in the pavement where they belong.

2301.3.A.6 MIT-SCAN T2 Non-Destructive Testing Device

The Contractor shall furnish a MIT-SCAN T2 non-destructive testing device having the ability to measure the location of concrete reinforcement, dowel bars and concrete pavement thickness in a single device. Agency and Contractor personnel shall mutually use this non-destructive testing device several times a day during concrete pavement construction. Agency observations do not relieve the Contractor of the requirement to properly place the concrete reinforcement and dowel bars as shown in the plans. In addition, the Department reserves the right to reject the pavement in accordance with 1503, "Conformity with Plans and Specifications" and 1512, "Unacceptable and Unauthorized Work."

The Engineer will not provide additional payment for furnishing the above equipment for the Department's use.

2301.3.H.1.a Quality Control Plan for Dowel Basket Assemblies

Provide a Quality Control Plan in writing to the Engineer for acceptance that provides a method for keeping the dowel basket assemblies anchored to the existing asphalt or bond breaker layer and into the underlying concrete. The Quality Control Plan shall include the following at a minimum:

(1) Proposed type and number of fasteners
(2) Dowel basket assembly anchoring plan (ie. Anchored all basket assemblies prior to concrete placement, one lane at a time, anchor all basket assemblies during the concrete placement operation, etc.)
(3) Procedure if assemblies do not hold with the proposed method
(4) Sampling rate for locating basket assemblies with the MIT-SCAN T2

- **<u>Ground Penetrating Radar</u>**
  - MnDOT has used GPR testing for investigation of unmixed concrete in a pavement as well as locating tie bars and dowel bars when issues have occurred.

- **<u>Microwave Oven Testing on the Plastic Concrete</u>**
  - MnDOT uses the microwave oven to verify the w/c ratio of the concrete at the plant.

2. In your experience, how does the reliability of NDT testing methods compare to traditional testing methods?

I believe they provide valuable information and home to use the MIT-SCAN T2 and reduce coring by an even greater percentage.