



**DEVELOPMENTAL SPECIFICATIONS
FOR
PCC PAVEMENT NON-DESTRUCTIVE THICKNESS DETERMINATION**

**Effective Date
July 20, 2010**

THE STANDARD SPECIFICATIONS, SERIES OF 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

Replace all of Articles 2301.04 and 2301.05 of the Standard Specifications with the following:

2301.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Portland Cement Concrete Pavement.

1. Square yards (square meters) of the type specified in the contract documents.
2. The ~~coring measurement~~ requirements for thickness do not apply to detour pavements, paved drives, and temporary pavements. The thickness of pavement constructed will be determined from ~~core depths~~ thickness measurements as follows:
 - a. The division of sections, lots, and ~~core measurement~~ locations will be according to ~~Materials I.M. 346 Appendix A.~~
 - b. At locations determined by the Engineer, ~~cut samples from the pavement, as directed above, by drilling with a core drill that will provide samples with a 4 inch (101.6 mm) outside diameter~~ the Engineer will measure for thickness according to Appendix A. ~~Restore the surface by tamping low slump concrete into the hole, finishing, and texturing. The Engineer will witness the core drilling, and identify and measure the cores immediately. The Engineer will measure the cores and determine the thickness index according to Materials I.M. 346. After measurement on the grade, deliver the cores to the Engineer's office or field laboratory. When cores are not measured on the grade, the Engineer will take immediate possession of the cores.~~
 - c. ~~Coring of pavement and other~~ Measurement work for thickness determination may be waived by mutual agreement for sections of the same design thickness less than 5000 square yards (4200 m²).
 - d. Only sections which are ~~cored~~ measured for thickness will be included in the thickness index determination. Areas not ~~cored~~ measured for thickness will be paid for at the contract unit price.

B. Integral Curb.

Incidental to the other items of work. Not measured for payment.

C. Concrete Median.

Square yards (square meters) shown in the contract documents. This will be calculated to the nearest 0.1 foot (0.1 m) of the length along the surface and the overall width of median when no integral curb is involved, or the width from back to back of curb when integral curb is involved.

D. Bridge Approach Sections.

Square yards (square meters) shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and a price per cubic yard (cubic meter) for excavation, the excavation required for preparation of natural subgrade will be measured as provided in Article 2102.04. The volume measured for payment will include only the materials actually removed above the elevation of the pavement subgrade and between vertical planes 1 foot (0.3 m) outside the edge of the finished pavement.
2. Other work connected with preparation of natural subgrade will not be measured for payment.
3. When the contract provides a unit price for earth shoulder construction (whether or not a unit price per cubic yard (cubic meter) of excavation is provided in the contract), excavation required for preparation of natural subgrade will not be measured for payment. Unless otherwise provided in the contract documents, work connected with preparation of natural subgrade will not be measured for payment.

F. Driveway Surfacing Material.

Tons (megagrams) or cubic yards (cubic meters), as provided in the contract and in Section 2315, placed at intersecting roads, drives, and turnouts. Excavation required for placement of this material will not be measured for payment.

G. Portland Cement Concrete Pavement Samples.

Not individually counted for payment when furnished according to Article 2301.04, A, or when required in the contract documents.

H. Saw Cut and Joint Sealing.

1. Saw cut for constructing joints in new pavement will not be measured for payment.
2. Saw cut for cutting old existing pavement, which is to be abutted with new pavement, will not be measured for payment.
3. Joint sealing will not be measured for payment.

I. Safety Fence for Pavement.

Not measured for payment.

2301.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Portland Cement Concrete Pavement.

1. Contract unit price for Standard or Slip-Form Portland Cement Concrete Pavement of the type specified per square yard (square meter).
2. Payment for the quantities of pavement in square yards (square meters) will be at a percentage of the contract unit price according to Table 2301.05-1.

Table 2301.05-1: Payment Schedule for Quantities of Pavement

Thickness Index Range	Percent Payment	Thickness Index Range	Percent Payment
English (Metric)		English (Metric)	
0.00 or more (0.00 or more)	103	-0.56 to -0.60 (-13.98 to -15.24)	91
-0.01 to -0.05 (-0.01 to -1.27)	102	-0.61 to -0.65 (-15.25 to -16.51)	90
-0.06 to -0.10 (-1.28 to -2.54)	101	-0.66 to -0.70 (-16.52 to -17.78)	89

-0.11 to -0.15 (-2.55 to -3.81)	100	-0.71 to -0.75 (-17.79 to -19.05)	88
-0.16 to -0.20 (-3.82 to -5.08)	99	-0.76 to -0.80 (-19.06 to -20.32)	87
-0.21 to -0.25 (-5.09 to -6.35)	98	-0.81 to -0.85 (-20.33 to -21.59)	86
-0.26 to -0.30 (-6.36 to -7.62)	97	-0.86 to -0.90 (-21.69 to -22.86)	85
-0.31 to -0.35 (-7.63 to -8.89)	96	-0.91 to -0.95 (-22.87 to -24.13)	84
-0.36 to -0.40 (-8.90 to -10.16)	95	-0.96 to -1.00 (-24.14 to -25.40)	83
-0.41 to -0.45 (-10.17 to -11.43)	94	-1.01 to -1.05 (-25.41 to -26.67)	82
-0.46 to -0.50 (-11.44 to -12.70)	93	-1.06 to -1.10 (-26.68 to -27.94)	81
-0.51 to -0.55 (-12.71 to -13.97)	92	-1.11 or less (-27.95 or less)	80

3. Use the following formula to determine the thickness index for the section of pavement thickness:

$$TI = \overline{X} - S - T$$

Where:

TI = thickness index for the section.

\overline{X} = mean core length thickness for the section.

T = design thickness see Table 2301.05-2.

S = core length measurement thickness standard deviation (of the sample) for the section.

Table 2301.05-2: Thickness Value for determining Thickness Index

Type of Base, Subbase, Subgrade just below the concrete	Value of T in Inches
Natural Subgrade or Soil Aggregate Subbase	Design Thickness
HMA Base, PCC Base, or Asphalt or Cement Treated Base	Design Thickness
Modified Subbase or Special Subbase	Design Thickness minus 0.25 inches (6 mm)
Granular Subbase	Design Thickness minus 0.35 inches (9 mm)

4. Replace pavement represented by cores deficient from design thickness by 1 inch (25 mm) or greater. The deficient areas and the replacement of the deficient cores will be determined according to **Materials I.M. 346 Appendix A**.
5. At the Contractor's option, **cores that are measurement readings that are larger than the thickness value (from Table 2301.05-2) by three standard deviations or greater than design thickness** may be removed from analysis for thickness index determination. Do not remove more than 10% of the total **cores measurements** in a section. Do not replace **cores measurements** removed from the analysis.
6. Gaps in the pavement less than 500 feet (150 m), required by staging, will be considered irregular areas for analysis of pavement thickness determinations.
7. The percent payment for projects which have all **core length measurement readings** greater than **design thickness T** in Table 2301.05-2 will be at least 100%.

APPENDIX A EVALUATING PORTLAND CEMENT CONCRETE PAVEMENT THICKNESS

SCOPE

Thickness measurements will be taken on Portland Cement Concrete (PCC) pavement, to determine the pavement thickness and the thickness index for each section. Refer to Specification DS-09043.

APPARATUS

1. An MIT Scan T2 gauge will be used to perform thickness measures.
2. Steel Targets will be 11.81 inches (300.0 mm) in diameter, 24 gauge, meeting ASTM A 653, commercial steel with a G90 coating (about 275 g/m² total both sides).

DEFINITIONS

Section: All Portland Cement Concrete in a project of the same bid item. Irregular areas, as defined herein, of the same bid item shall form a separate section.

Lot: A portion of a section normally 200 feet (50 m) in length and 2 traffic lanes wide.

Regular area pavement sections:

- All mainline pavement for normal travel lanes. Includes middle (both direction) turn lanes
- Paved shoulder – if same thickness as pavement and part of pavement bid item include with pavement. If separate bid item, treat as separate section.
- Paved median - if same thickness as pavement and part of pavement bid item, and longer than 300 feet (100 m), include with pavement.
- Auxiliary lanes of full width longer 300 feet (100 m).
- Widening greater than 6 feet (2 m).

Irregular areas:

- Widening less than 6 feet (2 m).
- Side street connections.
- Ramps, including gore areas, and collector distributor roads.
- Deceleration and acceleration lanes.
- Turn lanes, including taper sections.
- Tapers.
- Radiuses.
- Median crossovers

PROCEDURES

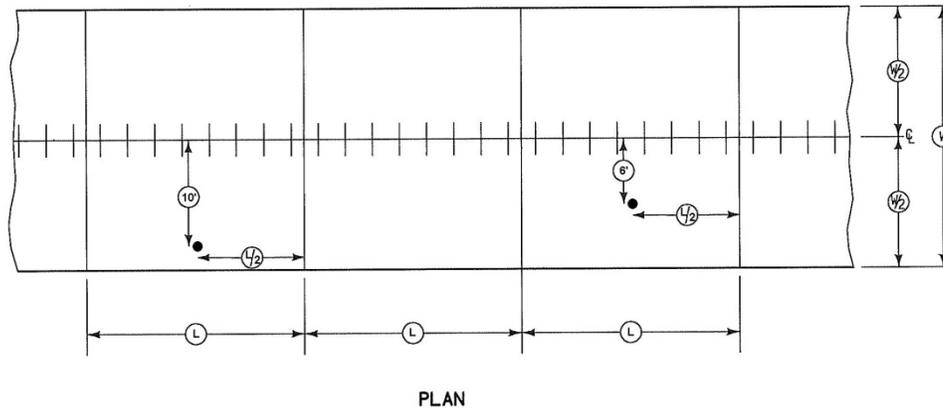
The District Materials Engineer will determine the location of each lot, the random location of each metal target, and the random thickness measuring scheme for each section using an Iowa DOT developed MSEXcel spreadsheet.

A. Target Location for Regular Areas

1. Divide the section longitudinally into 200 foot (50 m) long lots. One target will be located in each lot based on the spreadsheet selection (The targets should be placed half way between dowel baskets). See Figure 1. A minimum of ten targets will be tested. If a target location falls on a bridge or in an approach section, it will be eliminated.
2. The transverse location of the targets will be randomly determined by the spreadsheet program. The random locations will be either 6 or 10 feet (2 or 3 m) left or right of centerline. When tie steel is present at the edge of the pavement or lane, the locations will be 5 or 9 feet (1.5 or 2.5 m).
3. The program will randomly determine which targets to measure. If a measurement location falls on a bridge or bridge approach pavement, it will be eliminated and the next closest target not in the original random selection will be used for measurement.

- Shoulders. Divide the section into 200 foot (50 m) long lots. Place targets approximately mid-point transversely on shoulders wider than 6 feet (1.82 m). On 6 foot (1.82 m) shoulders, the targets should be 4 feet (1.2 m) from the edge of the pavement.

Figure1. Target Location



B. Target Location for Irregular Areas

- All irregular areas of the same design thickness will be grouped together for determining the number of lots. The Engineer may waive sections of the same design thickness that total less than 5,000 square yards (4200 sq. m).
- Place targets randomly in all irregular areas larger than 100 square feet (10 m²). One target will be randomly located in each selected irregular area, unless one or more of the areas are significantly larger than the others, then more than one target may be located in the large area. Targets must be placed at least 2 feet (0.6 m) away from tie steel and 4 feet (1.2 m) from dowel bars. A minimum of ten targets will be tested to represent each section of irregular areas. All targets will be measured.

C. Testing

Follow the manufacturer's instructions for operating the thickness gauge. It is important to avoid testing close to any steel including vehicles, equipment, steel toed shoes as well as tie bars, dowel bars and baskets, and manhole covers. When wearing steel toed shoes, always keep both toes at least 2 feet (0.6 m) from the gauge during the test. Three repeat readings will be taken. The readings should all be within 1 to 2 mm of each other. If the difference between any of the readings is more than 3 mm, take 2 additional readings. If the two additional readings are within 3 mm of any of the first 3 readings, the measurement is valid for that location. If not, note that the location is not valid and select the next target location not originally selected for testing.

The US made targets produce a slight bias on the T2 unit (approximately 3 mm less than the actual thickness). The correction factor is programmed into the reporting spreadsheet. The correlation factor is:

$$\text{Corrected Thickness Reading} = -0.00003723X(\text{T2 reading})^2 + 1.01629229X(\text{T2 reading}) + 1.44772852$$

D. Section Evaluation

1. Use the following formula to determine the mean thickness for the section:

$$\bar{X} = \frac{\sum X}{n}$$

Where: \bar{X} = mean length for the section

$\sum X$ = sum of core lengths for the section

n = number of cores taken within the section

Round the mean thickness to two decimal places.

2. Use the following formula to determine the sample standard deviation of the thickness of the section:

$$S = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

Where:

S = thickness standard deviation for the section.

\bar{X} = mean thickness for the section

X = individual thickness values for the section.

n = number of tests representing the section.

\sum = sign indicating the sum of all values of $(X - \bar{X})^2$

Round the sample standard deviation to two decimal places.

NOTE: Calculations of the standard deviation are best made with an electronic calculator with standard deviation capability that uses the formula containing the quantity (n-1).

3. Use the following formula to determine the thickness index for the section of pavement thickness.

$$TI = (\bar{X} - S) - T$$

Where:

TI = thickness index for the section

\bar{X} = mean thickness length for the section

T = from Table 2301.05-2

S = measurement thickness standard deviation (of the sample) for the section

Round the thickness index to two decimal places.

NOTE: If the mean thickness minus the standard deviation is less than T of the section, the thickness index will be a negative number.

4. Basis of Payment. Payment for the quantities of pavement in square yards (square meters) in each section will be as shown in Article 2301.05 and based on the thickness index as determined in accordance with these instructions.

E. Deficient Areas

1. If any measurement is deficient from T by 1 inch (25.4 mm) or more, the measurement should be rechecked to confirm the reading and the equipment. If the repeat measurement is also 1 inch (25.4 mm) or more below T, mark the location directly over the target. The Contractor shall drill a 4.0 inch (101.6 mm) diameter core at that location. If the core length confirms the measurement, continue to drill cores as described below.

2. Deficient areas, represented by cores deficient in length by 1 inch (25.4 mm) or more from design thickness, are to be replaced. These areas will be determined by drilling a core 60 feet (18 m) in each direction longitudinally at the same transverse location from the deficient core. Drilling will be continued at 60 feet (18 m) intervals until a core is obtained which is not deficient by 1 inch (25.4 mm) or more from design thickness. Interpolate between this core and the adjacent core to determine the limits of the deficient area. This is the area to be removed and replaced at contractor's expense. These additional cores are to be used to define the deficient area and will not be used in the thickness index calculation. When an obstruction, such as a bridge, intersection, previous work, etc., prevents drilling a core at the required 60 feet (18 m) interval in either direction longitudinally, continue the balance of the distance on the other side of the obstruction.
3. Any readings taken in the area for removal will be eliminated from the analysis for the entire section. After replacement, the contractor will take cores as directed by the engineer to verify the thickness.