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PROVINCIAL
STANDARD
SPECIFICATION**

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**CONSTRUCTION SPECIFICATION FOR
CONCRETE PAVEMENT AND CONCRETE BASE**

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350.01 SCOPE

This specification covers the requirements for the construction of concrete pavement and concrete base.

350.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction:

OPSS 314	Untreated Granular Subbase, Base, Surface, Shoulder and Stockpiling
OPSS 360	Full Depth Repair of Concrete Pavement and Concrete Base
OPSS 364	Partial Depth Repairs in Concrete Pavement
OPSS 369	Sealing or Resealing of Joints and Cracks in Concrete Pavement
OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete
OPSS 914	Waterproofing Bridge Decks with Hot Applied Asphalt Membrane
OPSS 919	Formwork and Falsework

Ontario Provincial Standard Specifications, Material:

OPSS 1002	Aggregates - Concrete
OPSS 1302	Water
OPSS 1305	Moisture Vapour Barriers
OPSS 1306	Burlap
OPSS 1308	Joint Filler (Concrete)
OPSS 1315	White Pigmented Curing Compounds for Concrete
OPSS 1350	Concrete - Materials and Production
OPSS 1441	Load Transfer Assemblies
OPSS 1442	Epoxy Coated Steel Reinforcement for Concrete

Canadian Standards Association:

CSA A23.1-94/A23.2-94 Concrete Materials and Methods of Concrete Construction/Methods of Test for Concrete

Ministry of Transportation Publication:

MTO Laboratory Testing Manual:

LS-101 Procedures for Calculating Percent Within Limits

350.03 DEFINITIONS

For the purposes of this specification the following definitions shall apply:

Concrete Pavement: means a rigid pavement structure with an exposed concrete surface which may include concrete shoulders.

Concrete Base: means a rigid pavement structure which is overlaid with asphaltic concrete, on the same contract, and may include concrete shoulders.

Percent Within Limits (PWL): means an estimate of the percentage of the lot population that is within specification limits, determined by using the mean and standard deviation of the lot.

Standard Deviation: means the square root of the value found by summing the squares of the difference between each test result and the mean of the test results divided by the number of test results minus one.

350.04 SUBMISSION AND DESIGN REQUIREMENTS

Where concrete pavement or concrete base is to be placed from October 1 to April 1, the Contractor must submit a plan detailing curing and protection plans. The plan shall describe the method by which in-place minimum concrete temperatures shall be maintained. No concrete shall be placed unless the plan is approved by the Contract Administrator.

350.05 MATERIALS

350.05.01 Concrete

Concrete and concrete materials shall be according to OPSS 1350 with the following amendments:

- a. The coarse aggregate for concrete pavement and concrete base shall have a combined gradation of nominal maximum size 37.5 mm and 19.0 mm aggregate and shall be according to the requirements of OPSS 1002.
- b. The class of concrete shall be 30 MPa according to OPSS 1350. The Cementing Materials Content subsection and the Strength Tests and Requirements subsection of OPSS 1350 do not apply.
- c. For all concrete pavement and concrete base, the air content shall be $6.0\% \pm 1.5\%$.
- d. If the concrete is formed, the slump shall be $70 \text{ mm} \pm 20 \text{ mm}$.
- e. Concrete shall be placed with a mix temperature within the range of 10°C and 28°C .

350.05.02 Burlap

Burlap shall be according to OPSS 1306.

350.05.03 Moisture Vapour Barrier for Curing

Moisture vapour barrier for curing shall be according to OPSS 1305.

350.05.04 Curing Compound

White pigmented membrane curing compound for concrete shall be according to OPSS 1315.

350.05.05 Water for Curing

Water for curing shall be according to OPSS 1302.

350.05.06 Tie Bars and Load Transfer Devices

Tie bars shall be according to OPSS 1442 and load transfer devices shall be according to OPSS 1441.

350.05.07 Joint Materials

Expansion joint filler shall be according to OPSS 1308.

Joint sealant material shall be according to OPSS 369.

350.06 EQUIPMENT

350.06.01 Compacting

Concrete shall be consolidated by means of surface vibrators, internal vibrators, or a combination of both that provide full depth consolidation without segregation.

350.06.02 Hot Poured Rubberized Asphalt Joint Sealing

Hot poured rubberized asphalt joint sealing equipment shall be according to OPSS 914.

350.06.03 Forms

Forms shall be according to OPSS 919.

350.06.04 Automatic Dowel Bar Inserter

Where an automatic dowel bar inserter is used, it must be capable of placing dowel bars as specified. The dowel bars shall be inserted to mid-depth of the slab and centred on the transverse joint locations and spaced as shown on the plans. The equipment shall be capable of consolidating the concrete around the dowel bars.

350.06.05 Diamond Grinder

Where a diamond grinder is used, it shall be power-driven, self-propelled equipment specifically designed to grind and texture concrete pavement and concrete base. It shall be equipped with a grinding head with at least 50 diamond blades per 300 mm of shaft. The grinding head shall be at least 0.9 m wide. The grinder shall be equipped with the capability to adjust the depth, slope and crossfall to ensure that concrete is removed to the desired dimensions and uniformly feathered and textured across the width and length of the required area. The equipment shall also include a slurry pick-up system.

350.07 CONSTRUCTION

350.07.01 Preparation Work

350.07.01.01 General

Before placing concrete on granular base, the granular immediately ahead of the concrete placing operation shall be wetted down thoroughly. The wetting down shall be carried out without leaving standing water.

350.07.02 Joints

350.07.02.01 General

Joints shall be of the type and at the location shown in the Contract.

The initial sawcut, for longitudinal and transverse contraction joints, shall be sawn as soon as possible, normally within 12 hours of paving operations. Sawcutting operations shall not result in ravelling or other damage to the concrete. The initial cut shall be for one third the depth of the concrete slab.

The joints shall be cleaned and sealed according to OPSS 369.

Dowel bars at the transverse contraction joints shall be placed using load transfer devices or an automatic dowel bar inserter.

350.07.02.02 Load Transfer Devices

Load transfer devices shall be as shown in the Contract.

350.07.02.03 Transverse Construction Joints

Transverse construction joints shall be made at the end of each day's run or when interruptions occur in the concreting operation. Transverse construction joints shall be formed at a contraction or expansion joint, except in exceptional cases of plant breakdown or adverse weather conditions. In these exceptional cases, a construction joint may be formed in the mid slab area subject to the provision that the portion of the slab placed, and the portion of the slab to be placed, is not less than 2 m in length. Construction joints in adjacent lanes of pavement shall align with joints in the previously placed lane.

350.07.02.04 Position and Alignment Tolerances

350.07.02.04.01 Dowel Bars

The dowel bars shall be placed within a tolerance of ± 6 mm in the vertical and horizontal planes of the pavement.

350.07.02.04.02 Joints

All joints shall be placed within a tolerance of ± 15 mm from the position and alignment of the centre of the dowel bars.

350.07.02.05 Tie Bars

At longitudinal joints, epoxy coated tie bars shall be installed where specified and as detailed in the Contract. Tie bars shall be inserted so that voids are not created around the bar. Tie bars shall not be placed within 600 mm of a transverse joint.

350.07.02.06 Dowel Bars at Transverse Joints

At all expansion and contraction joints, dowel bars shall be installed according to the details in the Contract. The location of dowel bars shall be marked to permit precise joint forming or cutting operations directly over the centre of the dowel bars.

When an automatic dowel bar inserter is used, the Contractor shall be required to remove a 2 m x full paver width section of concrete pavement or concrete base within the first days paving. Additional sections will be required until the Contractor's operations conform to the specification. The joint to be removed will be selected by the Contract Administrator. The section will be inspected by the Contract Administrator to ensure that the placement and alignment of the dowel bars meet requirements. The section removed shall be repaired according to OPSS 360.

350.07.02.07 Protection of Tie Bars and Dowel Bars

Protection of dowel bars shall be according to OPSS 905.

Bars with coating damage greater than 5% of the surface area of each bar shall not be used.

For bars with coating damage of 1% or less of their surface area, all damaged areas of the bar coating shall be repaired.

350.07.03 Concreting

Concrete shall be placed at or near its permanent location in such a manner so as to avoid segregation of the materials. Any excess concrete beyond the pavement edge shall be removed immediately.

Transverse joint load transfer devices shall be placed a minimum of 100 m in advance of the paving operations.

When an interruption in placing concrete of more than 45 minutes occurs, a transverse construction joint shall be formed. Concrete shall not be placed against any material which is at a temperature above 35°C or against any material whose temperature is below 5°C.

The maximum ambient air temperature for placing concrete is 32°C.

350.07.03.01 Consolidating

Concrete shall be thoroughly consolidated against and along the face of all forms and into the face of previously placed concrete.

For fixed-form placement, hand-held vibrators shall be used to supplement consolidation adjacent and along the full length of the form. They shall also be inserted at regularly spaced intervals along both sides of dowel assemblies. Vibrators shall never be operated longer than 15 seconds in any one location.

For slip-form pavers, the concrete shall be consolidated by vibrators of sufficient number, spacing and frequency to provide uniform consolidation to the entire pavement width and depth. The vibrators shall not operate while the paver is stopped.

The vibrators shall not come in contact with the subgrade, subbase, forms, tie bars or dowel assemblies.

350.07.03.02 Finishing

No water or other chemical agents shall be applied to the concrete surface for finishing purposes.

For concrete pavements where fixed forms are being used or where concrete is being placed against an existing pavement and before surface texturing, the edge of the pavement shall be finished with an edging tool having a radius of not more than 6 mm. The finished pavement edge shall be left smooth, true to line and grade.

350.07.03.03 Texturing of Surface

After all finishing operations are completed on concrete pavements and before initial curing and protection of the concrete, the plastic surface of the concrete shall receive an initial and final texturing. Initial texturing shall be performed with a longitudinal burlap drag to produce a uniform textured surface. Burlap shall be kept in a clean and damp condition, free from encrusted mortar. Final texturing shall be achieved using equipment manufactured to produce transverse grooves 3 mm ± 1 mm wide on 16 mm ± 3 mm centres with a groove depth of 4 mm ± 1 mm.

Grooving shall extend to within 75 mm ± 15 mm of the pavement edge. Grooving for small or irregular areas may be done by hand methods.

The surface shall be free in all cases from displaced aggregate particles and local projections.

350.07.03.04 Surface Tolerance

The surface of the concrete is to be such that when tested with a 3 m long straightedge placed in any location and direction, including the edge of pavement, except across the crown or drainage gutters, there shall not be a gap greater than 3 mm between the bottom of the straightedge and the surface of the pavement.

Diamond grinding will be required to ensure the concrete surface meets these requirements.

350.07.04 Curing

350.07.04.01 General

Curing shall be according to OPSS 904 with the following exceptions:

Curing shall be applied to all exposed surfaces as soon after the texturizing operation as can be achieved without damaging the surface.

As soon as forms are removed, the sides of the exposed concrete faces shall be sprayed with the white pigmented curing compound at the specified rate of application. Curing compound shall not be applied to joint faces receiving sealant or to concrete surfaces to which concrete or mortar is to be bonded.

350.07.05 Joint Sealing

Joint sealing shall be according to OPSS 369.

350.07.06 Miscellaneous Protection

350.07.06.01 Rain

Concrete shall not be placed in the rain. The Contractor shall take all necessary precautions to protect plastic concrete from rain.

350.07.06.02 Traffic

Traffic, other than foot traffic, rubber-tired sawing equipment, and rubber-tired side wheels of form mounted placing and finishing equipment necessary to construct adjacent lanes, shall not be permitted on the concrete until it has attained 20 MPa.

Samples required for early strength determination shall be taken and tested by the Contractor. A minimum of 1 set of two cylinders per 500 m length of paving shall be required for early opening determination. Samples shall remain on site as specified until time of testing.

The concrete pavement shall be protected from damage to the surface at all times when steel-tracked equipment is used.

350.07.06.03 Shoulders

Shouldering operations may commence once the adjacent concrete has attained 20 MPa. Completion of the shoulders shall be according to OPSS 314.

350.07.06.04 Cold Weather

Concrete shall not be placed when the ambient air temperature is below 0°C and shall not be placed against any material whose temperature is below 5°C.

The Contractor shall provide protection to ensure the minimum in-place temperature of the concrete pavement or concrete base is 15°C for the first three days of curing, and at 10°C for the subsequent 4 days.

350.07.06.04.01 Insulation Removal for Sawcutting

When the concrete pavement or concrete base requires protection by insulation, no more than 25 linear metres of concrete pavement or concrete base shall be exposed for sawcutting operations at any one time. In no case shall any concrete pavement or concrete base be exposed for more than one hour during sawcutting.

350.07.07 Concrete Base

350.07.07.01 General

The work required for concrete base includes the work required for concrete pavement except as modified by this subsection.

350.07.07.02 Joints

A final reservoir cut is not required at the joints.

350.07.07.03 Texturing of Surface

Texturing of the surface is not required.

350.07.07.04 Joint Sealing

The sealing of joints in concrete base is not required.

350.07.07.05 Surface Tolerance

The provisions of subsection 350.07.03.04 apply except that the tolerance is increased to 6 mm.

350.07.08 Sampling and Testing

350.07.08.01 Slump and Air Content

Field sampling and testing of plastic concrete for conformance to slump and air content requirements shall be the Contractors responsibility as detailed below.

Slump and air content shall be tested according to OPSS 904 with the following exceptions:

The frequency of slump and air content testing shall be according to Table 1.

**Table 1
Sampling and Testing - Minimum Frequencies**

Tests	Frequency
Air Content	Each load until satisfactory control is established. Then 1 random test per 5 truck loads
Slump for Fixed Form Paving	Each load until satisfactory control is established. Then 1 random test per 5 truck loads
Notes: Test Procedures shall be according to CSA A23.2-94. Satisfactory control is considered to have been established when tests on five consecutive truck loads or batches of concrete are within specification requirements.	

350.07.08.02 Coring

Coring shall be carried out when the concrete is 28 to 35 days old. The Contractor may elect to core for compressive strength testing prior to 28 days provided the strength testing is performed within two days of coring.

The location of the core in each subplot will be selected by the Owner using a table of random numbers. No core shall be taken within 250 mm of any joint or edge of slab.

The Contractor shall cut one core in each subplot. The cores shall be 100 mm in diameter and shall be drilled through the complete depth of concrete pavement or concrete base perpendicular to the surface of the slab.

350.07.08.03 Filling of Core Holes

Each core hole shall be filled immediately after coring with an approved non-shrink grout. The patch shall be finished flush with the surface of the concrete slab.

Immediately before filling, the vertical surface of each core hole shall be cleaned of the paste left from the coring operation by wire brushing, and all free water shall be removed. After filling each hole, all excess material shall be removed from the surface of the slab.

350.07.08.04 Identification of Cores

Each core shall be legibly marked with durable ink immediately after its removal from the core hole. The core identification numbers will be specified by the Owner.

350.07.08.05 Transportation of Cores

The concrete cores shall be delivered to a laboratory designated by the Owner. The cores shall be delivered on the same day they were obtained.

The Contractor is responsible for transporting these cores in a safe manner to avoid damage to the cores.

350.08 **QUALITY ASSURANCE**

350.08.01 **Acceptance Criteria for Strength and Thickness**

350.08.01.01 **General**

Acceptance of the concrete pavement or concrete base for each lot will be based on the mean and standard deviation of the lot measurements for core compressive strength and slab thickness. The Contract Administrator will calculate the Percent Within Limits for each criteria as described in LS-101.

350.08.01.02 **Core Compressive Strength and Slab Thickness**

The slab thickness will be determined based on core length for each subplot, each core shall be measured for length prior to trimming. Four measurements rounded to the nearest millimetre shall be made around the perimeter of the core to determine the actual concrete thickness. These measurements shall be taken at the ends of two perpendicular diameters.

Cores will be tested for compressive strength when the concrete is 30 to 42 days old. If the contractor elects to core prior to 28 days, the compressive strength tests will be performed within two days of coring. The cores shall be stored in the laboratory at an ambient air temperature of $\geq 15^{\circ}\text{C}$ and $\leq 25^{\circ}\text{C}$ and moisture conditioned for 40 - 48 hours prior to testing. The testing shall be according to CSA A23.2-9C.

If the lot PWL is greater than or equal to 90%, the lot is acceptable for the criteria. If the lot PWL is greater than 90%, the lot will be accepted with a bonus for the criteria. If the lot PWL is less than 90% and greater than or equal to 50%, the lot is accepted for the criteria with a price adjustment. If the lot PWL is less than 50%, the lot is rejectable and shall be subject to repair and reassessment.

Notwithstanding the overall PWL, if any individual core compressive strength or if any individual length is less than 60% of the specified compressive strength or specified slab thickness, the Contractor shall repair the subplot.

For calculation of PWL, the lower limit is 30 MPa for compressive strength. The lower limit for thickness shall be specified as the design thickness minus 5 mm.

350.08.01.03 **Lot Size**

350.08.01.03.01 **Compressive Strength and Thickness**

A lot shall consist of the total quantity of concrete pavement or concrete base on the contract of the same specified thickness.

Each lot will be divided into 1000 m² sublots or a minimum of three sublots for compressive strength and thickness. The Owner will test one core from each subplot to determine the core compressive strength and slab thickness.

350.08.01.04 **Re-testing**

350.08.01.04.01 **Compressive Strength and Thickness**

The Contractor or the Contract Administrator may question an individual test result within three working days of receiving the test result for that subplot. The Contractor shall notify the Owner of his intention to re-core. A new core shall be obtained from locations adjacent to the location of the original set of cores. The new core shall be obtained at a maximum age of 56 days and tested not later than 7 days after the coring. The lot will be re-evaluated as specified under basis of payment.

350.08.01.05 Removal of Unacceptable Concrete

If individual subplot results for core compressive strength or thickness of concrete pavement or concrete base dictates removal and replacement of a subplot, additional cores shall be taken by the Contractor to establish the extent of the deficient area.

The cores shall be taken at 3 m intervals along the length of the pavement in both directions starting 3 m from the location of the original core.

The area to be removed shall be bounded by the nearest contraction joint and longitudinal joint or concrete pavement or concrete base edge outside the deficient area so that there shall be no additional joints.

Where the overall subplot results dictate removal and replacement, the Contractor shall remove and replace the entire subplot.

350.08.01.06 Cracking in Concrete Pavement

All cracking, in excess of one third the depth of the slab thickness shall be repaired as a full depth repair according to OPSS 360.

Cracks less than one-third the thickness of the slab shall be repaired according to OPSS 364.

350.09 MEASUREMENT FOR PAYMENT

350.09.01 Actual Measurement

**350.09.01.01 Concrete Pavement
Concrete Base**

Measurement will be the surface area of concrete pavement or concrete base placed in square metres.

350.09.02 Plan Quantity Measurement

**350.09.02.01 Concrete Pavement
Concrete Base**

When measurement is by Plan Quantity, such measurement will be based on the units shown in the clause under Actual Measurement.

350.10 BASIS OF PAYMENT

**350.10.01 Concrete Pavement - Item
Concrete Base - Item**

Payment at the contract price for the above items shall be full compensation for all labour, equipment and material required to do the work except that, where work does not conform to the quality requirements, adjustment for each lot will be made according to the following. The price adjustment will be based on the average of the Pay Factors (PF) for strength and thickness.

When retesting is completed, the test results used to determine the price adjustment shall be as detailed in Table 2. Payment for retesting will be made only when the retest results in an increased payment.

350.10.01.01 Compressive Strength and Slab Thickness

Adjustment of the contract price for compressive strength and slab thickness shall be based on the following formulae and Table 2.

For concrete pavement and concrete base:

$$PF_{\text{strength}} = 55 + 0.5 \text{PWL}$$

$$PF_{\text{thickness}} = 55 + 0.5 \text{PWL}$$

Table 2

CRITERIA for PAYMENT when RETESTING		
	Difference Between New and Old Core	Test Core Used for Payment Adjustment
Thickness	≤ 5 mm	Original Core
	> 5 mm	New Core
Strength	≤ 5%	Original Core
	> 5%	New Core

350.10.01.02 Additional Coring and Testing

Payment will not be made for additional coring and testing to determine the limits of slab removal. The Owner will pay for reborings and testing for strength and thickness only when the retests result in an increase in payment.