

OPSS 366, April 2023, Construction Specification for Repairing Concrete Pavement and Concrete Base, is deleted in its entirety and replaced with the following:

366.01 SCOPE

This specification covers the requirements for full depth and partial depth repairs of concrete pavement and concrete base using conventional concrete repairs, high early strength concrete repairs, and fast-track concrete repairs (full depth repair only).

366.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 320	Open Graded Drainage Layer
OPSS 350	Concrete Pavement and Concrete Base
OPSS 369	Sealing or Resealing of Joints and Cracks in Concrete Pavement and Concrete Base
OPSS 904	Concrete Structures
OPSS 929	Abrasive Blast Cleaning - Concrete Construction

Ontario Provincial Standard Specifications, Materials

OPSS 1002	Aggregates - Concrete
OPSS 1010	Aggregates - Base, Subbase, Select Subgrade and Backfill Material
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1306	Burlap
OPSS 1308	Joint Filler in Concrete
OPSS 1315	White Pigmented Curing Compounds for Concrete
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1441	Load Transfer Assemblies
OPSS 1442	Epoxy Coated Reinforcing Steel Bars for Concrete

Ontario Ministry of Transportation Publications

Laboratory Testing Manual:

LS-410	Method of Test for Compressive Strength of Drilled Cores
LS-432	Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-435	Method of Test for Linear Shrinkage of Concrete
LS-449	Method of Test for Load Transfer Test of Concrete Pavement Using a Falling Weight Deflectometer

MTO Forms:

PH-CC-433-A Concrete Mix Submission Form A

MTO Designated Sources for Material List:

9.30.25 Acrylic and Epoxy Resins

CSA Standards

A23.2-3C Making and Curing Concrete Compression and Flexural Test Specimens*

A23.2-9C Strength of Cylindrical Concrete Specimens*

A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*

*[Part of A23.1:24/A23.2:24 - Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete]

ASTM International

C171-20 Sheet Materials for Curing Concrete

366.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Autogenous Cylinders means cylinders used for estimating compressive strength of concrete in the repair areas when fast-track concrete is used. These cylinders are stored in insulated curing containers in which the elevated curing temperature is obtained from heat of hydration of the cement.

Cold Weather means as defined in OPSS 350.

Conventional Concrete Repair means a concrete pavement or concrete base repair process excluding high early strength concrete repairs or fast-track concrete repairs.

Diamond Grinding means altering the profile and texture of a concrete surface by utilizing grinding equipment that employs diamond tipped blades.

Fast-Track Concrete Repair means a process in which a section of concrete pavement or concrete base is closed to traffic, concrete is removed, repairs are completed, and the section is re-opened to traffic within a specified time period of 24 hours or less.

Full Depth Repair means a repair area in the concrete pavement or concrete base which is the full thickness of the existing concrete pavement or concrete base.

High Early Strength Concrete Repair means a process in which a section of concrete pavement or concrete base is closed to traffic, concrete is removed, repairs are completed, and the section re-opened to traffic within 72 hours or within the timeframe specified in the Contract Documents.

Horizontal Alignment means as defined in OPSS 350.

Horizontal Side Shift means as defined in OPSS 350.

Hot Weather means as defined in OPSS 350.

Longitudinal Side Shift means as defined in OPSS 350.

Partial Depth Repair means a repair area in the concrete pavement or concrete base which has a minimum depth of 50 mm to a maximum depth of one-third the thickness of the existing concrete pavement or concrete base.

Staged Repair means a repair area which cannot be repaired in one complete operation due to traffic or construction sequence constraints and must be completed in separate stages.

Vertical Alignment means as defined in OPSS 350.

366.04 DESIGN AND SUBMISSION REQUIREMENTS

366.04.01 Design Requirements

366.04.01.01 Concrete Mix Design

The concrete mix shall be designed to provide adequate strength and durability for the intended use and to meet the requirements specified in the Contract Documents.

366.04.02 Submission Requirements

366.04.02.01 Concrete Mix Design

The concrete mix design(s) shall be submitted according to OPSS 1350.

Linear shrinkage test results shall be submitted to the Contract Administrator within 40 Days of the mix design submission, for information purposes. Concrete specimens may be obtained from a laboratory batch or sampled in the field. Linear shrinkage testing shall be according to LS-435.

366.04.02.02 Calibration Charts and Autogenous Cylinder Method for Fast-Track Concrete Repairs

The following information shall be submitted to the Contract Administrator with the concrete mix design for the fast-track concrete repairs as specified in the Autogenous Cylinder Method Calibration Charts for Fast-Track Concrete Repairs subsection:

- a) Calibration chart indicating compressive strength versus temperature.
- b) Calibration chart indicating temperature versus time.
- c) Ambient air temperature during development of the calibration charts.

The above data shall be accompanied by a covering letter, signed by an Engineer, identifying the curing method, the test method, and detailing the development of the calibration chart.

For fast-track concrete repairs, calibrations charts shall be developed prior to commencement of the trial area. Calibrations charts shall be developed as specified in the Autogenous Cylinder Method Calibration Charts for Fast-Track Concrete Repairs subsection. If a trial area is not required, calibration charts shall be developed prior to construction of the fast-track repairs.

All supporting test data shall not be more than 12 months old at the time the concrete mix design is submitted to the Contract Administrator.

If the ambient air temperature at time of placement differs from the ambient air temperature during the development of the calibration charts by more than 10°C, new calibration charts shall be submitted.

In the event that field performance or conditions are no longer representative of the conditions under which the submitted calibration charts were developed, the mix design and charts shall be resubmitted prior to proceeding with concrete repairs.

366.04.02.03 Concrete Removal Plan

A concrete removal plan, describing the method to be used to remove the existing concrete shall be submitted to the Contract Administrator at least 14 Days prior to the start of the work. The plan shall be according to the requirements in the Concrete Removal subsection and shall include the following:

- a) sawcutting and removal process,
- b) equipment,

- c) disposal plan,
- d) method to repair or replace disturbed, removed or damaged underlying material including the type of replacement material, mixing and placement method.

Concrete removal shall not proceed until the concrete removal plan has been accepted by the Owner.

366.04.02.04 Chipping Hammers

The manufacturer's published specifications on the chipping hammers shall be submitted to the Contract Administrator 7 Days prior to the commencement of the partial depth removal operation.

366.04.02.05 Temperature Control Plans

366.04.02.05.01 Cold Weather

Temperature control plans for all concrete repairs except fast-track concrete repair, shall be submitted according to OPSS 904 in the event of cold weather conditions.

366.04.02.05.02 Hot Weather

For all concrete repairs subject to hot weather conditions, a temperature control plan that describe the methods to be used to control the temperature of the concrete shall be submitted to the Contract Administrator 7 Days prior to placement.

366.04.02.06 Curing Compound

Curing compound submissions shall be according to OPSS 904.

366.04.02.07 Effluent Management

Effluent management submissions shall be according to OPSS 350.

366.05 MATERIALS

366.05.01 Bond Breaker

Bond breaker shall be RC-250, Tectyl 506, or an alternative type of material acceptable to the Owner.

Dowel bars and load transfer devices shall be shop coated with bond breaker according to the bond breaker manufacturer's recommendations, except for dowels which are installed into existing concrete.

366.05.02 Bonding Agent

Bonding agent shall consist of Portland cement or Portland limestone cement and fine aggregate mixed with water to form a stiff mixture. Portland cement and Portland limestone cement shall be according to OPSS 1301. Fine aggregate shall be according to OPSS 1002. The consistency of the mixture shall be such that it can be applied with a stiff brush to the concrete surface in a thin even coating that will not run or puddle.

366.05.03 Burlap

Burlap shall be according to OPSS 1306.

366.05.04 Concrete

Concrete and materials for concrete shall be according to the Materials section of OPSS 1350 with the following exceptions and additions:

- a) The nominal maximum size of coarse aggregate shall be as specified in Table 1.
- b) The minimum 28-Day concrete compressive strength shall be 35 MPa, unless otherwise specified in the Concrete Documents.
- c) The compressive strength of the concrete in the repair area shall be a minimum of 20 MPa prior to opening to traffic.
- d) For partial depth repairs in areas where the greatest dimension (width or length) of the repair area is less than 300 mm, a proposal to use a proprietary patching material may be submitted to the Contract Administrator for approval.
- e) The requirements for rapid chloride permeability do not apply.
- f) For fast-track concrete repairs, the following apply:
 - i. Fast-track concrete repairs shall not be used for partial depth repairs;
 - ii. The maximum temperature of concrete at the time of discharge from the truck shall not exceed 35°C;
 - iii. The requirement for greenhouse gas (GHG) reduction does not apply;
 - iv. The requirement for plastic air content does not apply;
 - v. Superplasticizer may be used and may be added at the plant or site. Testing of slump prior to addition of superplasticizer is not required; and
 - vi. Calcium chloride based accelerator or other accelerators may be used. When used, it shall be measured accurately to ensure a consistent dosage for each load, and it shall be added and mixed in a manner to ensure consistent distribution throughout the load.
- g) For high early strength concrete repairs, the use of accelerating admixtures shall not be permitted.

366.05.05 Curing Compound

Curing compound for concrete shall be according to OPSS 1315.

366.05.06 Epoxy Adhesives

Epoxy resins used for dowel and tie bars shall be from the MTO DSM list # 9.30.25, Acrylic and Epoxy Resins, approved for horizontal applications and mixed in the nozzle (cartridge). Cementitious grouts shall not be permitted for this application.

366.05.07 Expansion Joint Filler

Expansion joint filler shall be according to OPSS 1308.

366.05.08 Moisture Vapour Barrier

Moisture vapour barrier shall be white opaque polyethylene film according to ASTM C171 and shall not be less than 100 µm thick.

366.05.09 Proprietary Patching Materials

Proprietary patching materials shall be from the Ministry's List of Concrete Patching Materials. The list shall be obtained from the Contract Administrator.

366.05.10 Tie Bars, Dowel Bars and Load Transfer Devices

Tie bars and dowel bars shall be according to OPSS 1440. Tie bars and dowel bars shall be epoxy coated according to OPSS 1442. Load transfer devices shall be according to OPSS 1441.

366.05.11 Water

Water used for curing of concrete, pre-soaking of burlap, making bonding agent and mixing proprietary patching materials shall be according to OPSS 1302.

366.06 EQUIPMENT

366.06.01 Air Compressor

The compressor for air blasting shall have a minimum capacity of 3.5 m³/min. The compressed air shall be free from oil and other contaminants.

366.06.02 Batching Plant and Delivery Equipment

The batching plant shall be according to the Batching Plant subsection of OPSS 1350. Delivery equipment shall be according to the Delivery Equipment subsection of OPSS 1350.

366.06.03 Chipping Hammer

Chipping hammers shall be hand-held and have a maximum weight of 9.0 kg prior to any handle modification, where applicable, and a maximum piston stroke of 102 mm. All hammers shall have the manufacturer's name and part or model number engraved on them by the manufacturer. All information shall be clearly legible. The manufacturer's published specifications shall be the sole basis for determining weight and piston stroke.

366.06.04 Diamond Grinder

When a diamond grinder is used, it shall be power-driven, self-propelled equipment specifically designed to grind and texture concrete surfaces. 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 cross-fall 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 diamond grinder shall be equipped with a vacuum system that is, capable of removing all standing effluent, leaving the roadway in a clean, near dry condition after each pass. Residue shall not be permitted to encroach into open lanes, ditches or enter, into closed drainage systems. The management of effluent from diamond grinding operation shall be according to OPSS 350.

366.06.05 Gang Drill

The gang drill shall consist of not less than three independently powered pneumatic drills. Drilling shall not damage adjacent concrete.

366.06.06 Hand Finishing Equipment

Floats used to finish concrete shall be made of magnesium.

366.06.07 Placing, Consolidating and Finishing Equipment

Equipment used for placing, consolidating and finishing concrete for full depth repairs 3 m or greater in length (measured in the direction of traffic) shall be a vibratory steel screed or steel cylinder screed with integral internal vibration including automatic shut-off, and shall operate on fixed forms.

For partial depth repairs and full depth repair areas less than 3 m in length (measured in the direction of traffic), the concrete may be placed and consolidated using hand-held vibrators and finished with a straightedge.

366.06.08 Straight Edge

Straight edge shall be commercially made of metal, and 3 m long.

366.06.09 Thermocouples and Dataloggers

Thermocouples and associated instrumentation shall have an accuracy of $\pm 1.5^{\circ}\text{C}$, record temperatures at time intervals not exceeding 15 minutes, and shall display the temperature.

366.07 CONSTRUCTION

366.07.01 Autogenous Cylinder Method Calibration Charts for Fast-Track Concrete Repairs

For fast-track concrete repairs, autogenous cylinder calibration charts shall be developed for the purpose of determining the rate of early strength development of the fast-track concrete mixes. The minimum length of time for the calibration chart shall be the period of lane closure specified in the Contract Documents.

The size, preparation and testing of cylinders shall be as specified in the Early Strength Determination for Fast-Track Concrete Repairs clause.

Development of the calibration charts for fast-track concrete repair shall be according to the following:

- a) Compressive strength testing at each time interval shall be carried out on sets of two cylinders.
- b) The first set of cylinders shall be tested no later than 3 hours after the cylinders are cast.
- c) After the first set of cylinders are tested, testing shall continue at a minimum frequency of every 30 minutes for the length of time of the lane closure.
- d) A thermocouple or sensor shall be installed in one of the cylinders in each set, and the temperature of the concrete shall be recorded at a minimum of every 30 minutes after casting until the time of testing.

366.07.02 Trial Area for Fast-Track Concrete Repairs

A typical fast-track full depth concrete repair shall be demonstrated at the trial repair area specified in the Contract Documents a minimum of 7 Days prior to any concreting operation. A trial repair area is not required if the Contractor has demonstrated successful placement of fast-track concrete repairs, meeting all specification requirements, within the last 5 years on another ministry Contract.

If a trial repair area is not specified in the Contract Documents, a location acceptable to the Contract Administrator shall be selected to demonstrate a repair. The selected repair area shall be a minimum of 2 m long by 3.75 m wide and 0.250 m deep.

The ability to fully complete the trial repair area within the time frame of the lane closure specified in the Contract Documents shall be demonstrated. The trial repair shall simulate the Contract site conditions as if it were the last repair of the closure and shall include sampling and testing as specified in the Material Sampling and Testing subsection. The trial repair shall use the same mix design and equipment as will be used in the fast-track concrete repair areas in the work. The trial repair area shall not be overlaid and shall remain exposed for at least 7 Days to permit inspection for deficiencies.

The calibration chart for the mix design strength versus temperature and the calibration chart for the mix design temperature versus time using the autogenous cylinder method shall be verified.

Five cores shall be obtained from the trial repair area as specified in the Coring for 28-Day Compressive Strength and Air Void System Parameter Testing clause. Three cores shall be tested for compressive strength and two cores shall be tested for air void system (AVS) as specified in the Quality Assurance section. The compressive strength and AVS shall meet the requirements of this specification.

Repairs shall not proceed until written permission from the Contract Administrator has been received indicating that all of the above conditions have been met.

366.07.03 Operational Constraints

366.07.03.01 General

The Contract Administrator shall be notified in writing of the intent to repair the concrete pavement or concrete base 7 Days prior to the commencement of the repairs.

Concrete shall not be placed when the air temperature is below 5°C, or is above 30°C. Concrete shall not be placed on or against any material with a surface temperature below 5°C, or above 30°C.

Vehicles shall not be permitted to drive on areas where the concrete pavement or concrete base has been removed, in whole or part.

The concrete pavement or concrete base shall be protected from damage to the surface at all times when steel-tracked equipment is used. Traffic, other than foot traffic and rubber-tired sawing equipment, shall not be permitted on the concrete until it has attained a compressive strength of 20 MPa.

366.07.03.02 Concrete Base Repairs

The Contract Administrator shall be notified 72 hours prior to the asphalt pavement removal. After asphalt pavement removal is complete, the concrete base surface shall be power swept prior to the visual inspection and/or falling weight deflectometer (FWD) testing. Access and any traffic control signing shall be provided to facilitate visual inspection and FWD testing carried out by the Contract Administrator. Equipment which may cause vibrations in the pavement structure shall not be used within 100 m of FWD testing.

366.07.03.03 High Early Strength Concrete Repairs

Repairs to each high early strength concrete repair location shall be completed within the time period specified in the Contract Documents.

If the repair is not progressing at a rate that will permit the opening of traffic within the specified time period, appropriate temporary measures acceptable to the Contract Administrator shall be undertaken to allow opening to traffic. These measures shall be at the Contractor's expense. A high early strength concrete repair shall replace the above temporary work during the next scheduled closure.

366.07.03.04 Fast-Track Concrete Repairs

Fast-track concrete repairs shall not be placed between October 1 and May 1. Fast-track concrete repairs shall not be performed in cold weather conditions. Fast-track concrete repairs shall be full depth.

Repairs to each fast-track concrete repair location shall be completed within the time period specified in the Contract Documents.

If the repair is not progressing at a rate that will permit the opening to traffic within the specified time period, appropriate temporary measures acceptable to the Contract Administrator shall be undertaken to allow opening to traffic. These temporary measures shall be at the Contractor's expense. A fast-track concrete repair shall replace the above temporary work during the next scheduled closure.

366.07.04 Concrete Removal

366.07.04.01 Full Depth Repairs

Full depth repair areas shall be as specified in the Contract Documents or as demarcated by the Contract Administrator. Repairs shall extend the full width of the lane and shall be a minimum of 2 m in length. Partial lane-width repairs shall not be permitted.

The outer limits of the concrete removal area shall be sawcut full depth. Where exposed concrete pavement or concrete base conditions are sufficient to support traffic loading, advanced sawcutting is permitted up to 7 Days in advance of the expected date of removal. Sawcuts shall extend no more than 100 mm into existing adjacent concrete that is to remain in place. Sawcuts in concrete that are to remain in place shall be filled with an epoxy resin acceptable to the Owner.

Concrete removal shall be by a lift-out method rather than breaking in place. Adjoining concrete and underlying base shall remain undisturbed. Heavy breaking equipment such as hoe rams shall not be used in the removal operation.

If during the removal, the underlying material below the concrete pavement or concrete base is disturbed, removed, or damaged, the underlying materials shall be repaired and/or replaced with the same type of underlying material at no additional cost to the Owner.

When the underlying material is OGD, repair and/or replacement shall be according to OPSS 320. For small, localized repair areas, repair using an alternative method to place OGD may be used if accepted by the Owner as part of the concrete removal plan.

When the underlying material is granular, the material requirements shall be according to OPSS 1010. Compaction of the granular materials shall be by means of:

- a) A plate tamper with a minimum mass of 80 kg; or
- b) A self-propelled (walk-behind) single or tandem steel drum with a minimum static mass of 500 kg used in vibration mode.

If during the removal process the adjacent concrete in the lane is damaged or cracked due to the removal procedure, the damaged area shall be cut back full depth to sound concrete and repaired as specified in this specification and as directed by the Contract Administrator. The full area shall be repaired as one continuous placement.

366.07.04.02 Partial Depth Repairs

Partial depth repair areas shall be as specified in the Contract Documents or as demarcated by the Contract Administrator. The perimeter of the repair area shall be sawcut vertically to a depth of 25 mm. The concrete within the sawcut area shall be removed using a chipping hammer to a minimum depth of 50 mm, and to a maximum depth of one-third the thickness of the existing concrete pavement or concrete base, without damaging the underlying sound concrete. Any wire mesh in the concrete shall be removed within the repair area.

If the partial depth concrete removal operation reveals deterioration extending to a depth greater than one-third the thickness of the existing concrete pavement or concrete base, the repair shall be treated as a full depth repair and concrete shall be removed as specified in the Full Depth Repairs clause of the Concrete Removals subsection. A full depth repair shall not proceed without prior approval from the Contract Administrator.

If during the removal process the adjacent concrete in the lane is damaged, the damaged area shall be cut back to sound concrete and repaired according to this specification and as directed by the Contract Administrator. The full area shall be repaired as one continuous placement.

366.07.05 Preparation Work

366.07.05.01 Full Depth Repairs

Prior to placing concrete, the underlying material immediately ahead of the concrete placing operation shall be wetted down thoroughly. The wetting down shall be carried out without leaving standing water.

All standing water shall be removed, and any disturbed underlying material shall be repaired prior to concrete placement operation.

366.07.05.02 Partial Depth Repairs

All concrete surfaces to receive new concrete shall be abrasive blast cleaned according to OPSS 929.

Immediately prior to wetting the concrete surface, all dust and loose material shall be removed from the prepared surface of the repair area by using compressed air.

The surface of the patch to receive new concrete shall be maintained in a wet condition for a period of 1 hour prior to placing any new concrete. Prior to placing concrete, excess water shall be removed from the surface using compressed air.

Immediately prior to filling the repair area with concrete, a thin even coat of bonding agent shall be brushed onto all vertical and horizontal prepared surfaces against which concrete will be placed. After application of the bonding agent, any fine aggregate separated from the mixture or any excess bonding agent shall be removed from the surface of the concrete.

The bonding agent shall be applied within 30 minutes after mixing and shall not be permitted to dry prior to placing any concrete on it. In the event that the bonding agent has dried, it shall be removed and reapplied prior to concrete placement. All bonding agent or concrete deposited in areas other than the intended point of discharge shall be removed immediately.

366.07.06 Joints for Full Depth Repairs

366.07.06.01 General

The locations and the type of joints for concrete pavement and concrete base shall be as specified in the Contract Documents. Possible joint types specified may include construction, transverse, longitudinal, and expansion joints. All joints shall be cut or formed to the joint details specified in the Contract Documents.

A reservoir cut and sealant are not required for concrete base.

Where the operation requires a staged repair, a construction joint shall be placed between stages.

366.07.06.02 Installation of Dowel Bars and Tie Bars

366.07.06.02.01 General

The protection of dowel and tie bars shall be according to OPSS 350. Prior to installation of dowel bars and tie bars or placement of concrete, bars which are loose, broken, cracked or otherwise damaged shall be removed and replaced according to OPSS 350.

Dowel bars and tie bars shall be installed at locations specified in the Contract Documents.

Prior to the installation of dowel bars and tie bars, the existing concrete pavement and concrete base thickness shall be verified for each repair location to determine the mid-depth location for each dowel bar and tie bar.

Gang drills shall be used to drill holes in the existing concrete for insertion of the dowel bars and tie bars according to the following:

- a) Holes for dowel bars and tie bars shall be drilled mid-depth in the existing concrete. The mid-depth location of each dowel bar and tie bar shall be based on the actual measured thickness of the existing concrete.
- b) Where steel reinforcement is present in the existing concrete, tie bars and dowel bars may be adjusted ± 25 mm horizontally and ± 10 mm vertically, to avoid drilling through the steel reinforcement.
- c) The diameter of the drill hole shall be no more than 5 mm larger than the diameter of the dowels or tie bars.
- d) If during the drilling process the existing concrete is cracked due to the drilling procedure, the cracked area shall be cut back full depth to sound concrete.

Prior to filling the drill holes, the inside surfaces of each drill hole shall be wire brushed and then cleaned using compressed air. The dowel bars and tie bars shall be secured into the existing concrete with epoxy adhesive. The epoxy adhesive shall be injected into the back of the cleaned drill hole and the dowel or tie bar, with grout retention disks attached, shall be inserted to completely encase the bars with epoxy adhesive for the full depth of the hole.

Dowel bars and tie bars shall be installed and secured in a manner that will ensure they remain in the proper position and orientation during the concreting operation.

The epoxy adhesive shall be fully cured prior to placing concrete. Immediately prior to placing concrete, the free end of the dowel bars (not tie bars) and the exposed vertical concrete face along the transverse joint shall be treated with a bond breaker.

Where tie bars are not specified, the exposed vertical concrete face along the longitudinal joint shall be treated with a bond breaker.

Holes that have been started but not completed shall be cleaned and filled with a proprietary patching material.

366.07.06.02.02 Installation Tolerances

The dowel bars shall be placed mid-depth of the concrete pavement or concrete base thickness and parallel to the longitudinal axis (horizontal alignment) and the horizontal plane (vertical alignment) of the concrete pavement or concrete base within the following tolerances:

- a) Vertical alignment: ± 15 mm along the length of the dowel bar.
- b) Horizontal alignment: ± 15 mm along the length of the dowel bar.
- c) Longitudinal side shift: The centre of the dowel bar shall lie within ± 50 mm from the transverse joint.
- d) Depth:
 - i. For a concrete pavement or concrete base thickness of less than 215 mm: mid-depth ± 6 mm.
 - ii. For a concrete pavement or concrete base thickness from 215 to 229 mm: mid-depth $+15$ / -12 mm.
 - iii. For a concrete pavement or concrete base thickness of 230 mm or greater: mid-depth $+25$ / -15 mm.

The tie bars shall be installed within a tolerance of ± 15 mm from mid-depth of the concrete pavement or concrete base thickness. Tie bars shall not be placed within 600 mm of a transverse joint.

366.07.06.03 Transverse Joints

Transverse joints shall be cut or formed to the joint details specified in the Contract Documents and skewed if required. Joints shall have a minimum spacing of 2 m and a maximum spacing of 4 m.

Expansion joints shall be placed where specified in the Contract Documents and when replacing existing expansion joints.

366.07.06.04 Mid-Lane Longitudinal Joints for Fast-Track Concrete Repairs

In repair areas where the transverse joint spacing is 3 m or less in length, a longitudinal joint shall be created in the middle of the lane and for the full length of the repair.

Tie bars shall be placed at mid-depth of the concrete pavement or concrete base along the full length of the longitudinal joint. The tie bars shall be 25M deformed bars and shall be 760 mm in length. These bars shall be spaced every 400 mm and shall not be placed within 400 mm of a transverse joint.

Tie bars shall be installed and secured so that they remain in the proper position and orientation during the concreting operation.

366.07.06.05 Sawcutting, Cleaning and Sealing of Joints

Sawcutting, cleaning and sealing of joints shall be according to OPSS 369 with the following addition:

For fast-track concrete repairs, equipment specifically designed for dry-cut joint sawing shall be used and the sawing shall be carried out within 2 hours of final finishing. In lieu of sawcutting, the joint may be formed to a minimum depth of one-third the pavement thickness when the concrete is in the plastic state.

366.07.07 Production of Concrete

Production of concrete shall be according to the General, Temperature Control, Mixing Time and Mixing Rate, and Delivery subsections in OPSS 1350.

366.07.08 Placing of Concrete

Prior to placing concrete, the Contract Administrator may request a demonstration of the equipment.

Delivery of concrete shall be according to OPSS 1350.

Placing of concrete in the repair areas shall be according to the Placing of Concrete subsection of OPSS 350 with the following additions:

- a) Concrete shall be placed in such a way as to avoid disturbing or displacing tie bars, dowel bars or load transfer devices.
- b) When an interruption of more than 45 minutes occurs during placing of full depth repairs using conventional concrete, or 20 minutes for high early strength concrete or 5 minutes for fast-track concrete repairs, a transverse construction joint shall be formed. Notwithstanding the time limits, there shall be no delays which will result in a cold joint. Concrete placed in the areas between the newly formed joint and the previous joint is subject to removal and replacement at no additional cost to the Owner if the Contract Administrator deems it necessary.
- c) For high early strength concrete and fast-track concrete repairs, the use of insulation to retain heat is permitted.

366.07.09 Consolidating

Concrete shall be thoroughly consolidated against and along the face of all forms of existing concrete and into the face of previously placed concrete. The vibrators shall not come in contact with the base, subbase, subgrade, underlying material, forms, tie bars, dowel bars or load transfer devices.

For fixed-form placement, hand-held vibrators shall be used to supplement consolidation adjacent to and along the full length of the form. They shall also be inserted at regularly spaced intervals along both sides of load transfer devices, when used.

366.07.10 Concrete Finishing

No water or other chemical agents shall be applied to the concrete surface or finishing tools to aid in the finishing.

The concrete edge adjacent to fixed forms or existing concrete pavement or concrete base shall be finished using an edging tool prior to texturing. The edging tool shall have a radius of not more than 6 mm. The finished concrete pavement or concrete base edge shall be left smooth, true to line and grade.

366.07.11 Texturing of Pavement Surface

The plastic surface of the concrete pavement and concrete base shall receive an initial texturing immediately after finishing and before the application of curing on the concrete. The initial texturing shall be performed by dragging burlap longitudinally to produce a uniform textured surface. The burlap shall be kept in a clean condition and free from tears and encrusted mortar. It shall be kept damp but shall not add excessive water to the concrete surface.

Concrete pavement shall receive a final texturing by tining, unless otherwise specified. Tining shall meet the following requirements:

- a) The tine orientation (i.e., transverse or longitudinal) of the repair shall match that of the surrounding pavement.
- b) Tines shall be 3 mm $\pm$ 1 mm wide on 16 mm $\pm$ 3 mm centres with a tine depth of 4 mm $\pm$ 1 mm.
- c) Tines shall be straight and run parallel to the transverse or longitudinal axis of the concrete pavement.
- d) Tining shall not extend within 75 mm $\pm$ 15 mm of the concrete pavement edge. The surface of the concrete shall be free in all cases from displaced aggregate particles and local projections.

Tining is not required on concrete base unless it will be exposed to traffic during staging. Tining is not required on concrete pavement when diamond grinding and grooving of the concrete surface is specified in the Contract Documents, unless it will be exposed to traffic prior to grooving.

366.07.12 Curing

Curing shall be applied within 15 minutes of placing concrete and immediately following texturing.

The curing period shall be a minimum of 7 Days for concrete cured with curing compound and for concrete subject to cold weather. For all other types of curing, the curing period shall be a minimum of 4 Days.

For high early strength and fast-track concrete repairs, only curing compound shall be used for curing and may remain in place following the 7 Day curing requirement.

For conventional concrete repairs, concrete shall be cured using one of the following methods, according to the applicable clauses in OPSS 904:

- a) Curing with Curing Compound; or
- b) Curing with Burlap and Water, except when the air temperature is below 0°C, curing shall be according to the Curing with Moisture Vapour Barrier clause in OPSS 904.

When curing compound is used, it shall not be applied to joint faces against which joint sealing compound is to be placed or to concrete surfaces to which concrete is to be bonded.

Curing compound used on the surface of a concrete base shall be removed completely prior to the application of tack coat and overlaying with asphalt pavement. The method of removal shall be by abrasive blasting

according to OPSS 929 and it shall not result in any damage to the concrete surface. The removal process shall meet all environmental constraints specified in the Contract Documents.

366.07.13 Retaining Heat for High Early Strength Concrete and Fast-track Concrete Repairs

Insulating blankets or protection systems of any type may be used for retaining heat to accelerate the strength gain of high early strength and fast-track concrete repairs. Insulating blankets used for the purpose of accelerating strength gain for high early strength concrete and fast-track concrete repairs are not required to meet the requirements for cold weather protection of other types of concrete.

366.07.14 Cold Weather Protection - Conventional and High Early Strength Concrete Repairs

366.07.14.01 General

The temperature of the concrete during cold weather shall be monitored and controlled for a period of 7 Days to ensure that the concrete temperature does not fall below 15°C for the first 3 Days of curing and 10°C for the subsequent 4 Days. The monitoring shall commence at the start of the concrete placing operation.

The cold weather protection system shall be designed for the worst conditions that can be reasonably anticipated from local weather records, forecasts, site conditions, and past experience for the time period during which the protection is required. For cold weather conditions, concrete shall be protected according to the Concrete Subject to Cold Weather clause in OPSS 904. The conditions shall be monitored, and the protection system modified as required.

Cold weather protection may be removed for sawcutting of joints; however, when removed, no concrete shall be left unprotected for more than 1 hour and no more than 25 linear metres of concrete shall be exposed at any one time.

366.07.14.02 Monitoring and Control of Temperature

During cold weather, monitoring and control of the concrete and ambient air temperature shall be recorded and submitted to the Contract Administrator. The monitoring shall commence when the concrete is placed.

For each Day's placement of concrete, thermocouples or sensors shall be embedded within 5 mm of the concrete surface in a minimum of four locations distributed throughout the repair areas, as directed by the Contract Administrator. At least one additional thermocouple or sensor shall be installed to measure ambient air temperature above the surface of the concrete and outside of the specified cold weather protection.

The recording of concrete temperatures shall begin at the start of concrete placement. The temperature shall be recorded automatically at intervals no greater than 15 minutes. The thermocouples and instrumentation shall be left in place and temperatures recorded until the end of the temperature monitoring period.

Concrete and ambient air temperature readings shall be monitored and verified on site every 6 hours or more frequently as required for the first 3 Days, and every 12 hours or more frequently as required for the remainder of the monitoring period. Temperature verification shall be carried out in person at each concrete repair location. All necessary action shall be taken to maintain the temperature within the specified limits.

The Contract Administrator shall be provided physical and digital access to verify temperature readings.

366.07.14.03 Submission of Temperature Records

At the end of each Day during the temperature monitoring period, datalogger temperature records for all of the thermocouples and sensors and a record of any actions taken to maintain control of temperature shall be submitted to the Contract Administrator. At the end of the temperature monitoring period, the complete temperature record for all thermocouples and sensors, including graphical plot of temperature versus time, shall be submitted to the Contract Administrator.

366.07.15 Surface Tolerance

The surface of the concrete repair shall join flush with the existing concrete pavement or concrete base.

The surface of the concrete pavement shall be such that when tested with a 3 m long straightedge placed in any location and direction, including the edge of pavement and joints, 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 concrete. For concrete base, the tolerance over a 3 m straightedge shall be a maximum of 6 mm.

Use of diamond grinding to meet the above requirements shall require the prior approval of the Contract Administrator. The maximum depth of concrete removed by diamond grinding shall not exceed 10 mm.

366.07.16 Material Sampling and Testing

366.07.16.01 Slump, Air Content and Temperature

Plastic concrete sampling, testing, acceptance, field adjustments, visual acceptance, and submission of plastic concrete test results shall be according to the Material Sampling and Testing subsection of OPSS 1350, with the following exceptions and additions:

- a) Testing of plastic air content is not required for fast-track concrete repairs.
- b) The minimum frequency of testing slump and concrete temperature shall be once for each load of concrete.
- c) For fast-track concrete repairs, if the slump exceeds the maximum allowable slump of 230 mm, the load of concrete shall be rejected. Re-testing slump of fast-track concrete is not permitted.

366.07.16.02 Coring for 28-Day Compressive Strength and Air Void System Parameter Testing

For all concrete pavement and concrete base repairs including fast-track concrete repairs, cores shall be removed from the hardened concrete for acceptance testing by the Owner. Coring shall be carried out when the concrete is 7 to 10 Days of age.

Concrete shall be sampled on a lot basis as specified the Quality Assurance section of this specification. For each lot, a total of five cores shall be obtained. Cores shall be taken at random locations specified by the Contract Administrator. Four cores shall be taken from one repair area in the lot within 1 m of one another; three for 28-Day compressive strength testing, and one for AVS testing. A single core shall be taken from another repair area within the lot for AVS testing. Cores shall be 100 mm diameter and full depth.

Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain steel reinforcement or other embedded material. A covermeter shall be used to establish the location of steel reinforcement and other embedded material prior to coring. No core shall be taken within 500 mm of any joint or repair area edge.

The Contract number, lot number, repair area identification information, component type (concrete pavement or concrete base), and date of concrete placement and extraction shall be marked legibly on each core with durable ink immediately after removal.

Each core shall be placed in a plastic bag and sealed to prevent loss of moisture, before they are placed in a security bag in the presence of the Contract Administrator. The cores, a transmittal form, and the MTO form PH-CC-433-A, Concrete Mix Design Submission Form A, of the concrete mix design for the concrete pavement or concrete base shall all be submitted to the Contract Administrator. Core holes shall be filled according to OPSS 1350.

366.07.16.03 Early Strength Determination for Conventional Concrete Repairs

For conventional concrete repairs, the Contractor may elect to take cores for early strength determination in addition to the cores required for determination of 28-Day compressive strength. In order to demonstrate that

the pavement has achieved sufficient strength for loading of construction vehicles or traffic, one set of three cores shall be taken for each Day's placement, from the last repair placed during that Day. Cores shall be 100 mm diameter and full depth. All cores of the same set shall be removed at a location no more than 1 m from the location of the first core for that set.

When the Contractor elects to take cores for early strength determination, core removal and handling shall be carried out as specified the Coring for 28-Day Compressive Strength and Air Void System Parameter Testing clause.

The Contract Administrator shall be provided with 1 Business Day advance notice to arrange testing by the designated quality assurance laboratory.

Core holes shall be filled according to OPSS 1350.

366.07.16.04 Early Strength Determination for High Early Strength Repairs

Concrete cylinders shall be used to determine compressive strength of high early strength repairs for the purposes of opening to traffic. The Contractor is responsible for the timing and frequency of testing of the cylinders and shall determine when the concrete pavement or concrete base has attained a minimum compressive strength of 20 MPa.

A minimum of three sets of three test cylinders shall be cast from the final repair area of the closure. The cylinders shall be 100 mm in diameter and 200 mm long.

Concrete cylinders for early strength determination shall be cast and transported according to CSA A23.2-3C. Curing of cylinders for early strength determination shall consist of storing the cylinders as near as possible to the repair that they represent. The cylinders shall receive the same protection from the elements on all surfaces as is given to the high early strength repair that they represent. The Contractor shall identify the testing time for the cylinders and provide the Contract Administrator with at least 1 Business Day's advance notice. The Contractor shall deliver cylinders for early strength determination to the designated laboratory immediately prior to the time of testing.

Compressive strength testing shall be carried out according to CSA A23.2-9C by the Owner to verify that the concrete in the repair area has attained a minimum compressive strength of 20 MPa.

The repair area shall not be opened to traffic until a set of cylinders has attained an average compressive strength of 20 MPa or greater.

366.07.16.05 Early Strength Determination for Fast-Track Concrete Repairs

The autogenous cylinder method shall be used to determine compressive strength of fast-track concrete repairs for purposes of opening to traffic. The Contractor is responsible for the timing and frequency of testing of the autogenous cylinders and shall determine when the concrete pavement or concrete base has attained a minimum compressive strength of 20 MPa.

A minimum of three sets of two autogenous test cylinders shall be cast for the final repair area of each lane closure according to CSA A23.2-3C. The cylinders shall be 150 mm in diameter and 300 mm long. Compressive strength testing of autogenous cylinders shall be carried out according to CSA A23.2-9C by the Contractor to verify that the concrete in the repair area has attained a minimum compressive strength of 20 MPa. The testing shall be performed at a laboratory certified as a concrete testing laboratory by the Canadian Council of Independent Laboratories (CCIL) that has successfully participated in the MTO correlation program. The concrete compressive strength specimen shall be tested to complete failure. These test results shall be communicated immediately to the Contract Administrator, prior to re-opening to traffic.

The compressive strength of the concrete in the repair area shall be based on the following procedure:

- a) Install thermocouple or sensors at a minimum of two test locations in the final full depth repair area for each lane closure. The thermocouple or sensors shall be embedded within 5 mm of the concrete surface

and at the edge of the repair area. Thermocouple or sensors shall also be embedded in each of the autogenous cylinders.

- b) Monitor and record the temperature of the repaired slab and autogenous cylinders a minimum of once every 15 minutes.
- c) Autogenous test cylinders shall be tested in pairs for compressive strength at time intervals determined by the Contractor, until a compressive strength of 20 MPa or greater is obtained. The repaired slab shall not be opened to traffic until the slab temperature has reached at least the same temperature as the cylinders which attained a compressive strength of 20 MPa or greater.

The Contract Administrator shall be provided physical and digital access to verify temperature readings. If the datalogger does not have a digital display for verifying the temperature, the Contract Administrator shall be provided with the necessary instruments to verify thermocouple function and readings.

A record of the temperatures of the repaired slab and autogenous cylinders, and the compressive strength test results shall be submitted to the Contract Administrator for each lane closure.

366.07.17 Unacceptable Repair Areas

Concrete found to be unacceptable shall be removed and replaced with new concrete meeting the requirements specified in the Contract Documents.

The area to be removed shall extend to the nearest transverse joint and longitudinal joint or edge outside the deficient area so that there are no additional joints.

Concrete which does not meet the surface tolerance may be repaired by diamond grinding in lieu of removal and replacement, subject to approval by the Owner.

366.07.18 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

366.08 QUALITY ASSURANCE

366.08.01 Acceptance of Concrete Pavement and Concrete Base Repairs

Concrete pavement and concrete base repairs shall be acceptable if the requirements of this specification are met, including:

- a) Compressive strength prior to opening to traffic.
- b) 28-Day compressive strength.
- c) AVS in hardened concrete.
- d) FWD test results indicating a load transfer efficiency of greater than or equal to 70%.
- e) Surface tolerance.
- f) Defects listed in the Defects subsection of this specification are not present in the work.

366.08.02 Lot Size for 28-Day Compressive Strength and Air Void System Acceptance Testing

Concrete shall be accepted on a lot basis. A lot shall consist of up to 400 m² of each type of repair of the same concrete mix design. Conventional concrete repairs, high early strength concrete repairs and fast-track

concrete repairs shall be treated as separate lots. Partial depth and full depth repairs shall be treated as separate lots.

For each lot, one set of three cores shall be tested for 28-Day compressive strength and two cores shall be tested for AVS.

366.08.03 Acceptance of 28-Day Compressive Strength

366.08.03.01 General

One set of three core samples per lot shall be tested to determine the acceptability of 28-Day compressive strength of the lot. Compressive strength shall be determined according to LS-410. The 28-Day compressive strength result of a lot shall be the average of the set of the three acceptance cores, rounded to one decimal place.

28-Day compressive strength of a lot shall be considered acceptable when:

- a) The average 28-Day compressive strength of the set of three cores is equal to or greater than the specified strength; and
- b) No individual core result is more than 10% below the specified strength.

Unacceptable lots shall be rejected. Concrete from unacceptable lots shall be removed and replaced.

Individual test results shall be forwarded to the Contractor as they become available.

366.08.03.02 Referee Testing

366.08.03.02.01 General

Referee testing for 28-Day compressive strength shall be according to OPSS 1350, except that referee testing shall be carried out on a new set of cores removed within 24 hours of invoking the referee testing. A set of referee cores for 28-Day compressive strength shall consist of three individual cores and shall be taken from the same repair area from which acceptance samples were obtained in the presence of the Contract Administrator. The core size and core extraction shall be according to the Coring for 28-Day Compressive Strength and Air Void System Parameter Testing clause.

All cores of the same set shall be removed at a location no more than 1 m from the location of the first core for that set.

Coring shall be carried out according to CSA A23.2-14C. No core shall be taken within 500 mm of any joint or repair area edge. The Contractor shall use a covermeter to establish the location of steel reinforcement and other embedded material prior to coring. Cores shall not contain steel reinforcement or other embedded material.

The Contract number, lot number and repair area identification information shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag and sealed to prevent loss of moisture.

The Contractor shall fill the core holes according to OPSS 1350.

366.08.03.02.02 Referee Testing Cost

The cost of referee testing of 28-Day compressive strength shall be as specified in the Contract Documents.

When the referee results indicate that the refereed lot is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed lot is not acceptable, the Contractor shall be charged the cost of the 28-Day compressive strength referee testing.

366.08.04 Acceptance of Air Void System in Hardened Concrete

366.08.04.01 General

One half of each core shall be tested according to LS-432 to determine the acceptability of concrete AVS of the lot. The other half of each core shall be retained by the Owner for audit purposes.

For a lot to be considered acceptable, the cores shall have an air content of 3.0% or more and a spacing factor of 0.230 mm or less.

An unacceptable lot is a lot represented by one or two cores that fail to meet the AVS parameters.

Unacceptable lots shall be rejected. Concrete from unacceptable lots shall be removed and replaced.

Individual test results shall be forwarded to the Contractor as they become available.

366.08.04.02 Referee Testing

366.08.04.02.01 General

Referee testing of AVS parameters may only be invoked by the Contractor within 3 Business Days of receiving the test result.

When referee testing is invoked, all core samples representing a lot shall be referee tested and the acceptance test results discarded. The lot referee test results shall replace the acceptance test result in the acceptance requirements of this specification.

Referee testing shall be carried out on the same half of the core sample that was tested for acceptance.

Cores shall be tested according to LS-432. Referee test results shall be forwarded to the Contractor as they become available.

366.08.04.02.02 Referee Testing Cost

The cost of AVS referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed lot is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed lot is not acceptable, the Contractor shall be charged the cost of the AVS referee testing.

366.08.05 Falling Weight Deflectometer Acceptance Testing

366.08.05.01 General

The Contract Administrator shall be notified in writing when the repaired concrete section condition is sufficient to support traffic loading. The work shall be made available for FWD testing by the Owner. Equipment which may cause vibrations in the pavement structure shall not be used within 100 m of FWD testing.

The Contract Administrator shall determine the load transfer efficiency across all transverse joints of the full depth concrete repair area by carrying out FWD testing. FWD testing, equipment calibration, and reporting shall be according to LS-449. The location of the FWD loading plate and first sensor for each test shall be marked by the Contract Administrator.

The new joint shall be acceptable if the FWD test results for both the approach and leave slabs indicate load transfer efficiency of 70% or greater. The new joint with a load transfer efficiency less than 70% shall be removed and replaced full depth and full lane width as specified in the Contract Documents.

366.08.05.02 Referee Testing

FWD referee testing may only be invoked by the Contractor within 3 Business Days of receiving the test result. Referee testing shall be according to LS-449. The referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The FWD loading plate and first sensor shall be placed in the same location with the same sensor arrangement marked for acceptance test.

Referee test results shall be forwarded to the Contractor, as they become available.

366.08.05.03 Referee Testing Cost

When the referee results indicate that the refereed joint is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed joint is not acceptable, the Contractor shall bear the cost of the FWD referee testing of the joint and the full mobilization fee.

366.08.06 Acceptance of Surface Tolerance

Each repair area shall meet the requirements of the Surface Tolerance subsection of this specification. Repair areas that do not meet the surface tolerance requirements of this specification shall be considered unacceptable and shall be repaired as specified this specification or removed and replaced.

366.08.07 Defects

Concrete repair areas are unacceptable if they contain any of the following defects:

- a) Concrete with any visible surface cracks in the repair, unless the Contractor demonstrates, at no cost to the Owner, that the depth of the crack is less than 10 mm.
- b) Concrete with honeycombing or other deficiencies detected visually.
- c) Partial depth repairs with debonding identified by sounding.
- d) Dowel bars and tie bars not meeting the requirements of this specification.

Unacceptable repairs shall be removed and replaced.

366.09 MEASUREMENT FOR PAYMENT

366.09.01 Actual Measurement

366.09.01.01 Conventional Concrete Repair (Full Depth) Conventional Concrete Repair (Partial Depth) High Early Strength Concrete Repair (Full Depth) High Early Strength Concrete Repair (Partial Depth) Fast-Track Concrete Repair

Measurement of conventional concrete repair, high early strength concrete repair, and fast-track concrete repair shall be by the area of the repair in square metres. Each repair area shall be measured to the nearest 0.1 m².

366.09.02 Plan Quantity Measurement

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

366.10 BASIS OF PAYMENT

366.10.01

Conventional Concrete Repair (Full Depth) - Item
Conventional Concrete Repair (Partial Depth) - Item
High Early Strength Concrete Repair (Full Depth) - Item
High Early Strength Concrete Repair (Partial Depth) - Item
Fast-Track Concrete Repair - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material required to do the Work.

TABLE 1
Nominal Maximum Size of Coarse Aggregate

Concrete Repair Depth	Nominal Maximum Size of Coarse Aggregate
Partial Depth	19.0 mm
Full Depth	19.0 mm or combined gradation of nominal maximum aggregate size of 37.5 mm and 19.0 mm