



CONSTRUCTION SPECIFICATION FOR CONCRETE PAVEMENT AND CONCRETE BASE

TABLE OF CONTENTS

350.01	SCOPE
350.02	REFERENCES
350.03	DEFINITIONS
350.04	DESIGN AND SUBMISSION REQUIREMENTS
350.05	MATERIALS
350.06	EQUIPMENT
350.07	CONSTRUCTION
350.08	QUALITY ASSURANCE
350.09	MEASUREMENT FOR PAYMENT
350.10	BASIS OF PAYMENT

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 366	Repairing Concrete Pavement and Concrete Base
<u>OPSS 369</u>	<u>Sealing or Resealing of Joints and Cracks in Concrete Pavement and Concrete Base</u>
OPSS 904	Concrete Structures
OPSS 919	Formwork and Falsework
OPSS 929	Abrasive Blast Cleaning - Concrete Construction

Ontario Provincial Standard Specifications, Material

OPSS 1212	Hot Poured Rubberized Asphalt Joint Sealing Compound
<u>OPSS 1302</u>	<u>Water</u>
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 Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM) Manual

MTO Laboratory Testing Manual:

LS-100 Method of Rounding-off Data and Other Numbers
LS-101 Procedures for Calculating Percent within Limits
LS-296 Method of Test for Calibrating, Correlating, and Conducting Surface Smoothness Measurements Using an Inertial Profiler
LS-410 Method of Test for Compressive Strength of Concrete Cores
LS-432 Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-433 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
LS-450 Method of Test for Determination of Concrete Pavement Thickness Using Drilled Core Specimens

MTO Forms:

PH-CC-433A Concrete Mix Submission Form A

CSA Standards

A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*
* [Part of A23.1-1419/A23.2-19 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

ASTM International

C171-16-20 Sheet Materials for Curing Concrete
E3013/E3013M-17-22 Evaluating Concrete Pavement Dowel Bar Alignment Using Magnetic Pulse Induction

Other

Environmental Protection Act, R.S.O 1990

350.03 DEFINITIONS

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

Concrete Base means a rigid pavement structure, which is overlaid with asphaltic concrete, and ~~may include~~ includes concrete shoulders when present.

Concrete Pavement means a rigid pavement structure with an exposed concrete surface, and ~~may include~~ includes concrete shoulders when present.

Cold Weather means those conditions when the ambient air temperature is at or below 5 °C. -It is also considered to exist when the ambient air temperature is at or is likely to fall below 5 °C within 96 hours after completion of concrete placement. -Temperature refers to shade temperature.

Effluent means liquid waste that is a direct result of concrete grinding ~~and~~, grooving ~~and~~ sawcutting. Effluent includes any stormwater, or surface drainage that becomes mixed with this material. ~~Effluent is classified as liquid industrial waste Class 146(L).~~

Environmental Compliance Approval (ECA) means as interpreted by Section 2.1 of the Ontario Environmental Protection Act.

Grout Retention Disk means a plastic disk that provides a barrier that prevents dowel adhesive from escaping from a dowel hole or tie bar hole before it has hardened.

Horizontal Alignment means the deviation of the dowel bar from true parallel alignment from the edge of the concrete pavement or concrete base, measured over the entire length of the dowel bar.

Horizontal Side Shift means the location of the dowel bar relative to the planned location from the concrete pavement or concrete base edge, nearest longitudinal joint, or nearest parallel dowel bar.

Hot Weather means those conditions when the ambient air temperature is at or above ~~28°C~~ 28 °C. It is also considered to exist when the ambient air temperature is at or is likely to rise above ~~28°C~~ 28 °C within 24 hours after concrete placement. - Temperature refers to shade temperature.

International Roughness Index (IRI) means a specific mathematical transform of a true profile in which a low pass filter (usually consisting of a moving average with a 250 mm base length) followed by a “Quarter Car Filter” are applied to the true profile then the absolute values of the vertical vibration of the “Quarter Car Filter” are accumulated and divided by the subplot length. -It is expressed in units of m/km.

Load Transfer Device means a metal support, or dowel basket, that holds a dowel in place ahead of paving operations.

Longitudinal Side Shift means the longitudinal translation of the dowel bar relative to its planned location perpendicular to the concrete pavement or concrete base edge.

~~MIT Scan~~ **MPI Device** means a magnetic ~~imaging tool~~ pulse induction (MPI) equipment meeting the requirements of ASTM E3013 and specifically developed for measuring dowel bar position and ~~tie bar~~ alignment in concrete pavements and concrete bases.

Mean Roughness Index (MRI) means the number calculated by averaging the IRI values from the two ~~–~~ wheel path profiles.

Percent ~~within~~ Within Limits (PWL) means an estimate of the percentage of the lot population that is within the specified limits, determined by using the mean and standard deviation of the lot according to LS-101.

~~Slab means a strip of concrete laid as a single un-jointed piece.~~

Vertical Alignment means the deviation of the dowel bar from true parallel alignment from the surface of the concrete pavement or concrete base, measured over the entire length of the dowel bar.

350.04 DESIGN AND SUBMISSION REQUIREMENTS

350.04.01 Design Requirements

350.04.01.01 Concrete Mix Designs

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

350.04.02 Submission Requirements

350.04.02.01 Concrete Mix Design

Concrete mix design(s) submissions shall be according to OPSS 1350.

350.04.02.02 Curing Compound

Curing compound submissions shall be according to OPSS 904.

350.04.02.03 Temperature Control Plans

350.04.02.03.01 Cold Weather

A temperature control plan ~~shall be submitted~~ according to the Temperature Control Plans clause of OPSS 904 ~~shall be submitted~~ for concrete paving operations that require curing during cold weather.

350.04.02.03.02 Hot Weather

For concrete paving operations subject to hot weather, a description of the methods to be used to control the temperatures of the concrete and underlying base shall be submitted to the Contract Administrator ~~seven~~ 7 Days prior to placement.

350.04.02.04 Temperature Records

For concrete paving operations that require curing during cold weather, temperature records shall be submitted according to the Submission of Temperature Records clause of OPSS 904.

350.04.02.05 Effluent Management

~~When operations will result in effluent from concrete grinding and grooving, a~~ written agreement from the operator of the receiving site or property owner selected to accept the effluent, shall be submitted to the Contract Administrator a minimum of 14 Days prior to commencement of the effluent producing work.

At the completion of the work, a copy of a release signed by the same receiving site operator or property owner shall be submitted to the Contract Administrator.

A copy of the Contractor's ~~Environmental Compliance Approval~~ ECA for a Waste Management System shall be submitted to the Contract Administrator prior to the commencement of ~~the any work that will generate~~ effluent ~~producing work.~~

350.05 MATERIALS

350.05.01 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, except for dowels which are installed into existing concrete.

350.05.02 Burlap

Burlap shall be according to OPSS 1306.

350.05.03 Concrete

Concrete and concrete materials shall be according to ~~the Materials section of~~ OPSS 1350 with the exception that the maximum allowable proportion by mass of the total cementing material for slag shall be 30%.

The minimum specified ~~28-day~~Day compressive strength shall be 35 MPa.

350.05.02 ~~Bond Breaker for Dowel Bars and Load Transfer Devices~~

~~RC 250, Tectyl 506 or an Owner approved equivalent~~03 Burlap

350.05.04 Curing Compound

Curing compound shall be according to OPSS 1315.

350.05.05 Epoxy Adhesives

Epoxy resins ~~dowel~~ adhesives used for dowel and tie bars shall be ~~from~~ the type MTO DSM approved for horizontal ~~dowel~~ applications and mixed in the nozzle (cartridge). ~~Epoxy adhesive shall be from the ministry's DSM list.~~ Cementitious grouts shall not be permitted for this application.

350.05.06 Expansion Joint Filler

Expansion joint filler shall be according to OPSS 1308.

350.05.07 Forms

Forms shall be according to OPSS 919.

350.05.08 ~~Joint Sealing Compound~~

~~Hot poured rubberized asphalt joint sealing compound shall be according to OPSS 1212 and shall be one of the joint sealing compounds on the ministry's DSM list.~~

350.05.09 Moisture Vapour Barrier

The ~~material~~moisture vapour barrier shall be a white opaque polyethylene film according to ASTM C171 and at least 100 µm thick.

350.05.1009 Proprietary Patching Materials

Proprietary patching materials shall be from the Owner's list of acceptable concrete patching materials. -The list of proprietary patching materials may be obtained from the Contract Administrator.

350.05.1110 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.

350.05.1211 Water

Water used for curing and pre-soaking of burlap shall be according to OPSS ~~1350~~1302.

350.06 EQUIPMENT

350.06.01 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.

350.06.02 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.

350.06.0203 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 have 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 repair area.

350.06.04 Effluent Collection Systems

The diamond grinding and grooving machines 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. Effluent shall not be permitted to encroach into open lanes, enter into closed drainage systems or surrounding areas.

350.06.05 Gang Drill

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

350.06.06 Grooving Machines

Grooving machines shall have circular diamond-tipped blades, mounted on a multi-blade arbor, and shall be self-propelled and specifically designed to groove concrete pavement. The grooving machine shall have a depth control device capable of detecting variations in the concrete pavement surface and automatically adjust the cutting head height to maintain the specified groove depth. The grooving machine shall have alignment control devices.

At the beginning of each work shift, all grooving machines shall be equipped with a full complement of grooving blades capable of cutting grooves of the specified width, depth, and spacing.

350.06.0307 Hand Finishing Equipment

Floats used to finish concrete shall be made of magnesium or wood.

350.06.0408 Saw Cutting Equipment

The saw cutting equipment shall be self-propelled, guided, and capable of saw cutting the joints to the dimensions ~~as~~ specified in the Contract Documents. - The saw cutting equipment shall be capable of cutting the joints without causing spalling or damage to the adjacent concrete.

The saw cutting equipment for longitudinal joints shall have guided wheels, which run along each longitudinal vertical face of the concrete pavement or concrete base.

The saw shall be equipped with a diamond blade.

350.06.0509 Slip-Form Paving Equipment with Automatic Dowel Bar Inserter (DBI)

When ~~an automatic dowel bar inserter~~ a DBI is used, the equipment shall be capable of:

- a) Controlling insertion of the dowel bars and tie bars to achieve the required depth, alignment and spacing-;

b) Automatically marking the centre of the dowel bars for the joint cutting operation, by applying a mark adjacent to the concrete on both sides of the slip-form paver using spray paint or other permanent and visible marking; and

c) Consolidating the concrete around the automatically-inserted dowel bars; and tie bars.

~~350.06.06 The grooving machine shall have a depth control device capable of detecting variations in the pavement surface and automatically adjusting the cutting head height to maintain the specified groove depth and spacing.~~

10 07 Straight Edge

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

350.06.0811 Thermocouples and Dataloggers

Thermocouples and associated instrumentation shall ~~have:~~

a) Have a combined accuracy of ± 1.5 °C;

b) ~~shall record~~ Record temperatures at hourly intervals or less; ~~and shall display~~

c) Display the temperature.

~~350.06.09 Residue shall not be permitted to encroach into open lanes or enter into closed drainage systems.~~

06.10 Heating Kettle for Joint Sealing Compound

~~The heating kettle shall be a double boiler, oil jacketed kettle, equipped with mechanical agitator and separate thermometers for the oil bath and the melting vat. The heating kettle shall be designed and operated in such a way that uniform, indirect heat is provided and overheating of the joint sealing compound is prevented.~~

350.06.11 Hot Compressed Air Lance

~~The hot compressed air lance shall have an oil free discharge of air at a temperature greater than 200 °C and less than 500 °C and an air velocity greater than 1,000 m per second.~~

12 Air Compressor

~~The air compressor used to supply the hot compressed air lance shall be equipped with oil and moisture filters and providing a minimum pressure of 700 kPa at a minimum air volume of 4.25 cubic metres per min (150 cfm).~~ **06.13**

350.07 CONSTRUCTION

350.07.01 General

~~The Contract Administrator shall be notified in writing of the intent to place the~~ The concrete pavement ~~or concrete base seven Days prior to the commencement of the concrete paving operation.~~

~~Concrete pavement and concrete base shall be constructed true to grade, cross-section and to the dimensions as specified in the Contract Documents.~~

~~The concrete pavement or~~ and concrete base shall be protected from damage ~~to the surface.~~ 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. Concrete base shall not be opened to traffic until the surface course pavement has been placed.

Shouldering operations and construction of adjacent lanes may commence once the concrete has attained a compressive strength of 20 MPa. ~~Construction of shoulders~~ Shoulders shall be ~~according to OPSS 314 as specified in the Contract Documents.~~

350.07.02 _____ Production of Concrete

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

350.07.03 _____ Placing of Concrete

350.07.03.01 _____ General

Immediately ahead of the concrete placing operation, the ~~subgrade~~ underlying material shall be wetted by means of a uniform spray of water sufficient to wet the ~~subgrade~~ underlying material thoroughly without leaving standing water.

The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation.

Concrete shall be placed within 1.5 m of its final position. ~~Concrete shall not be dropped from more than 1.5 m above the~~ subgrade ~~underlying material.~~ Concrete shall not be placed more than 10 m ahead of the concrete paving equipment.

Concrete shall be placed at a steady rate, such that a monolithic concrete is obtained without the formation of cold joints.

When there is an interruption in placing concrete greater than 20 minutes, the surface of the concrete shall be covered with wet burlap. ~~The Contract Administrator shall be notified immediately of any interruption resulting in a cold joint. A proposal for remedial action shall be submitted to the Contract Administrator for approval.~~

Any excess concrete beyond the concrete pavement or concrete base edge shall be removed immediately.

350.07.03.02 _____ Concrete Placing Restrictions

No concrete shall be placed until all curing material ~~and, in cold weather, all, including~~ cold weather protection material when required, has been delivered to the site.

Concrete shall only be placed when the ambient air temperature is 1 °C and rising, ~~or~~ and is less than 32 °C.

All surfaces against which concrete is to be placed shall be free of:

- a) Standing water;~~;~~
- b) ~~ice~~ ice and snow;~~;~~ and
- c) ~~debris~~ Debris.

Concrete shall not be placed against any material which is at a temperature above 35 °C, ~~or~~ nor against any material whose temperature is below 5 °C.

Concrete shall not be placed on or against frozen ground. ~~De-icing chemicals shall not be used.~~

Fresh concrete shall be protected from contact with rain or snow and concrete shall not be placed during rain or snowfall.

350.07.04 _____ Consolidation

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

Concrete shall be thoroughly consolidated against and along the face of all forms and into the face of previously placed concrete. -The vibrators shall not come in contact with the base, subbase, subgradeunderlying 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.

350.07.05 _____ Finishing

When a slip-form paver is used, hand finishing is not required but is permitted to address localized areas of open texturing, undulations, projections, or ridges.

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

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

350.07.06 _____ Initial Texturing of Concrete Pavement or Concrete Base Surface

The plastic surface of the concrete 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.

350.07.07 _____ Curing

350.07.07.01 _____ General

~~Curing~~For slip-form placement, curing shall be applied immediately after initial texturing of the concrete surface, and within 15 minutes of concrete being formed by the paver. For fixed-form placement, curing shall be applied immediately after initial texturing of the concrete surface.

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

Concrete pavement and concrete base shall be cured using one of the following methods, according to the applicable clauses of OPSS 904:

- a) Curing with Curing Compound clause ~~5~~2 or
- b) Curing with Burlap and Water clause.

Formed surfaces shall require no additional curing where the formwork is left in place for the minimum specified curing period. -If formwork is removed during the curing period, formed surfaces shall be cured using one of the methods listed above.

When curing compound is used, it shall not be applied to joint faces against which joint sealing compound will be placed or, to concrete surfaces to which concrete or mortar 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 shot blasting~~blast cleaning according to OPSS 929, and it shall not result in any damage to the concrete surface. The removal process shall meet all environmental constraints ~~as~~ specified in the Contract Documents.

350.07.08 _____ Cold Weather Protection

350.07.08.01 _____ General

During cold weather, the temperature of the concrete shall be monitored and controlled for a minimum period of ~~seven~~7 Days to ensure that the concrete temperature does not fall below 15 °C for the first ~~three~~3 Days of curing and then 10 °C for the following ~~four~~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 ~~measures specified in the Minimum Concrete Subject to Cold Weather Protective Measures table of clause in~~ OPSS 904. -The conditions shall be monitored, and the protection system shall be 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 ~~one~~1 hour and no more than 25 linear metres of concrete shall be exposed at any one time.

350.07.08.02 _____ Monitoring and Control of Temperature

During cold weather, records of monitoring and control of the concrete and ambient air temperature shall be ~~recorded and~~ submitted to the Contract Administrator.

For each Day's placement of concrete, ~~thermocouple wires~~thermocouples or sensors shall be embedded ~~near~~within 5 mm of the concrete surface in a minimum of four locations, ~~equally~~ distributed throughout the placed concrete, as directed by the Contract Administrator. ~~Thermocouples for monitoring~~At least one additional thermocouple or sensor shall be installed to measure ambient air temperature ~~shall be installed in the shade close to above~~ the surface of the concrete ~~at a minimum frequency of one thermocouple per placement during~~ 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 ~~one hour until the end of the monitoring period.~~ 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 ~~six~~6 hours; or more frequently as required; for the first ~~three~~3 Days, and every 12 hours or more frequently as required for the remainder of the temperature monitoring period. -Temperature verification shall be carried out in person at each concrete ~~placement~~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.

A record of temperatures for 350.07.08.03 _____ Submission of Temperature Records

~~At the end of~~ each Day during the temperature monitoring period ~~shall be prepared.~~ ~~At the end of the temperature monitoring period, a complete temperature record including graphical plot of~~ datalogger temperature ~~versus time shall be prepared.~~

07.08.02.01 ~~Submission of Temperature Records~~

~~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 each Business Day during the temperature monitoring period.~~ At the end of the temperature monitoring period, the complete temperature ~~record~~ records for all of the thermocouples and sensors, including graphical plots of temperature versus time, shall be submitted to the Contract Administrator.

350.07.09 ~~_____~~ Joints

350.07.09.01 ~~_____~~ General

Joints shall be of the type and at the locations specified in the Contract Documents. ~~Joint types include longitudinal, transverse, construction and expansion joints. Joints shall be constructed to the dimensions as specified in the Contract Documents, except the dimensions for longitudinal and transverse joints which shall be according to the Longitudinal and~~

Transverse ~~Joints clause of this specification.~~

~~Where new concrete pavement or concrete base is placed adjacent to existing concrete pavement or concrete base, concrete shall be connected along longitudinal joints using tie bars and along transverse joints using dowel bars, according to the Contract Documents. Tie bars and dowel bars shall be installed in the hardened concrete according to the Installation of Tie Bars and Dowel Bars in Hardened Concrete clause. Transverse joints in new joints in new concrete~~ pavement shall be at the same locations and continuous with transverse joints in the existing adjacent concrete pavement.

350.07.09.02 ~~_____~~ Longitudinal and Transverse Joints

~~Longitudinal and transverse joints shall be sawcut a minimum of one third the depth of the For concrete pavement or and concrete base and shall be a maximum of 6 mm in width. Longitudinal and transverse joints shall be completely filled to the bottom of the sawcut with hot poured rubberized joint sealing compound according to the Sawcutting, Cleaning and Sealing of Joints clause of this specification. There, there shall be no reservoir cut and a backer rod shall not be used.~~

For concrete pavement, the dimensions of the longitudinal and transverse joints shall be as specified in the Contract Documents for full depth joint filling without reservoir cut.

For concrete base, the dimension of the joint shall be as specified in the Contract Documents.

350.07.09.03 ~~_____~~ Construction Joints

Transverse construction joints shall be made at the end of each Day's production or when an interruption greater than 20 minutes occurs in the concrete paving operation. ~~Construction joints shall be located at a transverse contraction joint or expansion joint location.~~

350.07.09.04 ~~_____~~ Tie Bars and Dowel Bars

350.07.09.04.01 ~~_____~~ General

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

350.07.09.04.02 ~~_____~~ Protection of Tie Bars and Dowel Bars

Unprotected on-site storage shall not exceed 30 Days and total on-site storage time shall not exceed 120 Days. When protection is required, bars shall be covered with opaque polyethylene sheeting ~~or other equivalent~~

~~protective material.~~ For stacked bundles, the protective covering shall be draped over the sides of the bundles and around the perimeter of the stack. The covering shall be secured, with provisions for air circulation around the bars to prevent condensation under the protective covering.

The bars shall be stored clear of the ground on timbers or other suitable protective cribbing spaced to prevent sags in the bundles. Stacks of bundles of straight bars shall have blocking to prevent contact between the layers of bundles.

350.07.09.04.03 Repair of Tie Bars and Dowel Bars

Bars with coating damage less than 1% of the surface area of the bar shall be repaired. Bars with coating damage greater than 1% of the surface area of the bar shall not be used.

Repairs to damaged epoxy coating shall be according to OPSS 1442. Repairs shall not be performed when the temperature of the bar or the ambient air is 5 °C or less, or when moisture is present on the bar. All repairs to the coating of bars shall be completed at least ~~1224~~ hours before permission to place concrete is given. Repairs should be performed immediately after the damage occurs and shall be done before rusting begins. If any rust is present, it shall be completely removed before the patching material is applied. Repaired dowel bars shall be coated with a bond-breaker.

350.07.09.04.0204 Installation of Tie Bars in Plastic Concrete

Tie bars at longitudinal joints shall be installed as specified in the Contract Documents. Tie bars may be installed in the plastic concrete using an inserter or by means of tie bar baskets. Tie bars shall not be manually inserted into the plastic concrete.

Tie bars shall be installed within a tolerance of ± 15 mm from the specified depth. Tie bars shall not be placed within 600 mm of a transverse joint.

~~Tie bars shall be installed in the plastic concrete so that voids are not created around the bar. Tie bars which are loose, broken, cracked or otherwise damaged shall be removed and replaced, at no additional cost to the Owner. Drill a hole offset 75 mm horizontally from the rejected bar and install a replacement bar according to the procedure specified in the Installation of Tie Bars and Dowel Bars in Hardened Concrete clause.~~

350.07.09.04.0305 Installation of Dowel Bars in Plastic Concrete

Dowel bars at transverse joints shall be installed as specified in the Contract Documents. Dowel bars may be installed in the plastic concrete using ~~an automatic dowel bar inserter~~ a DBI or by means of load transfer devices. Dowel bars shall not be manually inserted into the plastic concrete.

When load transfer devices are used, they shall be placed a minimum of 100 m in advance of the concrete placing operation. Load transfer devices shall be prevented from moving, by the use of stakes placed on both sides of the load transfer device. A minimum of three stakes shall be uniformly spaced on each side of the load transfer device for each lane, to prevent movement during the concrete paving operation. The spacer wire shall be cut in two places and the mid-section removed after staking the load transfer device in position. The section of spacer wire removed shall be a minimum of 300 mm in length.

Dowel bars shall be placed parallel to the longitudinal axis (horizontal alignment) and horizontal plane (vertical alignment) of the concrete pavement or concrete base within a tolerance of ± 15 mm along the length of the dowel bar.

The location of the centre of the dowel bars shall be precisely marked to permit joint forming or cutting operations directly over the centre of the dowel bars. Transverse joints shall be sawcut within a tolerance of ± 50 mm from the center of the dowel bars (longitudinal side shift).

Dowel bars shall be placed mid-depth of the concrete pavement or concrete base within the following tolerances:

- a) For a concrete pavement or concrete base thickness of < 215 mm; lower limit = - 6 mm, upper limit = +6 mm.
- b) For a concrete pavement or concrete base thickness from 215 to 229 mm; lower limit = -12 mm, upper limit = +15 mm.
- c) For a concrete pavement or concrete base thickness of 230 mm or greater; lower limit = -15 mm, upper limit = +25 mm.

350.07.09.04.0406 Installation of Tie Bars and Dowel Bars in Hardened Concrete

When tie bars and dowel bars are installed in hardened concrete, they shall be at the locations and within the tolerances specified in the Installation of Tie Bars in Plastic Concrete and Installation of Dowel Bars in Plastic Concrete clauses as applicable.

Tie bars and dowel bars shall be installed in hardened concrete by drilling holes into the existing concrete using a gang drill. For concrete that is less than ~~seven~~ 7 Days of age, prior to drilling, cylinders according to the Testing for Early Strength subsection of OPSS 904 shall be prepared to demonstrate that the concrete has reached a minimum compressive strength of 20 MPa. The diameter of the drill hole shall be no more than 5 mm larger than the diameter of the dowel or tie bar. Prior to ~~filling~~ filling prior to installing the ~~drill holes~~ dowel bar or tie bar, the inside surface of each drill hole shall be wire brushed and then cleaned using compressed air. The dowel or tie bar shall be secured into the existing concrete with an 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.

To replace damaged tie bars, a hole offset 75 mm horizontally from the rejected bar shall be drilled and a replacement bar shall be installed. Damaged tie bars shall be cut flush with the concrete surface.

For dowel bars only (not tie bars), the free end of the dowel bars and the exposed vertical concrete face along the transverse joint shall be coated with bond breaker immediately prior to placing concrete.

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

350.07.09.05 Sawcutting, Cleaning and Sealing of Joints in Concrete Pavement

350.07.09.05.01 General

Concrete pavement ~~and concrete base~~ joints shall be sealed. ~~For concrete pavement, sealing~~ Sealing of joints ~~shall~~ may be done prior to, or after final texturing of the concrete pavement.

350.07.09.05.02 Sawcutting, cleaning, and sealing of Joints

~~Sawcutting equipment shall be used to create the joints. Routers shall not be used for creating the joint.~~

~~The initial sawcut for longitudinal and transverse joints shall be carried out as soon as the joint can be sawcut without ravelling the joint or damaging the concrete surface, and prior to any cracks developing.~~

~~Longitudinal and transverse sawcutting operations shall be carried out concurrently. Sawcutting of the joints to the specified dimensions may be done with the initial sawcut or in two parts with an initial sawcut and a final sawcut. The initial sawcut, and the final sawcut, if applicable, shall be a minimum of one third the depth of the concrete pavement or concrete base and shall not be so deep as to cut the tie bars or dowel bars. The final dimensions of the joint shall be according to the Longitudinal and Transverse Joints clause of this specification.~~

~~350.07.09.05.03~~ — ~~Cleaning of Joints~~

~~Cleaning of joints shall remove all sawcut slurry, grinding and grooving effluent and any other debris from the joint. Cleaning of joints shall consist of flushing the joints with water in one direction to remove slurry and debris.~~

~~For joints OPSS 369, with the addition that are sealed prior to final texturing; they shall be cleaned at each of the following times:~~

~~a) Immediately after each sawcutting operation, and samples of hot poured rubberized joint 24 to 36 hours before sealing.~~

~~joints that are sealed after final texturing; they shall be cleaned at each of the following times:~~

~~a) Immediately after each sawcutting operation, and~~

~~b) immediately after final texturing.~~

~~05.04~~ — ~~Preparation and Sealing of Joints~~

~~Joint sealing compound shall not be placed until new concrete has cured for a minimum of seven Days. be required for quality assurance testing by the Owner.~~

~~A 4-litre sample shall be taken from the heating and mixing kettle at the beginning, middle and the end of the process of joint sealing compound installation for each calendar year and shall be provided to the Contract Administrator for testing by the Owner. Upon request, a more frequent sampling of the joint sealing compound shall be carried out for quality assurance testing by the Owner.~~

~~Joints shall be sealed prior to opening to traffic. Joints that will be open to traffic may be sealed temporarily, subject to approval by the Owner. A proposal to temporarily seal joints shall be submitted to the Contract Administrator, for acceptance.~~

~~350.07.09. Joint sealing compound shall not be placed when the ambient air or pavement or base surface temperatures are less than 5 °C.~~

~~Prepared transverse joints shall be filled prior to longitudinal joints.~~

~~Joints shall be sealed 24 to 36 hours after completion of the final cleaning. This time period shall be extended only if necessary to ensure the joint is dry. Joints shall be kept in a dry condition for a minimum period of 24 hours prior to sealing. Joints shall be clean and dry when the joint sealing compound is placed.~~

~~Immediately prior to sealing operations, all joint faces shall be abrasive blast cleaned 06 **Sawcutting and Cleaning of Joints in Concrete Base**~~

~~Concrete base joints shall not be sealed. Sawcutting and cleaning of joints for concrete base shall be according to OPSS 929369.~~

~~The joint and adjacent concrete pavement or concrete base surface shall then be blown clean and dried, using a hot compressed air lance.~~

~~Joint sealing compound shall be installed according to the manufacturer's recommendations.~~

~~The joint sealing compound shall be placed by a manual pouring cone or hose and wand fitted with a tip from a low pressure pump connected to the heating kettle. The tip shall be small enough to fit inside the joint and extend to the bottom of the sawcut.~~

~~When filling the joint, the tip of the cone or wand shall be placed at the bottom of the joint to ensure uniform application.~~

~~The joint shall be filled with joint sealing compound so that upon cooling, the joint sealing compound is recessed 3 to 6 mm below the adjacent pavement or base surface. If the initial placement of material subsides below the required recess depths, additional joint sealing compound shall be placed within eight hours of the original placement.~~

~~Joint sealing compound damaged by construction traffic or by the Contractor's operations shall be replaced.~~

~~Any spilled material or excess material in the joints or cracks shall be removed immediately and the pavement surface cleaned.~~

350.07.10 _____ Optional Diamond Grinding to Improve Surface Tolerance and Smoothness

Diamond grinding, to improve concrete pavement surface tolerance and smoothness prior to Owner acceptance testing, may be completed at the Contractor's option. -The optional diamond grinding shall be completed prior to final texturing of the concrete pavement.

When this option is selected, a written proposal, according to the Repairs subsection, shall be submitted to the Contract Administrator at least ~~five~~⁵ Business Days prior to commencing the diamond grinding. - The proposal shall list the diamond grinding locations by subplot(s), station limits, and include the length of each location. Where the distance between individual locations within the same lane is less than 100 m, these locations shall be specifically identified in the proposal along with the length between the two locations.

The optional diamond grinding shall not commence until written permission to proceed has been received from the Contract Administrator.

The optional diamond grinding shall be deemed to be a repair. ~~As specified in the Mean Roughness Index clause, no subplot that has been repaired by diamond grinding for any reason shall receive a payment factor greater than 1.000.~~

350.07.11 _____ Final Texturing of Concrete Pavement Surface

350.07.11.01 _____ Trial Section

The ability to texture the concrete pavement surface according to the requirements of this specification by grooving shall be demonstrated by means of a 500 m single lane trial section. -The location of the trial section shall be selected by the Contract Administrator.

The Contract Administrator ~~will~~^{shall} give permission to proceed with the final texturing on the Contract when it has been demonstrated to the satisfaction of the Contract Administrator that the trial section meets the requirements of this specification.

The Contract Administrator may require additional trial section(s) to be constructed, at no additional cost to the Owner, using alternate means as required, until it has been demonstrated that the requirements of this specification have been met.

350.07.11.02 _____ Final Texturing of Concrete Pavement

Concrete pavements shall receive a final texturing by grooving. -Concrete base shall not receive a final texturing. Final texturing shall be done after the curing period and, if applicable, the cold weather protection period, is complete. ~~Concrete repairs as specified in the Contract Documents shall be completed prior to final texturing. The~~^{The} concrete pavement surface shall be grooved with a grooving machine longitudinally ~~at areas as specified in the Contract Documents or as directed by the Contract Administrator.~~ Longitudinally grooved areas shall be straight and run parallel to the longitudinal axis of the concrete pavement, begin and end at lines radial to the concrete pavement center line and shall be centered within the lane width, or as specified in the Contract Documents.

The concrete pavement shall be grooved to the full width of the lane under construction ~~within the station to station limits established by the Contractor during each shift~~ with no grooves cut within 150 mm and no closer than 50 mm of longitudinal joints.

Grooves shall be ~~cut~~:

a) Cut 2.5 mm in width, with a tolerance of plus 1.5 mm, ~~and~~.

b) Cut between 3.0 and 6.0 mm in depth. ~~Over, except over~~ inductive loop detectors, ~~grooves where they shall be cut between 1.5 and 3.0 mm in depth. Grooves shall have a~~

c) Spaced 19 mm centre-to-centre ~~spacing of 19 mm~~ with a tolerance of plus or minus 2.5 mm. ~~Grooves shall be cut to within 150 mm and no closer than 50 mm of longitudinal joints.~~

Grooving that results in ravelling, aggregate fractures, spalls, or disturbance to the transverse or longitudinal joints, shall not be permitted and shall be controlled or corrected immediately as the work progresses.

If a single grooving blade on any individual grooving machine becomes incapable of cutting a groove within the specified tolerances, work ~~will~~shall be permitted to continue for the remainder of the work shift and the groove ~~will~~shall not be required to be recut. - Should two or more grooving blades on any individual grooving machine become incapable of cutting grooves within the specified tolerances, operations shall cease with this machine until repairs to the equipment are ~~effected~~completed.

The Contract Administrator shall immediately be notified in writing if any of the defects or conditions listed in the Acceptance of Concrete Surface Texturing subsection are present in the work and shall include the extent of the defects and an explanation of the cause. -A proposal for the remedial work for the above defects and conditions shall be submitted to the Contract Administrator for review. -Repairs shall not proceed until approval of the proposal has been received from the Contract Administrator. -Repairs shall be at no additional cost to the Owner.

350.07.12 _____ Surface Tolerance

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

For concrete base, the tolerance relative to a 3 m straight edge shall be maximum 6 mm.

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

Diamond grinding, according to the Repairs clause, shall be carried out to ensure the concrete surface meets these requirements.

350.07.13 _____ Material Sampling and Testing

350.07.13.01 _____ Sampling of Water, Admixtures, Limestone Filler and Cementing Materials

Sampling of water, admixtures, limestone filler and cementing materials shall be according to ~~the Material Sampling of Water, Admixtures, Limestone Filler and Testing subsection of Cementing Materials clause in~~ OPSS 1350.

350.07.13.02 _____ Sampling and Testing of Plastic Concrete

Sampling, testing, acceptance, adjustments, visual acceptance, and submission of results for plastic concrete shall be according to the ~~Material Sampling and Testing subsection of~~ following clauses in OPSS 1350; with the

exception that after satisfactory control has been established, testing shall be carried out on one load of concrete in every five loads:

~~Satisfactory control shall be established each Day. Satisfactory control is established when concrete from five consecutive loads are within the specified requirements without field adjustments. If any field adjustments are required, testing on each load shall be continued until five consecutive loads meet the requirements with no field adjustment. After satisfactory control has been established, testing shall be carried out on one load in every five, selected randomly by the Contract Administrator. If testing indicates that a load does not meet the requirements, testing shall resume on each load until satisfactory control is established.~~

- a) Testing of Plastic Concrete.
- b) Frequency of Testing Slump, Air Content and Temperature.
- c) Acceptance and Field Adjustment of Plastic Concrete.
- d) Visual Acceptance of Plastic Concrete.
- e) Within-Batch Uniformity of Plastic Concrete.
- f) Submission of Plastic Concrete Test Results.

350.07.13.03 Sampling for Acceptance Testing of Thickness, 28-Day Compressive Strength, Air Void System Parameters ~~and~~, Rapid Chloride Permeability and Acceptance of Joint Sealing

350.07.13.03.01 **General**

Core samples shall be removed from the concrete pavement or concrete base at locations identified by the Contract Administrator for acceptance testing of thickness, 28-Day compressive strength, air void system parameters and rapid chloride permeability.

The lot and subplot size and number of cores per subplot shall be according to the Quality Assurance section.

After sealing operations are complete, the Contract Administrator may require that additional cores, up to two cores per subplot, be taken at joint locations to evaluate the acceptability of the joint cleaning and sealing. If the samples show that the joint cleaning and sealing is not according to this specification, additional cores may be required at no addition cost to the Owner.

350.07.13.03.02 **Coring**

Core samples shall be obtained for acceptance testing. ~~Coring shall be carried out according to CSA A23.2-14C.~~ The cores shall be 100 mm in diameter and shall be drilled through the full depth of concrete pavement or concrete base, perpendicular to the surface of the pavement or base-concrete. No core shall be taken within 250 mm of any joint or edge of slab.

Removal of five cores per subplot for testing of 28-~~day~~Day compressive strength, air void system and rapid chloride permeability shall be carried out when the concrete is ~~seven~~7 to 10 Days of age. ~~The Contract Administrator shall randomly select a location for coring within the subplot and three cores for acceptance testing of 28-~~day~~Day compressive strength shall be removed from a single panel of concrete pavement or concrete base.~~ Cores for testing of air void system parameters and rapid chloride permeability shall be taken from a panel of concrete pavement or concrete base adjacent to the panel from which the cores for compressive strength testing were taken.

Core samples for measurement of thickness shall be taken after completion of any repairs and of final texturing. A single core shall be removed from each subplot for thickness measurement at a location randomly selected by the Contract Administrator.

Each core shall be marked legibly with durable ink immediately after removal with the following:

- a) The Contract number.
- b) Component type (concrete pavement or concrete base).
- c) Lot number.
- d) Sublot number.
- e) Exact location of each individual core.
- f) Date of concrete placement (i.e., yyyy-mm-dd).
- g) Date of extraction.

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-433A, Concrete Mix Design 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.

~~350.07.13.04~~ ~~Sampling of Hot Poured Rubberized Joint Sealing Compound~~

~~Upon request, during the process of joint sealing compound installation, a sample of the joint sealing compound shall be provided to the Contract Administrator for testing by the Owner.~~

~~Joint sealing compound samples shall be stored in sealed epoxy lined pails or suitable leak proof plastic containers.~~

~~Samples shall be accompanied by a sample data sheet and WHMIS label. When not specified or not included on the sample data sheet, samples shall be delivered with a transmittal form identifying the following information:~~

- ~~a) Contract number.~~
- ~~b) Name of Contractor and a contact person's name and telephone numbers.~~
- ~~c) Contract Administrator's name and telephone numbers.~~
- ~~d) Quantity, type of sample and product name. When a sample consists of more than one item, each item shall be individually identified.~~
- ~~e) Date sampled (i.e., yyyy mm dd).~~
- ~~f) Date shipped.~~
- ~~g) Sample location.~~

~~350.07.14~~ ~~Preparation for Measurement of Position and Alignment of Dowel Bars~~

~~350.07.14.01~~ ~~Joint Cut-Out Procedure~~

Joint cut-outs shall be carried out by the Contractor for evaluation of dowel bar position and alignment by the Contract Administrator. -The joint cut-out measurement shall be according to the Quality Assurance section. The Contract Administrator ~~will~~shall select the transverse joint to be evaluated.

At the selected joint, the concrete shall be removed by chipping hammer to a depth exposing the full length of all the dowel bars across the entire joint. -The concrete shall be removed without disturbing the dowel bars.

After the selected joint has been measured and evaluated by the Contract Administrator, the joint shall be removed and replaced with a full depth concrete repair, 2 m in length, according to OPSS 366, ~~with the exception that joint sealing shall be according to this specification.~~

350.07.14.02 **Preparation for Measurement of Position and Alignment of Dowel Bars**

The Contract Administrator shall be notified in writing when the concrete pavement or concrete base is ready for measurement by the Owner. -Lot size, measurement and acceptance of position and alignment of dowel bars using ~~MIT scan~~the MPI device shall be according to the Quality Assurance section.

Provisions shall be made for access to the site for acceptance testing of position and alignment of dowel bars.

The area to be measured shall be free of loose stone, debris, and obstructions.

After the measurements by the ~~MIT scan~~MPI device are completed, all areas to be repaired shall be marked on the concrete surface at the direction of the Contract Administrator and prior to the commencement of any corrective work.

350.07.15 **Preparation for Surface Smoothness Measurement**

The Contract Administrator shall be notified in writing when the concrete pavement or concrete base is ready for surface smoothness acceptance testing. -Surface smoothness acceptance testing shall be carried out after final texturing has been completed.

Provisions shall be made for access to the site for surface smoothness acceptance testing.

The surface to be tested shall be clear of any loose stone, debris, and obstructions which could affect the measurement. -The subplot number and station shall be clearly marked at the beginning of each subplot in a way that remains visible to the smoothness measuring operator until the final measurements are completed and accepted.

When reflectors are used for quality assurance or referee measurements, reflectors shall be obtained from the profiler operator and placed on the left/right shoulder or the highway median at the beginning and end of each profile run as required by the profiler operator. -After smoothness measurements are completed each ~~day~~Day, the reflectors shall be removed and returned to the profiler operator.

When global position system-distance measuring instrument (GPS-DMI) technology is used for quality assurance or referee measurements, the profiler operator shall collect static GPS coordinates while stopped on the shoulder. -Traffic protection for the collection of static GPS coordinates shall be provided.

After the measurements are analyzed, all areas to be repaired due to rejectable sublots or incidents of localized roughness or both, shall be marked on the concrete surface at the direction of the Contract Administrator and prior to the commencement of any corrective work.

350.07.16 **Repairs**

350.07.16.01 ~~Repair of~~ **Surface Tolerance and Surface Smoothness Deficiencies**

~~A~~A ~~repair proposal shall be submitted to the Contract Administrator at least five~~5 Business Days prior to ~~beginning~~carrying out any surface tolerance-~~related~~ or surface smoothness-~~related~~ repairs, ~~a written~~. The proposal shall be submitted to contain the Contract Administrator with the subplot and repair following:

- a) Sublot.
- b) Repair locations including the appropriate stations, ~~length~~.
- c) Length of each repair area, ~~and distance~~.
- d) Distance between the ends of the repair areas on the same lane that are within 100 m of each other.
- e) Detailed description of deficiency.

Repairs shall not begin until written permission to proceed has been received from the Contract Administrator.

Diamond grinding shall be the only method of repair acceptable for correction of surface tolerance and surface smoothness deficiencies including incidents of localized roughness.

Repairs by diamond grinding shall be completed prior to opening the concrete pavement or concrete base to traffic. -Diamond grinding shall be performed parallel to the lane with each pass overlapping the previous one by up to 25 mm. -There shall not be more than 3 mm of elevation difference between adjacent lanes and the concrete pavement or concrete base cross slope shall be maintained throughout the repaired area. -After repair, the concrete pavement or concrete base shall be of a uniform texture.

The maximum depth of removal of concrete by diamond grinding shall not exceed 10 mm. -The minimum width of all repairs shall be the width of the lane being repaired.

Repaired areas that do not meet the texturing requirements of this specification shall be re-textured according to the requirements of this specification, ~~at no additional cost to the Owner.~~

350.07.16.02 _____ Crack Repairs

~~Transverse cracking in excess of one third the depth of if any cracks are found in the concrete pavement or concrete base thickness shall be repaired as a full depth concrete repair, a minimum of 2 m in length, according to OPSS 366, with the exception that joint sealing shall be according to this specification.~~

~~Longitudinal cracking in excess of one third the depth of the pavement or base thickness shall be repaired by removing and replacing the full panel containing the crack, bounded by the nearest joints.~~

~~If any cracks are found to be less than one third the thickness of the pavement or base, a proposal for remedial work shall be submitted to the Contract Administrator for review. - Crack repairs shall not proceed until approval of the proposal has been received from the Contract Administrator.~~

350.07.17 _____ Management of Effluent ~~from Concrete Grinding and Grooving Operations~~

350.07.17.01 _____ General

Effluent ~~from concrete grinding and grooving operations~~ shall be captured and managed as specified in the Contract Documents.

~~These~~The requirements of this specification do not relieve the Contractor of obligations imposed by the Contractor's Environmental Compliance Approval ECA for a Waste Management System waste management system.

All approvals, releases, and agreements, and conditions that are required for the management of effluent shall be obtained prior to the commencement of the effluent producing work.

Effluent ~~resulting from concrete grinding and grooving operations~~ shall be transported to one of the following receiving sites:

- a) A waste disposal site with an Environmental Compliance Approval ECA for a Waste Disposal Site waste disposal site valid for liquid industrial waste Class class 146 (L);
- b) A waste processing facility with an Environmental Compliance Approval ECA for a Waste Disposal Site (Processing) waste disposal site (processing) valid for liquid industrial waste Class class 146 (L).

For each shipment of effluent from the construction area to any certified receiving site:

- a) The carrier shall have an Environmental Compliance Approval ECA for a Waste Management System waste management system valid for liquid industrial waste Class class 146 (L), and shall comply with the Carrier Information and the Environmental Compliance Approval clauses clause; and

~~b) The shipment Contractor shall be manifested as specified in the Manifest clause. present, on behalf materials resulting from concrete removal repair or construction concrete, appropriate measures such as providing a protection system(s) shall be taken to ensure that these materials do not enter into the waterbody or cause damage to any portion of the pavement structure not designated for removal.~~

~~For concrete sawcutting, grooving, or grinding, the appropriate measures such as providing a protection system(s) shall be taken to contain any removed material until it is disposed. Minimize the escape of dust such that no visible dust reaches the waterbody, adjacent wetlands, or property outside the right-of-way limits.~~

~~350.07.17.02~~ **Carrier Information**

~~The carrier shall have one of the certificates of approvals as specified in the General clause, under the Management of Effluent from Concrete Grinding and Grooving Operations subsection, a Regulation 347 Form 1 manifest for "Part A" to be completed by the Contract Administrator.~~

~~c) The Contract Administrator shall be notified a minimum of 2 weeks prior to the first shipment and a minimum of 24 hours prior to each subsequent shipment requiring the manifest.~~

Responsibilities of certified carriers shall include, but not be limited to, the following:

- a) Transportation of waste materials produced by the work according to the ~~Environmental Compliance Approval; ECA; and~~
- ~~b) Responsible for the waste~~
- b) Waste materials including, but not restricted to, manifesting of liquid industrial waste.

~~350.07.17.0302~~ **Environmental Compliance Approval**

The Contractor's ~~Environmental Compliance Approval ECA~~ for a ~~Waste Management System waste management system~~ and the receiver's ~~Environmental Compliance Approval ECA~~ for a ~~Waste Disposal Site waste disposal site~~ shall be valid for all of the following:

- a) The entire period of the work;
- b) The entire area within the limits of the work and the entire haul route; and
- c) The equipment to be utilized; and
- d) Waste classification 146 (L).

~~350.07.17.04~~ **Manifest**

~~The Contractor shall present, on behalf of the carrier, a Regulation 347 Form 1 manifest for "Part A" to be completed by the Contract Administrator. The Contract Administrator shall be notified a minimum of two weeks prior to the first shipment and a minimum of 24 hours prior to each subsequent shipment requiring the manifest.~~

~~350.07.18~~ **Management of Excess Material**

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

350.08 QUALITY ASSURANCE

350.08.01 Acceptance of Concrete Pavement and Concrete Base

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

- a) Thickness.
- b) ~~28-day~~Day compressive strength.
- c) ~~air~~Air void system in hardened concrete.
- d) ~~rapid~~Rapid chloride permeability.
- e) ~~position~~Position and alignment of dowel bars.
- f) ~~position~~Position of tie bars.
- g) ~~texturing~~Texturing.
- h) ~~curing~~Curing.
- i) ~~control~~Control of temperature.
- j) ~~surface~~Surface smoothness.
- k) ~~surface~~Surface tolerance, and
- l) ~~there~~There are no visible defects detected by inspection according to the Field Inspection subsection.

Unacceptable lots and sublots shall be rejected. -Concrete from rejected lots and sublots shall be removed and replaced ~~at no additional cost to the Owner.~~

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

~~The replacement concrete~~Concrete pavement or concrete base ~~for lots and sublots that have~~has been ~~removed and~~ replaced shall be evaluated for acceptance on the same basis as the original lots ~~or~~and sublots.

350.08.02 Field Inspection

The Contract Administrator ~~will~~shall inspect the work during production and ~~will~~shall reject all or a portion of the work based on the presence of one or more of the following defects:

- a) Insufficient depth of sawcut of joints.
- b) Ravelling or damaging the concrete surface adjacent to the sawcut joints.
- b) Joints that have not been cleaned and prepared according to this specification, prior to sealing.
- c) Joints that have not been sealed according to this specification.
- d) Cracks.
- e) Voids or honeycombing.

- f) Tie bars and dowel bars not meeting the specified lengths or diameters.
- g) Loose, broken or ~~cracked~~damaged tie bars.

h) Excessive bleeding or segregation of the concrete.

i) Presence of effluent that has not been removed according to this specification.

After sealing operations are complete, the Contract Administrator ~~will~~shall inspect any cores taken at joint locations to evaluate the acceptability of the joint cleaning and sealing. ~~The Contract Administrator will~~shall reject all or a portion of the work if the samples show that the joint cleaning and sealing is not according to this specification.

350.08.03 _____ Acceptance of 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness

350.08.03.01 _____ General

Acceptance of 28-~~day~~Day compressive strength, air void system parameters, rapid chloride permeability and thickness shall be based on testing of cores removed from the hardened concrete. ~~Acceptance of 28-day~~Day compressive strength and thickness shall be on a lot basis. ~~Acceptance of air void system parameters and rapid chloride permeability shall be on a subplot basis.~~

~~350.08.03.02 _____ Lot Size for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness~~

A lot shall consist of the total quantity of concrete pavement or concrete base of the same specified thickness and specified 28-~~day~~Day compressive strength. ~~Each lot~~For lots less than or equal to 50,000 m², each lot shall be divided into sublots of approximately ~~1000~~1,000 m². A minimum of three sublots are required for each lot. For lots greater than 50,000 m², ~~a proposal to divide~~ the lot shall be divided into sublots of approximately ~~2000~~2,000 m² ~~may be submitted.~~

A total of six cores shall be removed from each subplot:

- a) Three cores from each subplot for determination of the 28-~~day~~Day compressive strength.
- b) One core for determination of air void system parameters.
- c) One core for determination of rapid chloride permeability.
- d) One core for determination of thickness.

~~350.08.03.03 _____ Acceptance Testing for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness~~

350.08.03.03.01 28-Day Compressive Strength Testing

Testing of 28-~~day~~Day compressive strength shall be according to LS-410, with the exception that determination of concrete pavement thickness is not required. ~~The 28-day~~Day compressive strength of a subplot shall be the average of the set of three cores for the subplot, rounded to one decimal place.

350.08.03.03.02 Air Void System in Hardened Concrete

One half of one core representing the subplot shall be tested for air void system parameters to determine the acceptability of concrete. ~~The core shall be tested according to LS-432.~~ The other half of the core shall be retained by the Owner for audit purposes.

350.08.03.03.03 Rapid Chloride Permeability

The core taken for rapid chloride permeability shall be tested according to LS-433. -Acceptance testing shall be carried out at 28 to 32 Days.- Two 50 mm long samples shall be cut from the core representing the subplot for rapid chloride permeability and tested to determine the acceptability of the concrete within the subplot.

350.08.03.03.04 Thickness Testing

The concrete pavement or concrete base thickness for each subplot shall be determined based on the length of the core removed from each subplot for thickness testing, when measured according to LS-450.

350.08.03.04 Basis of Acceptance ~~for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness~~

350.08.03.04.01 28-Day Compressive Strength

Acceptance of concrete pavement or concrete base 28-Day compressive strength for each lot shall be based on the mean and standard deviation of the measurements for compressive strength of all sublots contained in the lot.

The Contract Administrator shall calculate the mean and standard deviation of the results and calculate the percent within limits (PWL) according to LS-101. -For calculation of PWL, the lower limit for 28-Day compressive strength is the specified minimum 28-Day compressive strength.

If the lot PWL is greater than or equal to 90%, the lot is acceptable. -If the lot PWL is greater than 95%, the lot ~~will~~shall be accepted with a bonus. -If the lot PWL is less than 90% and greater than or equal to 50%, the lot is accepted with a price adjustment according to the Basis of Payment section.- If the lot PWL is less than 50%, the lot shall be rejected.

Notwithstanding the overall PWL, if the compressive strength of a subplot is less than 60% of the specified compressive strength, the subplot shall be rejected.

350.08.03.04.02 Air Void System in Hardened Concrete

For a subplot to be considered acceptable, the core representing the subplot shall have an air content of 3.0% or more and a spacing factor of 0.230 mm or less. -Acceptable sublots shall be subject to full payment or a bonus payment.- Calculation of the bonus shall be according to the Basis of Payment section.

Sublots with an air content of less than 3.0% ~~and~~/or a spacing factor greater than 0.230 mm and but less than or equal to 0.260 mm shall be considered unacceptable but, ~~with~~at the ~~agreement~~discretion of the Owner, may be permitted to remain in the Work with a payment adjustment. -The payment adjustment shall be calculated based on individual sublots and applied according to the Basis of Payment section.

Sublots with a spacing factor greater than 0.260 mm shall be rejected.

350.08.03.04.03 Rapid Chloride Permeability

Sublots with rapid chloride permeability less than or equal to 2500 coulombs ~~are~~shall be considered acceptable. Sublots with a rapid chloride permeability result greater than 2500 coulombs and less than or equal to 3500 coulombs shall be considered unacceptable but, ~~with~~at the ~~agreement~~discretion of the Owner, may be permitted to remain in the Work with a payment adjustment.- The payment adjustment shall be calculated based on individual sublots and applied according to the Basis of Payment section.

Sublots with rapid chloride permeability results exceeding 3500 coulombs shall be rejected.

350.08.03.04.04 Thickness

Acceptance of concrete pavement or concrete base thickness for each lot shall be based on the mean and standard deviation of the measurements for thickness of all sublots contained in the lot.

The Contract Administrator shall calculate the mean and standard deviation of the results and calculate the ~~percent within limits (PWL)~~ according to LS-101.- For calculation of PWL, the lower limit for thickness is the specified thickness minus 5 mm.

If the lot PWL is greater than or equal to 90%, the lot is acceptable. -If the lot PWL is greater than 95%, the lot ~~will~~shall be accepted with a bonus. -If the lot PWL is less than 90% and greater than or equal to 50%, the lot is accepted with a price adjustment according to the Basis of Payment section. -If the lot PWL is less than 50%, the lot shall be rejected.

Notwithstanding the overall PWL, if the thickness of a subplot is less than 60% of the specified concrete pavement or concrete base thickness, the subplot shall be rejected.

350.08.03.05 ~~Referee Testing for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness~~

350.08.03.05.01 **General**

Referee testing for a subplot may only be invoked by the Contractor within ~~five~~3 Business Days of receiving the test results for that subplot.

Referee testing shall be carried out according to the ~~test methods specified in the~~ Acceptance Testing ~~for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness subsections of this specification clause.~~

The referee laboratory shall be designated by the Owner based on the applicable roster.- Referee test results shall be forwarded to the Contractor as they become available.

350.08.03.05.02 **28-Day Compressive Strength**

Referee testing of 28-Day compressive strength for a subplot shall be ~~done~~carried out on a new set of three cores removed within 24 hours of invoking the referee testing.- Cores for referee testing for each disputed subplot shall be taken in the presence of the Contract Administrator at a location no more than 1 m from the location that each of the disputed acceptance cores were removed.-The core size and core extraction shall be according to the Coring clause.

If the difference between the referee test result and the acceptance test result is less than or equal to the confirmation value, then the acceptance test result is confirmed and the acceptance test result shall be used in the determination of acceptance and payment for the concrete. -If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed and the acceptance test result shall be disregarded and not used in the determination of acceptance and payment.

The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance cores, expressed to one decimal place.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of referee testing. -When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

When acceptance results are eliminated from the analysis as a result of the referee process, the concrete shall be assessed based on the available strength results for the lot.

350.08.03.05.03 **Air Void System in Hardened Concrete**

Referee testing for air voids shall be carried out on the same half of the core sample that was tested for acceptance. -When the referee testing is invoked, the sample representing the subplot shall be referee tested

and the acceptance test results discarded. -The subplot referee test results shall replace the acceptance test result in the acceptance requirements of this specification.

When the referee results indicate that the refereed subplot is acceptable, the Owner shall bear the cost. -When the referee results indicate that the refereed subplot is not acceptable, the Contractor shall be charged the cost of the air void system referee testing.

350.08.03.05.04 Rapid Chloride Permeability

Referee testing of rapid chloride permeability of a subplot shall be done on a new core removed within 24 hours of invoking the referee testing. -Cores for referee testing for each disputed subplot shall be taken in the presence of the Contract Administrator at a location no more than 1 m from the location from which the disputed acceptance core was removed. -The core size, core extraction, and filling shall be according to the Coring clause.

When the referee result is greater than the acceptance test result or no more than 500 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. -When the referee test result for the ~~lot~~ subplot is more than 500 coulombs below the acceptance test result, the acceptance test result is then not confirmed and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of referee testing. -When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

350.08.03.05.05 Thickness

Referee testing of thickness for a subplot shall be done on the same core that was used for acceptance testing of thickness.

If the difference between the referee test result and the acceptance test result is less than or equal to the confirmation value, then the acceptance test result is confirmed and the acceptance test result shall be used in the determination of acceptance and payment for the concrete. -If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed and the acceptance test result shall be disregarded and not used in the determination of acceptance and payment.

The confirmation value for confirming the acceptance test result shall be 5.0 mm.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of referee testing. -When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

When acceptance results are eliminated from the analysis as a result of the referee process, the concrete shall be assessed based on the available thickness results for the lot.

350.08.04 Acceptance of Position and Alignment of Dowel Bars

350.08.04.01 General

All testing shall be carried out by the Owner. - Test results shall be forwarded to the Contractor as they become available.

Acceptance testing of position and alignment of dowel bars ~~will~~shall be carried out upon completion of construction of the concrete pavement or concrete base or as portions of the work are completed.

The Contract Administrator ~~will~~shall arrange for acceptance testing after:

- a) Written notification that the concrete pavement or concrete base is ready for acceptance testing is received;
- and

b) ~~the~~The Contract Administrator is satisfied that the concrete pavement or concrete base is free of loose stone, debris, and obstructions.

The Contract Administrator shall provide 48 ~~hours~~^{hours} notice of when the dowel bar position and alignment measurements ~~will~~^{shall} begin. When weather conditions are unsuitable for testing according to the equipment manufacturer's recommendations, testing shall be suspended and shall resume only when conditions are acceptable for testing.

350.08.04.02 _____ Lot Size ~~for Position and Alignment of Dowel Bars~~

The total quantity of concrete pavement or concrete base on the ~~contract~~^{Contract} shall be divided into lots, with each lot containing all the transverse joints with dowel bars placed by the same method (load transfer devices or automatic dowel bar inserter). ~~Each lot shall be divided into sublots such that each~~ transverse joint shall be ~~considered~~^{represent} a subplot.

350.08.04.03 _____ Measurement and Acceptance

One joint for every 10 sublots or a minimum of 10 joints shall be randomly selected by the Contract Administrator and dowel position and alignment shall be measured for that joint.

350.08.04.03 _____ ~~Measurement and Acceptance for Position and Alignment of Dowel Bars~~

Measurement of dowel position and alignment using ~~magnetic pulse induction equipment (MIT scan)~~^{MPI device} shall be according to ASTM E3013.

Verification of the ~~MIT scan~~^{MPI device} result by means of a joint cut-out, shall be done on a joint from the first subplot ~~for each method of placement (load transfer devices or automatic dowel bar inserter) and shall be carried out once per year for multi-year Contracts.~~ The procedure for joint cut-outs shall be according to the Joint Cut-Out Procedure clause. The Contract Administrator ~~will~~^{shall} inspect the joint and measure and record the depth, horizontal and longitudinal side shift, vertical and horizontal alignment of all the dowel bars and compare to the measurements obtained using the ~~MIT scan~~^{MPI device} to verify accuracy.

Acceptance of the dowel bar position and alignment for the lot ~~will~~^{shall} be based on the mean and standard deviation of the lot ~~MIT scan~~^{MPI device} measurements for vertical alignment, horizontal alignment, longitudinal side shift and depth. The dowel bar closest to the longitudinal joint shall be removed from the analysis due to possible interference of the tie bar. ~~All MIT scan~~^{MPI device} measurements for vertical alignment, horizontal alignment and longitudinal side shift shall be converted to positive values prior to calculating the mean and standard deviation. ~~The Contract Administrator will~~^{shall} calculate the PWL for each criterion ~~as described in~~^{according to} LS-101. For calculation of PWL, the upper limit and lower limits for each attribute are as specified in Table 1.

If the lot PWL is greater than or equal to 90%, the lot is acceptable 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 defined in the Basis of Payment section.~~ ~~If the lot PWL is less than 50%, the lot shall be rejected.~~

In addition, any subplot which contains an individual dowel bar which exceeds any of the criteria identified in Table 2 for vertical alignment, horizontal alignment, horizontal side shift, longitudinal side shift and depth, is rejectable and shall be removed and replaced. The Owner shall scan joints on either side of the unacceptable subplot, until five consecutive joints on each side are found with no rejectable bars. Any joints with rejectable bars shall be removed and replaced ~~, according to OPSS 366.~~ The area of concrete to be removed shall be according to the Acceptance of Concrete Pavement and Concrete Base ~~clauses~~^{subsection}.

350.08.04.04 _____ Referee Testing ~~for Position and Alignment of Dowel Bars~~

For each measurement taken by the Owner, ~~a single~~ written request for referee testing, no more than ~~five~~³ Business Days after receiving the test results may be made. ~~Each request shall identify the sublots~~^{subplot(s)} for referee testing.

Referee testing of dowel position and alignment shall be done using ~~magnetic pulse induction equipment (MIT scan)~~ the MPI device according to ASTM E3013.

Referee testing shall be done by the Owner. -Up to two representatives can witness the referee testing.- Referee test results shall be forwarded to the Contractor as they become available.

350.08.04.04.01 Referee Testing Cost

When the referee result for a subplot confirms the acceptance test result, the Contractor shall be charged the cost of referee testing. -When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

350.08.05 Acceptance of Concrete Surface Texturing

The Contract Administrator shall select, inspect, and measure grooving areas for acceptance. -The Contract Administrator ~~will~~ shall reject all or a portion of the passwork based on the presence of one or more of the defects identified below that fall within either one of the ~~criteria~~ conditions in Table 3:

- a) Width of grooves less than 2.5 mm or greater than 4.0 mm;
~~b~~
- b) Depth of grooves less than 3 mm or greater than 6 mm, except over inductive loop detectors where the depth shall be between 1.5 and 3.0 mm; and
- c) Distances between centres of grooves less than or greater than 19 mm \pm 2.5 mm.
- e) ~~Depth of grooves less than 3 mm or greater than 6 mm.~~

350.08.06 Acceptance of Surface Smoothness

350.08.06.01 General

Lot acceptance for surface smoothness of concrete pavement or concrete base shall be based on measurements of ~~Mean Roughness Index (MRI)~~ and incident(s) of localized roughness. -All acceptance testing of surface smoothness shall be performed by the Owner.- Test results shall be forwarded to the Contractor as they become available.

Requirements for smoothness apply regardless of whether the concrete pavement or concrete base is constructed adjacent to existing concrete pavement or concrete base, respectively, except as provided for in the Lot Size ~~for Surface Smoothness~~ clause, paragraph d) below.

Acceptance testing of surface smoothness ~~will~~ shall be done upon completion of construction of the concrete pavement or concrete base, or as portions of the work are completed.

The Contract Administrator ~~will~~ shall arrange for acceptance testing after:

- a) Final texturing has been completed, ~~and;~~
- b) ~~written~~ Written notification that the concrete pavement or concrete base is ready for acceptance testing is received; and
- c) ~~the~~ The Contract Administrator is satisfied that the concrete pavement or concrete base is free of loose stone, debris, and obstructions.

The Contract Administrator shall provide 48 ~~hours~~ hours notice of when the surface smoothness measurements will begin. ~~-When, -When the weather conditions are unsuitable for testing,~~ according to the equipment manufacturer's recommendations ~~-weather conditions are unsuitable for testing,~~ the testing shall be suspended and ~~shall resume~~ resumed only when the conditions are acceptable ~~for testing.~~

350.08.06.02 Lot Size ~~for Surface Smoothness~~

A lot shall consist of the total quantity of concrete pavement or concrete base. -Each lot shall be ~~generally~~ divided into approximately 100 m single lane sublots. -When the last subplot is less than 50 m in length, it ~~will~~shall be added to the previous subplot.

The Owner shall measure all through lane concrete surfaces with the following exceptions:

- a) Where the posted speed is 60 km/hour or less.
- b) Lanes less than 400 m in length.
- c) Shoulders.
- d) Within the first or last 10 m length of the new concrete pavement or concrete base section where the new concrete pavement or concrete base abuts against an existing asphalt or concrete pavement where the Contractor is not responsible for the adjoining surface.
- e) Bridge decks and within 10 m of bridge deck expansion joints or approach slabs.

350.08.06.03 Measurement and Acceptance of Surface Smoothness

Smoothness measurement of the surface of the concrete pavement or concrete base, and incidents of localized roughness shall be measured according to LS-296, using an inertial profiler. The inertial profiler shall do three runs of any pavement section. The surface smoothness of each subplot shall be determined by calculating the Mean Roughness Index (MRI), the average of the International Roughness Index (IRI) values from the left and right wheel path profiles.

For concrete pavement, a subplot's smoothness shall be acceptable if the average MRI is less than or equal to 1.000 m/km. -If the subplot's MRI is greater than 1.000 m/km but less than or equal to 1.250 m/km, the subplot is accepted with a price adjustment according to the Basis of Payment section or may be repaired by diamond grinding. -If the subplot's MRI is greater than 1.250 m/km, the subplot is unacceptable and shall be repaired by diamond grinding or removed and replaced.

For concrete base, a subplot's smoothness shall be acceptable if the average MRI is less than or equal to 1.200 m/km. -If the subplot's MRI is greater than 1.200 m/km but less than or equal to 1.500 m/km, the subplot is accepted with a price adjustment according to the Basis of Payment section or may be repaired by diamond grinding. -If the subplot's MRI is greater than 1.500 m/km, the subplot is unacceptable and shall be repaired by diamond grinding or removed and replaced.

In addition, for concrete pavement or concrete base, incidents of localized roughness of less than 2.400 m/km are acceptable. -Incidents of localized roughness between 2.400 m/km and 3.499 m/km are accepted with a price adjustment or may be repaired by diamond grinding. -Incidents of localized roughness greater than or equal to 3.500 m/km are unacceptable and shall be repaired by diamond grinding or removed and replaced.

350.08.06.04 Referee Testing ~~of Surface Smoothness~~

Referee testing for a subplot may only be invoked within ~~five~~5 Business Days of receiving the test results for that subplot with a written request to the Contract Administrator.

The referee inertial profiler shall be designated by the Owner based on the applicable roster. -Referee test results shall be forwarded to the Contractor as they become available.

All sublots that are requested for referee testing shall be re-measured, according to LS-296 within 21 Business Days of the Contract Administrator receiving the written request for referee testing. -The disposition of all of the

re-measured sublots and all incident(s) of localized roughness that are located within those sublots shall be based on the referee measurements and the results shall be binding on both the Contractor and the Owner.

~~For re-measured smoothness measurements that fall within 5% of the original measurement, the original measurement shall be accepted.~~

350.08.06.04.01 Referee Testing Cost

If referee testing is invoked and the MRI for the sublots tested in that request is either higher or less than 10% lower than the MRI determined from the original MRI measurements taken by the quality assurance inertial profiler for those sublots, then the Contractor shall be charged the cost of the referee testing, otherwise, the Owner shall bear the cost.

350.08.07 Acceptance of Repairs

350.08.07.01 General

At the discretion of the ~~Owner~~Contract Administrator, where defects or deficiencies have been repaired by either standard methods or by Contractor proposal, the ~~Owner~~Contract Administrator shall:

- a) ~~conduct a visual inspection and/or other measures as required including requesting;~~
- b) ~~request~~ additional coring ~~when required~~
- c) ~~or any other testing deemed necessary to assess the effectiveness of the repairs.~~

All repaired or replaced areas shall be measured by the Owner to ensure they meet the requirements of this specification.

350.08.07.0102 Acceptance of Repair of Surface Tolerance and Surface Smoothness Deficiencies

The Contractor shall inform the Contract Administrator, in writing, when the repaired sublots are ready for acceptance re-measurement by the Owner. ~~Sublots repaired by diamond grinding to correct deficiencies or as chosen by the Contractor, or areas that have been removed and replaced, shall be re-measured for surface smoothness.~~

A repaired subplot shall be evaluated for acceptance according to the Acceptance of Surface Smoothness clause and Acceptance of Concrete Surface Texturing subsection.

Grooving in areas that have been diamond ground after final texturing shall be re-evaluated for acceptance according to the Acceptance of Concrete Surface Texturing subsection.

The Contractor shall be responsible for the cost of re-measurement of repaired sublots.

350.08.08 ~~Acceptance of Hot Poured Rubberized Joint Sealing Compound~~

~~Hot poured rubberized joint sealing compound shall be acceptable if it meets the requirements of OPSS 1212, "All District" category. Unacceptable hot poured rubberized joint sealing compound shall be removed and replaced at no additional cost to the Owner.~~

350.08.09 Scaling Warranty

The Contractor shall warrant that throughout and at the end of the warranty period, there shall be no areas of medium or severe scaling of the concrete pavement and the total area of light scaling shall be no more than 20% of the concrete pavement surface. ~~Visual inspection and assessment of severity of scaling shall be according to Figures 1- 6. Areas of medium and severe scaling shall be removed and replaced. For light scaling greater than 20% of the component, a repair proposal shall be submitted to the Owner for approval.~~

350.08.0908.01 _____ **Warranty Period**

The warranty period shall begin on the date of the Certificate of Substantial Performance and shall continue for ~~three~~3 years.

350.08.0908.02 _____ **Termination of the Warranty**

~~The Owner shall terminate the warranty by issuing the Release from Warranty notice no later than 30 Days after the Owner confirms that the repair and performance requirements were met or exceeded.~~

~~**350.08.09.03** _____ **Non-Compliance to the Warranty**~~

~~Failure to comply with the requirements of the warranty may be referred to the Ministry of Transportation's Qualification Committee using the infraction report process without prejudice to any right or remedy the ministry may have in law.~~

350.08.09.04 _____ **Distress Survey**

The Owner may carry out a survey at any time during the warranty period. ~~Severity and extent of surface scaling~~ will~~shall~~ be evaluated ~~in accordance with~~according to the requirements of this specification.

Survey results shall be sent to the Contractor at least 60 ~~days~~Days prior to the end of the warranty.

350.09 _____ **MEASUREMENT FOR PAYMENT**

350.09.01 _____ **Actual Measurement**

350.09.01.01 _____ **Concrete Pavement**
_____ **Concrete Base**

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

350.09.02 _____ **Plan Quantity Measurement**

When measurement is by Plan Quantity, such measurement shall 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**

350.10.01.01 _____ **General**

Payment at the Contract price for the above tender item(s) shall be full compensation for all labour, equipment and material required to do the work subject to payment adjustments.

Payment will~~shall~~ not be made for diamond grinding, other repairs and areas removed and replaced as detailed in this specification.

350.10.01.02 **Combined Payment Factor for 28-Day Compressive Strength, Air Void System Parameters, Rapid Chloride Permeability and Thickness**

350.10.01.02.01 **General**

The total combined payment factor (PF_{TC}) for 28-Day compressive strength, air void system parameters, rapid chloride permeability and thickness shall be calculated using the following formula:

$$\text{Payment Factor (PF}_{TC}\text{)} = (\text{PF}_{\text{strength}} + \text{PF}_{\text{AVS}} + \text{PF}_{\text{RCP}} + \text{PF}_{\text{thickness}}) - 3$$

Where:

- PF_{strength} = Payment factor for 28-Day compressive strength
- PF_{AVS} = Payment factor for air void system parameters
- PF_{RCP} = Payment factor for rapid chloride permeability
- PF_{thickness} = Payment factor for thickness

The sum of PF_{strength}, PF_{AVS}, PF_{RCP}, and PF_{thickness}, shall be as calculated, but shall not be less than 3.8.

The combined payment factor 28-Day compressive strength, air void system parameters, rapid chloride permeability and thickness shall be rounded to three decimal places, according to LS-100.

350.10.01.02.01 ~~01~~ **02** **Payment Factors for Thickness and 28-Day Compressive Strength**

The payment factors for thickness (PF_{thickness}) and ~~28-day~~ 28-Day compressive strength (PF_{strength}) shall be determined according to Table 4.

350.10.01.02.02 ~~03~~ **03** **Payment Factor for Air Void System Parameters**

The payment factor for air void system parameters (PF_{AVS}) for the entire lot will shall be the average of the individual payment factors for all measured sublots within the lot.

The individual payment factors for each acceptable subplot and each unacceptable subplot that the Owner has permitted to remain in the Work will shall be determined by the Contract Administrator according to Table 5. For the purpose of calculating the individual payment factors for each subplot, the Contract Administrator shall round-off spacing factor test data to two decimal places and air content test data to one decimal place according to LS-100.

350.10.01.02.03 ~~04~~ **04** **Payment Factor for Rapid Chloride Permeability**

The payment factor for rapid chloride permeability (PF_{RCP}) for the entire lot will shall be the average of the individual payment factors for all measured sublots within the lot. The Contract Administrator shall round the payment factors for each subplot and lot to two decimal places according to LS-100.

The individual payment factor for each acceptable subplot shall be 1.00.

The individual payment factor for each unacceptable subplot that the Owner has permitted to remain in the Work will shall be determined by the Contract Administrator as follows:

$$\text{Sublot } \text{PayPayment} \text{ Factor} = 1.0 - \frac{(C - 2500)}{2000} \times 1.00 - \frac{C - 2500}{2000}$$

Where:

C = = Rapid chloride permeability of the subplot (coulombs)

350.10.01.03__ Payment Factor and Pay Adjustments for Surface Smoothness

350.10.01.03.01 Mean Roughness Index

A subplot's payment factor for smoothness willshall be based on the initial quality assurance measurements unless that subplot has been repaired by diamond grinding or the initial quality assurance ~~Mean Roughness Index (MRI)~~ has been substituted as a result of referee testing. - Where a subplot has been repaired by diamond grinding, the subsequent measurements taken after the repair willshall be used in the calculation for the payment adjustment to that subplot. - No subplot that has been repaired by diamond grinding for any reason shall receive a payment factor greater than 1.000. The Contractor's optional diamond grinding according to the Optional Diamond Grinding to Improve Surface Tolerance and Smoothness subsection shall be deemed to be a repair and shall not receive a payment factor greater than 1.000.

For concrete pavement, any subplot with an initial MRI measurement for the three runs that is greater than 1.000 m/km but less than or equal to 1.250 m/km, the Contractor may either accept the inclusion of its payment factor in the calculation for the lot or choose to repair at least a portion of the subplot by diamond grinding.

For concrete pavement, the individual payment factors for each subplot willshall be determined by the Contract Administrator by substituting the MRI's into the applicable formulae shown in Table 6 and rounding to three decimal places, according to LS-100.

~~The~~ For concrete pavement, the payment factor for the entire lot ($PF_{smoothness}$) shall be the lesser of the following:

- a) The average of the individual payment factors for all measured sublots of concrete pavement within the lot, rounded to three decimal places, according to LS-100; or
- b) 1.020.

~~PF_{smoothness} = the payment factor for smoothness for the lot~~

For concrete base, any subplot with an initial MRI measurement for the three runs that is greater than 1.200 m/km but less than or equal to 1.500 m/km, the Contractor may either accept the inclusion of its payment factor in the calculation for the lot or choose to repair at least a portion of the subplot by diamond grinding.

For concrete base, the individual payment factors for each subplot willshall be determined by the Contract Administrator by substituting the MRI's into the applicable formulae shown in Table 7 and rounding to three decimal places, according to LS-100.

~~The~~ For concrete base, the payment factor for the entire lot ($PF_{smoothness}$) shall be the lesser of the following:

- a) The average of the individual payment factors for all measured sublots of concrete base within the lot, rounded to three decimal places, according to LS-100, or
- b) 1.000.

~~PF_{smoothness} = the payment factor for smoothness for the lot~~

~~For contracts with Tender Opening Date of 2020, if the average Payment Factor is below 1.000, the Payment Factor shall be re-calculated using the equations given in Table 8. The modified Payment Factor shall be used to calculate the Payment Adjustment.~~

350.10.01.03.02 Incident(s) of Localized Roughness

The Contractor willshall either be given payment adjustments or be required to repair all incidents of localized roughness according to Table ~~9-8~~. Where two or more incidents of localized roughness are found to be within ~~3-2~~ m of one another and they are left unrepaired, the localized roughness at those locations willshall be treated as a single incident of localized roughness. -The MRI of that single incident of localized roughness willshall be

the MRI for all the individual incidents of localized roughness within that 32 m for assessment of payment adjustment.

The surface smoothness payment adjustment for any subplot which includes any unrepaired incidents of localized roughness willshall be unaffected by any payment adjustment given for such incidents of localized roughness.

350.10.01.04 _____ Payment Factor for Position and Alignment of Dowel Bars

The payment factor for position and alignment of dowel bars willshall be calculated using the following formula:

$$PF_{\text{dowel bars}} = PF_{\text{horizontal}} + PF_{\text{vertical}} + PF_{\text{sideshift}} + PF_{\text{depth}} - 3$$

Where:

$PF_{\text{horizontal}}$ = Payment factor for horizontal alignment

PF_{vertical} = Payment factor for vertical alignment

$PF_{\text{sideshift}}$ = Payment factor for longitudinal side shift

PF_{depth} = Payment factor for depth

The payment factors of the dowel bars for horizontal and vertical alignment, longitudinal side shift and depth shall each be calculated using the equations in Table 109, rounded to three decimal places, according to LS-100.

350.10.01.05 _____ Payment Adjustment

The payment factors (PF_{TC} , $PF_{\text{smoothness}}$, and $PF_{\text{dowel bars}}$) shall be used to calculate the overall payment adjustment(s) for thickness, strength, AVS, RCP, surface smoothness, and position and alignment of dowel bars. ~~If applicable, the overall maximum bonus shall be as calculated below except it shall not exceed 5.00 % for concrete pavement and 3.00 % for concrete base.~~

The payment adjustment willshall be calculated by the Contract Administrator using the following formula:

$$\text{Payment Adjustment} = \text{Lot Size (m}^2\text{)} \times \text{Tender Unit Price (\$/m}^2\text{)} \times \{((\text{T} \times ((PF_{\text{TC}} + PF_{\text{smoothness}} + PF_{\text{dowel bars}}) - 2)) - 1)\}$$

Where:

Lot Size = Total quantity of concrete pavement or concrete base having the same specified thickness, the same specified 28-Day compressive strength, and having dowel bars placed by the same method, in m².

T = Tender Unit Price in \\$/m²

$PF_{\text{smoothness}}$ = the payment factor for smoothness for the lot

The sum of PF_{TC} , $PF_{\text{smoothness}}$, and $PF_{\text{dowel bars}}$ shall be as calculated, but not less than 2.2.

~~Lot Size = Total quantity of concrete pavement or concrete base having the same specified thickness, the same specified 28-Day compressive strength, and having dowel bars placed by the same method.~~

When the total quantity of concrete pavement or concrete base for the ~~contract~~Contract is covered by one lot, a single payment adjustment willshall be calculated according to the formula above.

When the total quantity of concrete pavement or concrete base for the ~~contract~~Contract is divided into more than one lot due to different specified thickness, specified 28-Day compressive strength, or dowel bar placement method, the Contract Administrator willshall calculate multiple payment adjustments.

Table 11.10 illustrates how lot size is determined for each payment adjustment and which payment factors are input into the calculation.

TABLE 1
Specification Limits for Position and Alignment of Dowel Bars

Attribute	Lower Limit (mm)	Upper Limit (mm)
Horizontal alignment (mm)	Not Applicable	15
Vertical alignment (mm)	Not Applicable	15
Longitudinal Side Shift (mm)	Not Applicable	50
Depth Tolerance (for specified <u>concrete</u> pavement or <u>concrete</u> base thickness):		
< 215 mm	Mid-depth -6	Mid-depth +6
215 to 229 mm	Mid-depth -12	Mid-depth +15
≥ 230 mm	Mid-depth -15	Mid-depth +25

TABLE 2
Rejection Criteria for Position and Alignment of Dowel Bars

Attribute	Lower Limit (mm)	Upper Limit (mm)
Horizontal alignment (mm)	-38	38
Vertical alignment (mm)	-38	38
Horizontal or Longitudinal Side Shift (mm)	-75	75
Depth (for specified <u>concrete</u> pavement or <u>concrete</u> base thickness):		
< 215 mm	Mid-depth -10	Mid-depth +10
215 to 229 mm	Mid-depth -18	Mid-depth +23
230 to 259 mm	Mid-depth -25	Mid-depth +35
≥ 260 mm	Mid-depth -25	Mid-depth +40

TABLE 3
Grooving Rejection Criteria Condition

Extent <u>Number</u> of Grooving Outside Tolerances as Specified <u>Grooves in Acceptance Clause One Pass</u>	Continuous Length Greater Than
> 1/3 No. Grooves in pass	20 m
> 2/3 No. Grooves in pass	10 m

TABLE 4
Payment Factors for Strength and Thickness

Percent Within Limits (PWL)	Payment Factor (PF)
PWL > 95	PF = 1.000 + [0.001(PWL-95)] (Bonus)
90 ≤ PWL ≤ 95	PF = 1.00
50 ≤ PWL < 90	PF = 0.55 + 0.005 PWL

TABLE 5
Payment Factor per Sublot for Air Void System Parameters of Hardened Concrete

Spacing Factor, mm	Air Content, %																				
	≤1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	≥3.0
<0.200	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.02
0.200	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.01
0.210	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.01
0.220	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.01
0.230	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.00
0.240	0.50	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95
0.250	0.48	0.50	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95
0.260	0.45	0.48	0.50	0.52	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93

Notes:
A. Thick line between 0.230 and 0.240 mm spacing factor indicates maximum acceptable spacing factor.
B. Thick line between 2.9 and 3.0% air content indicates minimum acceptable air content.
C. Shaded cells indicate acceptable air void system parameters.

TABLE 6
Sublot Payment Factors Based on MRI for Concrete Pavement

MRI (m/km)	Sublot Payment Factors
≤ 0.500	1.200 (subject to Note 1 given below 1)
> 0.500 to 0.650	1.867 - (1.333 × MRI) (subject to Note 1 given below)
> 0.650 to 1.000	1.000
> 1.000 to 1.250	2.200 - (1.200 × MRI)

Notes:
1. The payment factor shall not exceed 1.000 for subsequent MRI measurements which are taken after repairs by diamond grinding regardless of the reason for the repairs.

TABLE 7
Sublot Payment Factors Based on MRI for Concrete Base

MRI (m/km)	Sublot Payment Factors
≤ 1.200	1.000
> 1.200 to 1.500	2.200 - (MRI)

TABLE 8
Payment Adjustments and Repairs for Incidents of Localized Roughness

MRI (m/km)	Payment Adjustment
2.400 to 3.499	<p><u>Notes:</u></p> <p><u>1. The payment factor for concrete base shall not exceed 1.000. The Contractor shall receive a payment reduction of \$3,000 for each incident of localized roughness located in multi-lane freeways, and \$2,500 for each incident of localized roughness located in all other Highway types.</u></p> <p><u>Repairs shall be allowed for any incident of localized roughness in this range. If the repair removes the incident of localized roughness, then the payment adjustment for that incident of localized roughness shall be waived.</u></p>
≥ 3.500	<u>All incidents of localized roughness in this range shall be repaired.</u>

TABLE 8
Modified Sublot Payment Factor for Smoothness

Year of Tender Opening	Modified Sublot Payment Factor (ModPF_{smoothness})
2020	$\text{ModPF}_{\text{smoothness}} = ((1 - \text{PF}_{\text{smoothness}}) \times 0.2) + \text{PF}_{\text{smoothness}}$

TABLE 9
Payment Adjustments / Repairs for Localized Roughness

Incidents of Localized Roughness (Note 1)	Payment Adjustment
2.400 to 3.499	The Contractor shall receive a payment reduction of \$3,000 for each incident of localized roughness located in multi lane freeways, and \$2,500 for each incident of localized roughness located in all other highway types. Repairs will be allowed for any incident of localized roughness in this range. If the repair removes the incident of localized roughness, then the payment adjustment for that incident of localized roughness will be waived.
≥ 3.500	All incidents of localized roughness in this range shall be repaired.
<p><u>Notes:</u></p> <p><u>1. MRI determined from three sets of measurements taken by an inertial profiler, m/km.</u></p>	

TABLE 10
Payment Factors for Position and Alignment of Dowel Bars

Percent Within Limits (PWL) <u>PWL</u>	Payment Factor (PF)
90 ≤ PWL ≤ 100	PF = 1.00
50 ≤ PWL < 90	PF = 0.55 + 0.005PWL

TABLE 110

Illustrative Examples of How to Determine Lot Size for Payment Adjustments

<p>Case A: All <u>When all</u> concrete pavement or concrete base has the same specified thickness, specified strength, and dowel bar placement method. Total quantity of concrete pavement or concrete base on contract <u>Contract</u> = 100,000 m²</p>
<p><u>Lot Size for Strength, AVS, RCP & Thickness Lot 1 = 100,000 m² (PF_{TC 1})</u> <u>Lot Size for Smoothness Lot 1 = 100,000 m² (PF_{smoothness 1})</u> <u>Lot Size for Dowel Bars Lot 1 = 100,000 m² (PF_{dowel bars 1})</u></p>
<p><u>Lot Size for Payment Adjustment = 100,000 m²</u> <u>Payment Adjustment = 100,000 m² x T x [(PF_{TC 1} + PF_{smoothness 1} + PF_{dowel bars 1}) - 2] - 1]</u></p>
<p>Case B: <u>When all concrete pavement or concrete base has the same specified thickness, specified strength, but different dowel bar placement methods.</u> <u>Total quantity of concrete pavement or concrete base on Contract = 100,000 m²</u></p>
<p>Lot Size for Strength, AVS, RCP & Thickness <u>Thickness</u> Lot 1 = 100,000 m² (PF_{TC 1}) Lot Size for Smoothness Lot 1 = 100,000 m² (PF_{smoothness 1}) Lot Size for Dowel Bars Lot 1 = 100 <u>75</u>,000 m² (PF_{dowel bars 1}) <u>Lot Size for Dowel Bars Lot 2 = 25,000 m² (PF_{dowel bars 2})</u></p>
<p>Lot Size for Payment Adjustment = 100 <u>75</u>,000 m² Payment Adjustment = 100 <u>75</u>,000 m² x Tender Unit Price x [(x T x [(PF_{TC 1} + PF_{smoothness 1} + PF_{dowel bars 1}) - 2] - 1]</p>
<p><u>Lot Size for Payment Adjustment 2 = 25,000 m²</u> <u>Payment Adjustment 2 = 25,000 m² x T x [(PF_{TC 1} + PF_{smoothness 1} + PF_{dowel bars 2}) - 2] - 1]</u></p>
<p>Case B: Concrete C: <u>When concrete</u> pavement or concrete base <u>is</u> divided into different lots due to specified thickness, specified strength, or <u>and</u> dowel bar placement method. Total quantity of concrete pavement or concrete base on contract <u>Contract</u> = 100,000 m²</p>
<p>Lot Size for Strength, AVS, RCP & Thickness Lot 1 = 40,000 m² (PF_{TC 1}) Lot Size for Strength, AVS, RCP & Thickness Lot 2 = 60,000 m² (PF_{TC 2}) Lot Size for Smoothness Lot 1 = 100,000 m² (PF_{smoothness 1}) Lot Size for Dowel Bars Lot 1 = 75,000 m² (PF_{dowel bars 1}) Lot Size for Dowel Bars Lot 2 = 25,000 m² (PF_{dowel bars 2})</p>
<p>Lot Size for Payment Adjustment 1 = 40,000 m² Payment Adjustment 1 = 40,000 m² x Tender Unit Price x [(x T x [(PF_{TC 1} + PF_{smoothness 1} + PF_{dowel bars 1}) - 2] - 1]</p>
<p>Lot Size for Payment Adjustment 2 = 35,000 m² Payment Adjustment 2 = 35,000 m² x Tender Unit Price x [(x T x [(PF_{TC 2} + PF_{smoothness 1} + PF_{dowel bars 1}) - 2] - 1]</p>
<p>Lot Size for Payment Adjustment 3 = 25,000 m² Payment Adjustment 3 = 25,000 m² x Tender Unit Price x [(x T x [(PF_{TC 2} + PF_{smoothness 1} + PF_{dowel bars 2}) - 2] - 1]</p>

FIGURE 1
Example of Light Scaling



FIGURE 2
Example of Light Scaling



FIGURE 3
Example of Medium Scaling



FIGURE 4
Example of Medium Scaling



FIGURE 5
Example of Severe Scaling



FIGURE 6
Example of Severe Scaling

