CONSTRUCTION SPECIFICATION FOR HOT IN-PLACE RECYCLING

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332.01 SCOPE

This specification covers the requirements for the preparation of the existing pavement surface; heating and hot milling the existing hot mix asphalt; adding and mixing in one or more of rejuvenating agent and beneficiating hot mix asphalt; and redistribution and compaction of the Hot In-Place Recycled mix in a single operation.

332.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be as specified in the Contract Documents.

332.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

332.02 REFERENCES

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Construction

OPSS 310 Hot Mix Asphalt

Ontario Provincial Standard Specifications, Material

OPSS 1101 Performance Graded Asphalt Cement
OPSS 1150 Hot Mix Asphalt
OPSS 1151 Superpave and Stone Mastic Asphalt Mixtures

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual

LS-261 Preparation of Marshall Specimens
LS-262 Bulk Relative Density of Compacted Bituminous Mixes
LS-263 Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus
LS-264 Theoretical Maximum Relative Density of Bituminous Paving Mixtures
LS-265 Determination of Percent Air Voids in Compacted Dense Bituminous Pavement Mixtures
LS-282 Quantitative Extraction of Asphalt Cement and Analysis of Extracted Aggregate from Bituminous Paving Mixtures
LS-284 Recovery of Asphalt from Solution by Abson Method or Rotavapor
LS-287 Determination of Percent Compaction of Compacted Bituminous Paving Mixture (MRD Method)

LS-292 Quantitative Determination of Asphalt Cement Content by Ignition and Analysis of Remaining Aggregate from Bituminous Paving Mixtures
LS-306 Bulk Relative Density of Compacted Bituminous Mixtures Using Paraffin Coated Specimens

ASTM International

D 6752-11 Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

American Association of State Highway and Transportation Officials (AASHTO)

M 323-13 Superpave Volumetric Mix Design
T 166-13 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
T 209-09 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
T 275-07 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens

332.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 310, OPSS 1150, OPSS 1151, and the following definitions apply:

Asphalt Cement (AC) means asphalt binder as defined in OPSS 1101.

Attribute means one of the following properties: designated large sieve (DLS), 4.75 mm sieve, 75 µm sieve, AC content, air voids, lift thickness, compaction, or recovered asphalt cement (RAC) performance grade.

Beneficiating HMA means a HMA designed so that the final HIR mix shall be as specified in the Contract Documents.

Design Lift Thickness (T_D) means the thickness in millimetres of the HIR mix as specified in the Contract Documents.

High Temperature Performance Grade (XX) means the high temperature performance grade specified in the Contract Documents and also referred to as the XX specified for the RAC where the RAC grade specified is PG XX-YY, and the maximum design pavement temperature.

Hot In-Place Recycled (HIR) Mix means the mixture of hot milled material containing one or more of the following components: rejuvenating agent and beneficiating HMA.

Hot Milled Material means the material produced during the heating and hot milling of the existing HMA.

Hot Milling means the process of applying adequate heat to the pavement to sufficiently soften the pavement, followed by the use of milling heads to uniformly remove the heated material to the depth specified in the mix design submission with minimal fracturing of the existing aggregates.

Joint means a vertical contact between a HIR mix and any pavement or any rigid object that exists at the time the HIR mix is laid.

Lift Thickness means the thickness in millimetres of the placed and compacted HIR mix.

Loose Mix means a representative sample of uncompacted HIR mix for testing mix properties or the RAC performance grade.

Low Temperature Performance Grade (-YY) means the low temperature performance grade specified in the Contract Documents and also referred to as the -YY specified for the RAC where the RAC grade specified is PG XX-YY, and the minimum design pavement temperature.

Mix Design means the design of the proportions of new and existing aggregates; new and existing AC; rejuvenating agent; and additives; when uniformly mixed, that results in an acceptable HIR mix.

Mix Properties means the AC content, gradation, and air voids.

Recovered Asphalt Cement (RAC) means the AC recovered from the HIR mix according to the Rotavapor Method in LS-284, using re-agent grade tricholorethylene, or other solvent acceptable to the Owner.

Rejuvenating Agent means a product that when added to the hot milled material; the RAC from the HIR mix meets the requirements of the Contract Documents.

Screed means the unit of the placement unit of the recycling train that strikes off and imparts initial compaction to the HIR mix.

332.04 DESIGN AND SUBMISSION REQUIREMENTS

The HIR mix design shall be as specified in the Contract Documents and according to the Design and Submission Requirements section of OPSS 1150 for HIR mixes required to meet a Marshall mix type and OPSS 1151 for HIR mixes required to meet a Superpave mix type.

HIR mix designs shall not incorporate RAP from other sources or RST into the HIR mix.

The following additional information shall be submitted to the Contract Administrator in writing with the mix design:

a) The amount, name, manufacturer, and supplier of the rejuvenating agent or beneficiating HMA or both, if to be used;

b) The hot milling depth to meet the required mix properties and the design lift thickness, as specified in the Contract Documents, with a maximum increase in pavement elevation of 15.0 mm;

c) The mix proportions, gradation, and source of the materials in the beneficiating HMA, if to be used;

d) A copy of all calculations that were completed to determine the amount of rejuvenating agent or beneficiating HMA or both, if to be used;

e) Air void laboratory test results and calculations for the HIR mix; and

f) A graph of temperature-kinematic viscosity relationship for the combined rejuvenating agent, the recovered AC present in the existing pavement, and the new AC in the beneficiating HMA.

g) When applicable, a declaration that the percentage of the beneficiating HMA comprising quartzite and dolomitic sandstone aggregates, or combinations thereof, is more than 75%.

Each mix design shall be valid for the section of roadway it was designed for.

332.05 MATERIALS

332.05.01 Hot In-Place Recycled Mix

The HIR mix produced shall be according to the mix design and meet the requirements of Tables 1, 2, and 3. For HIR mix required to meet a Marshall mix type, the HIR mix produced shall also meet the requirements of Table 4.

332.05.01.01 Recovered Asphalt Cement

The RAC recovered from the HIR mix produced shall be according to the Materials section of OPSS 1101 for PGAC and as specified in the Contract Documents.

332.05.01.02 Beneficiating Hot Mix Asphalt

The materials used in the production of the beneficiating HMA shall be according to OPSS 1150 for HIR mixes required to meet a Marshall type and OPSS 1151 for HIR mixes required to meet a Superpave mix type.

The composition of the beneficiating HMA shall not contain RAP or RST.

332.05.02 Release Agents

No release agents shall be used that may adversely affect the quality or performance of the HIR mix. Release agents shall be used according to the proprietary requirements.

Petroleum based release agents, excess water, or excess release agents shall not be used.

332.06 EQUIPMENT

332.06.01 Paving Equipment

Paving equipment shall be according to OPSS 310.

332.06.02 Rollers

Rollers shall be according to OPSS 310.

332.06.03 Heating Unit

Heating units shall apply heat in a uniform manner to the surface of the existing pavement to be hot milled. Open flame heating of the existing HMA pavement shall not be permitted.

Heaters shall be spaced and operated so that:

a) Sufficient heat penetration of the pavement shall be achieved, with heat penetration into the underlying pavement beneath the hot milling depth specified in the mix design submission;

b) The desired HIR mix temperatures are achieved; and

c) The existing HMA surface is not burnt or scorched.

332.06.04 Recycling Train

The recycling train shall be self-contained mechanical units specifically designed for HIR of HMA pavements. The recycling train shall have the capability to process the existing pavement to a depth of at least 50 mm.

Heaters used as part of the recycling train shall be according to the Heating Unit subsection.

The recycling train shall include hot milling, blending, and placement units.

332.06.04.01 Hot Milling Unit

The hot milling unit shall be capable of uniformly milling the preheated HMA to the hot milling depth specified in the mix design submission.

332.06.04.02 Blending Unit

The blending unit shall be capable of thoroughly mixing the hot milled material, rejuvenating agent, and beneficiating HMA.

332.06.05 Diamond Grinding

A diamond grinder shall be power-driven, self-propelled, and designed for grinding HIR mix or HMA. It shall be equipped with a grinding head with at least 50 diamond blades per 300 mm of shaft. The grinding head shall be at least 0.9 m wide. The grinder shall be equipped with the capability to adjust the depth, slope, and crossfall to remove HIR mix or HMA to the required profile and shall also include a slurry pick-up system.

332.07 CONSTRUCTION

332.07.01 Quality Control

QC procedures shall be conducted to ensure the HIR mix meets the requirements of the Contract Documents. The Contractor shall be responsible for interpretation of the QC test results and the determination of any action to be taken to ensure that all materials and work are as specified in the Contract Documents. QC documentation shall be made available to the Contract Administrator upon request. Sampling and testing methods shall be included in the QC documentation.

A laboratory that has current CCIL Type B Certification or AMRL equivalent certification or other equivalent certified laboratory acceptable to the Contract Administrator shall be used. Testing of the samples shall be conducted under the direct and constant supervision of technicians certified to perform the QC tests according to CCIL or equivalent certification.

A single sample for QC purposes may be obtained at the same time and location as QA acceptance samples. No additional loose mix samples shall be taken from the placed HIR mix.If further additional samples are required, a written request shall be made to the Contract Administrator, and samples shall only be taken upon written approval of the Contract Administrator. All sample locations shall be restored as specified in the Contract Documents.

332.07.02 Preparation of Existing Pavement

Prior to the HIR operation:

a) Existing HMA surfaces shall be clean and free of all loose, broken, and foreign materials.

b) Milled existing HMA surfaces shall be clean and free of all loose, broken, and foreign materials and shall be swept with a power broom.

c) Removal of cold mix patching material, crack sealant, and spray patch material shall be as specified in the Contract Documents (FS: pp 44)

Existing surfaces to be HIR may be corrected by additional cold milling, hot milling, addition of beneficiating HMA or a combination, in order to place and compact the HIR mix to the design thickness specified in the Contract Documents.

Removal of the existing pavement by the hot milling unit shall be performed in such a manner as to leave adjacent pavement and structures remaining in place undisturbed and undamaged. All damaged or disturbed portions shall be corrected expeditiously and repaired to the satisfaction of the Contract Administrator. Broken edges of portions to be left in place that are visible after construction shall be squared and neatly trimmed.

332.07.03 Transportation of Beneficiating Hot Mix Asphalt

The beneficiating HMA shall be transported from the asphalt plant to the work in leak proof truck boxes that have been previously cleaned of all foreign materials. If required, truck boxes shall be lightly coated with a uniform application of a release agent. Truck boxes shall be drained after each application and before loading.

Each truck shall use a tarpaulin of sufficient size to completely cover the load at all times.

332.07.04 Placing Hot In-Place Recycled Mix

332.07.04.01 Operational Constraints

The HIR process shall not be carried out if the roadbed is frozen.

The surface of a pavement which is to be HIR shall be dry at the time of the HIR processing. The HIR process shall be carried out when the roadway is clean and free of standing water. The HIR process shall not proceed in the rain.

The supply of any materials to the recycling train shall be accomplished with no traffic on the uncompacted mat. Public traffic shall not be permitted on freshly laid HIR mix until the temperature of the mat is 50 °C or less.

332.07.04.02 Paving

The heating units and recycling train shall heat and hot mill the HMA pavement across the complete lane width, and partial width shoulder if applicable, to the hot milling depth specified in the mix design submission.

The underlying pavement shall be heated to a minimum temperature of 50 ºC.

When inspection and testing indicates that the required average depth of heating and hot milling is not being met, the process shall be immediately corrected.

Rejuvenating agent and/or beneficiating HMA shall be added to and mixed with the hot milled material in the amount specified in the mix design. The HIR mix shall be homogeneous after mixing.

The final placement of the HIR mix by the recycling train shall be uniformly distributed to the specified profile and crossfall. The HIR mix shall be compacted to the design lift thickness specified in the Contract Documents and meet all acceptance criteria specified in the Contract Documents.

Each successive pass of the recycling train shall overlap the previously HIR adjacent surface by a minimum of 100 mm.

The temperature of the HIR mix immediately behind the screed and prior to rolling shall not be less than 120 °C.

Prior to roller compaction, obvious defects in the HIR mix placed shall be corrected. Irregularities in the alignment and grade along the outside edges shall be corrected. Excess HIR mix shall not be cast onto the surface of the freshly laid mat. After final compaction the surface shall be smooth and true to the established crown and grade, uniform in texture and shall be free of any defects.

All through lane HIR mix shall be completed prior to the placement of adjacent sideroads, speed change lanes, and other paved areas.

Areas that are not accessible to the heating and hot milling equipment shall have the HMA removed to the depth required to meet the design lift thickness requirements specified in the Contract Documents. These areas shall be tacked coated and paved with the HMA mix type the HIR is required to meet according to OPSS 310. The surface of each layer placed and compacted shall be level with the adjacent pavement. The paving of such areas shall be completed prior to the placing of any subsequent course on the HIR mix, if applicable, and as a separate operation from any other paving.

If the Contractor's actions fail to prevent continued medium or severe segregation regardless of cause, the Contract Administrator may instruct the Contractor to cease HIR operations until the problem has been corrected.

332.07.05 Longitudinal and Transverse Joints

All joints shall be made to obtain a complete bond between the two pavement edges and a smooth riding surface. The existing or previously placed pavement edge shall be a straight clean vertical surface for the full depth of the course. Where ramping or damage has occurred, trimming shall be required. All dirt or other foreign material and all loose material shall be removed from all vertical surfaces.

Longitudinal and transverse joints between the new HIR pavement and the existing pavement shall be butt joints as specified in the Contract Documents. All longitudinal joints at intersecting roads shall be butt joints. Heating beds on the heating units shall heat and soften material beyond the hot milling width by a minimum of 100 mm to achieve proper thermal bonding between the existing asphalt pavement and the HIR mix along the longitudinal joints. The longitudinal joints shall be parallel to the lane and visually uniform longitudinally, and within 50 mm of the demarcation between the lanes specified in the Contract Documents.

When matching a compacted joint, the depth of the uncompacted mat shall be set to allow for compaction. The paver screed shall overlap the adjoining mat by at least 50 mm.

332.07.06 Compaction

Compaction of the HIR mix shall be conducted using appropriate methods and equipment to provide a uniformly compacted mat according to the compaction requirements as per OPSS 310.

At all places not accessible to rollers, the HIR mix shall be compacted by mechanical self-powered gas-, electric-, or air-powered equipment.

332.07.07 Sampling

332.07.07.01 General

Samples shall be taken in accordance with the Contract Documents under the direction and in the presence of the Contract Administrator. Samples shall be placed in an appropriate container supplied by the Owner.

HIR mix and compaction requirements for filling all sample holes shall be the same as the adjacent undisturbed pavement. Sample holes shall be cleaned, dried, and filled and then compacted using a mechanical self-powered gas-, electric-, or air-powered compactor immediately after sampling.

332.07.07.01.01 Labelling

All samples shall be labelled with the following:

a) Contract number.

b) Location of sampling.

c) Date (i.e., yyyy-mm-dd) and time of sampling.

d) Asphalt type.

332.07.07.02 Hot In-Place Recycled Mix

The Contractor is responsible for obtaining QA and referee HIR mix samples using sample plates for Marshall mixes and other methods approved by the Contract Administrator for Superpave mixes.

When the mass of the sample does not meet the requirements of Table 5, the sample shall be discarded and a new one taken immediately.

332.07.07.02.01 Frequency and Location

The minimum frequency for sampling and testing shall be as specified in Table 5.

332.07.07.03 Lift Thickness Cores

The Contractor is responsible for obtaining QA and referee lift thickness core samples.

Each core shall be 100 mm in diameter, and shall consist of the full layer being sampled and at least one underlying layer, if one is present. Cores shall not be taken within 250 mm of a longitudinal or transverse joint or the edge of pavement.

332.07.07.03.01 Frequency and Location

The minimum frequency for sampling and testing shall be approximately once every 100 m along the length of the roadway or 300 m^2 of pavement surface.

332.07.07.04 Compaction Cores

When a coring and testing program is undertaken to resolve a dispute related to HIR compaction, the Contractor shall be responsible for all traffic control required to carry out the coring, obtaining, and labelling the core samples, delivery of the samples to a mutually agreed upon third party referee laboratory, and repairing core sample holes.

Each core shall be 150 mm in diameter, and shall consist of the full layer being sampled and at least one underlying layer, if one is present. Cores shall not be taken within 250 mm of a longitudinal or transverse joint or the edge of pavement.
Each set of samples shall be taken from the same lane, same transverse offset, and at a spacing of 1.0 m $\pm$ 0.1 m between each individual core edge.

Care shall be taken to ensure that cores are not damaged during coring operations or in transit. If a core is damaged, a replacement core shall be extracted at a location adjacent to the original core.

332.07.07.04.01 Frequency and Location

The minimum frequency of sampling and testing shall be as determined by the Contract Administrator.

332.07.08 Management of Excess Material

Management of excess material shall be as specified in the Contract Documents.

332.08 QUALITY ASSURANCE

332.08.01 General

The Contract Administrator is responsible for conducting QA procedures for all HIR attributes to meet the requirements of the Contract Documents. QA HIR testing shall be conducted at a frequency specified in Table 5 or as specified in the Contract Documents.

All QA testing shall be completed in a certified laboratory that is CCIL Type B or C, or AMRL accredited, or equivalent.

When the HIR fails to meet the requirements of the Contract Documents, the Contract Administrator may refuse further material until the mix properties are verified for compliance by one of the following methods:

a) For Marshall mixes, samples shall be used to determine compliance to asphalt cement content, aggregate gradation, air voids, flow, voids in mineral aggregate, and stability requirements.

b) For Superpave mixes, samples shall be used to determine compliance to asphalt cement content, aggregate gradation, and Superpave mix properties in accordance to AASHTO M 323.

332.08.02 Surface Tolerance

After final compaction, HIR mix shall be smooth and true to the established crown and grade. HIR mix shall be free from deviations exceeding 3 mm as measured in any direction with a 3 m straight edge. Defective areas shall be removed and replaced with acceptable HIR or HMA pavement and compacted to the satisfaction of the Contract Administrator.

332.08.03 Surface Appearance

The Contract Administrator may reject visually defective HIR areas based on, but not limited to the following defects: flushing, segregation, fat spot, surface damage, roller marks, or surface contamination. Defective areas shall be removed from the work and replaced with acceptable HIR or HMA pavement and compacted to the satisfaction of the Contract Administrator.

332.08.04 Asphalt Cement Content and Aggregate Gradation Acceptance

Aggregate gradation and asphalt cement content test results for HIR mix samples based on LS-282 and LS-292 shall meet the requirements specified in Table 1.

If the HIR mix is deemed borderline for aggregate gradation or asphalt cement content according to Table 1, the Contractor shall be notified in writing by the Contract Administrator and shall take immediate corrective action through process control. A total of three borderline test results for the same attributes representing up to 40,000 m^2 of HIR production shall result in the work being deemed rejectable.

Test results shall be acceptable if they meet the requirements specified in Table 1. If the HIR mix is deemed rejectable according to Table 1, both the Contract Administrator and the Contractor shall review, agree, and

identify the limits of rejected HIR mix that has been placed. Referee samples within the limits of the affected area shall be delivered by the Contractor to a mutually agreed upon third party referee laboratory to verify aggregate gradation or asphalt cement content or both. When the results from the referee samples are deemed rejectable according to Table 1, the HIR mix shall be removed and replaced with acceptable HIR or HMA pavement. Alternatively, the Contract Administrator may accept a guaranteed maintenance bond, an increased maintenance period, or a negotiated price adjustment.

332.08.05 Mix Properties Acceptance

The production air voids for all HIR mixes shall be evaluated according to Table 2. Marshall test results for HIR mix samples based on LS test procedures shall also meet the requirements specified in Table 4.

If the HIR mix is borderline for air voids as specified in Table 2, the Contractor shall be notified in writing by the Contract Administrator and shall take immediate corrective action through process control.

If the HIR mix does not meet Table 4 minimum requirements for Marshall stability or Marshall flow or is deemed rejectable for air voids according to Table 2, both the Contractor Administrator and the Contractor shall review, agree, and identify the limits of the rejected HIR mix that has been placed. Referee samples within the limits of the affected area shall be delivered by the Contractor to a mutually agreed upon third party referee laboratory to verify Marshall test or air voids results or both. When the results from the referee samples do not meet Table 4 minimum requirements or are deemed rejectable according to Table 2, the HIR mix shall be removed and replaced with acceptable HIR or HMA pavement. Alternatively, the Contract Administrator may accept a guaranteed maintenance bond, an increased maintenance period, or a negotiated price adjustment.

332.08.06 Lift Thickness Acceptance

The average thickness for a lift thickness core shall be based on the measurement from each quadrant of the core. The average thickness for the area shall be determined by averaging the core thicknesses.

When the average thickness is more than or equal to 95% of the specified thickness, the total surface area of the HIR mix is acceptable.

When the average thickness is less than 95% of the specified thickness, the area represented by the lift thickness core shall be subject to a payment adjustment as specified in the Payment Adjustment for Lift Thickness subsection.

332.08.07 Recovered Asphalt Cement Performance Grade Acceptance

All RAC test samples shall be obtained by recovery according to the Rotavapor Method in LS-284 using re-agent grade tricholorethylene, or other solvent acceptable to the Owner, from the loose mix HIR mix samples taken as specified in Table 5.

Test results that do not comply with the performance grading requirements shall be categorized as borderline or rejectable. RAC test results shall be categorized based on each test result's deviation from the individual design maximum or minimum pavement temperature and the sum of the deviations from the design maximum or minimum pavement temperatures defined as specified in Table 6. The actual performance grading that is either higher than the maximum design pavement temperature or lower than the minimum design pavement temperature is not considered a deviation.

If the HIR mix is deemed borderline for RAC performance grade according to Table 6, the Contractor shall be notified in writing by the Contract Administrator and shall take immediate corrective action through process control. A total of three borderline test results for the same attributes representing up to 40,000 m^2 of HIR production shall result in the work being deemed rejectable.

Test results shall be acceptable if they meet the requirements specified in Table 6. If the HIR mix is deemed rejectable according to Table 6, both the Contract Administrator and the Contractor shall review, agree, and identify the limits of rejected HIR mix that has been placed. Referee samples within the limits of the affected area shall be delivered by the Contractor to a mutually agreed upon third party referee laboratory to verify the RAC performance grading. When the results from the referee samples are deemed rejectable according to Table 6, the HIR mix shall be removed and replaced with acceptable HIR or HMA pavement. Alternatively, the Contract Administrator may accept a guaranteed maintenance bond, an increased maintenance period, or a negotiated price adjustment.

332.08.08 Compaction Requirements

332.08.08.01 General

Compaction testing of the placed HIR mix shall meet the requirements specified in Table 3.

Nuclear density test gauge results shall be used to assess in-place compaction. When compaction test results do not meet the minimum percent compaction specified in Table 3, the Contractor shall be notified in writing and either the affected area of HIR shall be removed and replaced with acceptable HIR or HMA, or in the case of a dispute, the Contractor or the Owner may request that a coring and testing program be undertaken to verify compaction percentage of the mix. The cores shall be provided to the Owner and compaction shall be determined according to the Compaction Determined by Core Density Testing clause using a mutually agreed upon third party referee laboratory. When compaction results from core densities do not meet the minimum percent compaction specified in Table 3, the HIR shall be removed and replaced with acceptable HIR or HMA.

332.08.08.02 Compaction Determined by Nuclear Density Gauge

Compaction testing shall be conducted randomly at a minimum frequency of every 100 m per lane or 150 m^2 area.

332.08.08.02.01 Marshal Hot In-Place Recycled Mix

Percent compaction shall be determined by comparing the nuclear density in situ Bulk Relative Density (BRD) according to LS-262 to the average plant produced Maximum Relative Density (MRD) according to LS-264.

332.08.08.02.02 Superpave Hot In-Place Recycled Mix

Percent compaction shall be determined by comparing the nuclear density in situ BRD to the average plant produced MRD both according to AASHTO T 209.

332.08.08.03 Compaction Determined by Core Density Testing

332.08.08.03.01 Marshall Hot In-Place Recycled Mix

Density testing of the cores shall be according to LS-287. Percent compaction shall be determined by comparing the core BRD according to LS-262 to the average MRD according to LS-264 of the plant produced HIR.

332.08.08.03.02 Superpave Hot In-Place Recycled Mix

Density testing of the cores shall be according to AASHTO T 166. If the percent water absorbed by the specimen is found to exceed 2% by volume as described in AASHTO T 166, then the bulk specific gravity shall be according to AASHTO T 275, LS-306, or ASTM D 6752. Percent compaction shall be determined by comparing the core BRD to the average MRD both according to AASHTO T 209 of the plant produced HIR.

332.09 MEASUREMENT FOR PAYMENT

332.09.01 Actual Measurement

332.09.01.01 Hot In-Place Recycled Mix

Measurement of HIR mix shall be by the horizontal area in square metres in place.

332.09.02 Plan Quantity Measurement

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

332.10 BASIS OF PAYMENT

332.10.01 Hot In-Place Recycled Mix– Item

Payment at the Contract price for the above tender item shall include full compensation for all labour, Equipment, and Materials required to do the work, including rejuvenating agent and beneficiating HMA quantities if used, and the applicable payment adjustments.

No additional payment shall be made for the work, labour, Equipment, and Materials required to remove the existing pavement, and place HMA in areas not accessible to the heating and hot milling equipment.

The preparation and correction of existing HMA surfaces carried out in order to meet the requirements of the Contract Documents, including removal of materials such as cold mix patching material, crack sealant, and spray patch material; cold milling, hot milling, and the addition of beneficiating HMA; shall be at no cost to the Owner.

HMA required to retrofit partially paved shoulders or for pavement widening shall be paid for at the Contract price for the appropriate HMA tender item. No additional payment shall be made under this item for HMA required to retrofit partially paved shoulders or for pavement widening.

When removing and replacing HIR mix, the Contractor shall be responsible for and shall carry out all associated work and replace or restore all associated damage and removals at no cost to the Owner.

Referee testing undertaken to resolve a dispute shall be at no extra cost to the Owner if the referee test results confirm that the HIR mix does not meet the requirements or is deemed borderline or rejectable according to the Quality Assurance section.

A coring, testing, and traffic control program undertaken to resolve a dispute shall be at no extra cost to the Owner if the HIR mix compaction is confirmed to not meet the requirements of the Compaction Requirements subsection.

When the Contract Administrator instructs the Contractor to cease HIR operations due to continued medium or severe segregation regardless of cause, the Owner shall not be held responsible for any additional costs that the Contractor may incur.

332.10.02 Payment Adjustment for Lift Thickness

When the average thickness is less than 95% of the specified thickness, the area represented by the lift thickness core shall be subject to a payment adjustment calculated as follows:

$$\text{Payment for the area} = \frac{\text{area} \times \text{average thickness}}{\text{specified thickness}}$$

TABLE 1
Asphalt Cement Content and Aggregate Gradation Tolerance Requirements

Properties and Attributes	Tolerance on	Tolerances %		
		Acceptable	Borderline	Rejectable
Asphalt Cement Content	Asphalt Cement Content specified (Note 1)	< 0.30	0.30 to 0.50	> 0.50
Designated Large Sieve (DLS)	Maximum and Minimum Percent Passing (Note 2 & 3)	< 1.0	1.0 to 5.0	> 5.0
4.75 mm Sieve	Maximum and Minimum Percent Passing (Note 2 & 3)	< 1.0	1.0 to 5.0	> 5.0
75 µm Sieve	Maximum Percent Passing (Note 2)	< 1.0	1.0 to 3.0	> 3.0
	Minimum Percent Passing (Note 3)	< 1.0		> 1.0

Notes:
1. Tolerances on the asphalt cement content specified in the Contract Documents apply as both plus and minus from the asphalt cement content specified in percent.
2. Tolerances on the maximum percent passing apply as plus from the maximum percent passing by dry mass of aggregate for the mix type the HIR mix shall be according to OPSS 1150 for Marshall mixes and OPSS 1151 for Superpave mixes.
3. Tolerances on the minimum percent passing apply as minus from the minimum percent passing by dry mass of aggregate for the mix type the HIR mix shall be according to OPSS 1150 for Marshall mixes and OPSS 1151 for Superpave mixes.

TABLE 2
Air Voids Requirements (LS-265)

Properties and Attributes	Mix Type HIR Mix is Required to Meet	Acceptable %	Borderline %	Rejectable %
Air Voids	DFC	2.0 to 4.5	1.5 to 1.9 and 4.6 to 5.0	< 1.5 and > 5.0
	All Other Mixes	2.5 to 5.0	1.5 to 2.4 and 5.1 to 6.0	< 1.5 and > 6.0

TABLE 3
Minimum Pavement Compaction Based on Maximum Relative Density

Properties and Attributes	Minimum Compaction %
Pavement Compaction	92.0

TABLE 4
Marshall Stability and Flow Properties

Mix Type HIR Mix is Required to Meet	Marshall Flow at 3.5% Air Voids: LS-261 and LS-263	Minimum Marshall Stability: Newtons (N) at 60 °C, LS-261 and LS-263
DFC	8.0 minimum	(Note 1)
HL 1, HL 3, and HL 4,	8.0 to 14.0	
HL 3F	9.0 to 18.0	
Notes: 1. Stability requirements shall be according to OPSS 1150.		

TABLE 5
Sampling and Testing of Hot In-Place Recycled Mix

Material Sample	Properties and Attributes	Quantity Per Day Per HIR Mix Type	Minimum Frequency of Sampling and Testing (Note 1)	Minimum Sampling Size
HIR Loose Mix	Asphalt Cement Content, Aggregate Gradation, and Mix Properties	≤ 4,000 m^2	One sample	20 kg (Note 2)
		> 4,000 and ≤ 12,000 m^2	One sample per 4,000 m^2 or part thereof	
		> 12,000 m^2	One sample per 4,000 m^2 (Note 2), minimum of 3	
HIR Loose Mix	RAC Performance Grade	Any	One sample per 40,000 m^2	10 kg
HIR Lift Thickness Core	Lift Thickness	Any	every 100 m along the length of the roadway or 300 m^2 of pavement surface	100 mm in diameter
HIR Compaction Core	Pavement Compaction	Any	every 100 m per lane or 150 m^2 of pavement surface	150 mm in diameter (Note 3)
Notes: 1. The Contract Administrator may reduce the testing frequency for HIR mix that is consistently being produced to meet the specification requirements. 2. For HIR mixes required to meet Marshall mix requirements the minimum sampling size shall be 10 kg. 3. HIR compaction core only required when compaction shall be determined by core density testing as specified in the Contract Documents.				

TABLE 6
Performance Grading Requirements and Categories for RAC

Category	**Deviation** (Note 3)	**RAC Requirements**
Borderline (Note 1)	below XX and	≤ 6 °C
	above -YY and	≤ 8 °C
	Sum	> 8 °C and ≤ 12 °C
Rejectable (Note 2)	below XX or	> 6 °C
	above -YY or	> 8 °C
	Sum	> 12 °C

Notes:
1. Performance grading shall be deemed borderline when both the individual deviations and the sum of deviations specified for the category are met.
2. Performance grading shall be deemed rejectable when any individual deviation or the sum of deviations specified for the rejectable category is met.
3. XX is the specified high temperature performance grade and design maximum pavement temperature. -YY is the specified low temperature performance grade and design minimum pavement temperature.

Appendix 332-A, November 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specifications in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

The designer should be aware of the following when selecting HIR:

HIR is limited to resurface pavements exhibiting only surficial distresses. HIR should be considered for roads with the following distress manifestations:

- Very slight to moderate ravelling / coarse aggregate loss, segregation, very slight to moderate flushing, and/or distortions

- Few to frequent very slight to moderate non-working cracks

- For 2 lane highways up to 1.0% correction in crossfall can be achieved across a single lane width using HIR, provided there are no bridge clearance or grade raise restrictions

- For multi-lane highways correction of crossfall with HIR is not recommended

HIR is not suitable for pavements exhibiting structural distresses, i.e. alligator cracking, lack of structural capacity, working cracks, severe distortions, and/or instability rutting. HIR is not suitable for pavements exhibiting severe or very severe ravelling / coarse aggregate loss due to stripping.

HIR is not permitted for use on bridge decks; therefore, if the contract contains multiple bridges that require paving, the designer should consider whether stopping and starting the HIR process at each bridge is acceptable for the contract.

HIR is recommended only for existing flexible pavements, excluding SMA, with a minimum asphalt pavement thickness of 70 mm. The specified HIR lift thickness is 40 mm to a maximum of 50 mm (including any beneficiating HMA). The measured lift thickness is the actual lift thickness of the HIR placed and may or may not be equal to the hot milling depth. A minimum of 25 mm of existing asphalt pavement should be maintained below the HIR.

The HIR process should not be used to recycle SMA or composite pavements.

HIR must be placed in warm, dry weather; and therefore, HIR contracts should be tendered so that the HIR work can be carried out between May 15th and October 15th, inclusive.

The designer should note that HIR equipment may be restricted to a specific processing width. The equipment is usually able to process a width of up to 4.0 m. This could restrict the use of HIR with partially paved shoulders. However, the placement width is similar to that of a conventional paver, and partially paved shoulders that cannot be removed along with the lane, due to the restricted processing width, could be removed conventionally ahead of the HIR operation to allow the new partially paved shoulder to be placed in conjunction with the lane. Partially paved shoulders that cannot be accommodated as part of the lane placement width and fully paved shoulders, if these are to be HIR, require a separate pass of the HIR equipment.

HIR is usually considered for projects at least 20 lane-kilometres, including fully paved shoulders. Partially paved shoulders and pavement widening can be retrofitted using this process. Advance grading and

compaction of the shoulders is required as well as beneficiating HMA to make up the extra being placed on the shoulders or in pavement widening.

The following information is given for estimating purposes only.

HIR can be considered a suitable resurfacing treatment for a project where the pre-engineering cores meet the following guidelines:

1. The existing aggregate gradation should meet the gradation requirements of mix type the HIR is required to meet, or be close enough that a reasonable amount of beneficiating HMA could be added to meet these requirements.

2. The RAC performance grade from the extracted AC of the existing asphalt pavement can achieve the target performance grade using the blending calculations in AASHTO M 323 for rejuvenator products and new PGAC added to a beneficiating HMA.

3. Average in-situ air voids of:
   > 4.5% a beneficiating HMA is normally not required,
   ≤ 4.5% and > 2.0% beneficiating HMA may be required, and
   ≤ 2.0% the designer should expect beneficiating HMA to be required.

   Generally in-situ air voids are between 2.0 and 2.5% for asphalt pavements 10 to 15 years old.

4. The existing pavement conditions should not vary greatly from one core to the next.

The designer should specify the following in the Contract Documents:

- HIR crossfall, profile, cross-section, and alignment. (323.03)

- HMA mix type the HIR mix is required to meet. A Marshall mix type or Superpave 12.5 mix type should be selected based on existing materials from the following list: (332.04)

- Design thickness. (323.04)

  A. Superpave 12.5
  B. Superpave 12.5FC 1
  C. Superpave 12.5FC 2
  D. DFC
  E. HL 1
  F. HL 3
  G. HL 3F
  H. HL 4

- The RAC recovered from the HIR mix produced. (332.05.01.01)

- Quality assurance sample requirements. (332.07.01)

- HIR sample delivery location. (332.07.01)

- Removal of cold mix patching material, crack sealant, and spray patch material. (332.07.02)

- Lane demarcation. (332.07.05)

- Longitudinal and transverse joints. (332.07.05)

- Management of excess material. (332.07.08)

- QA HIR testing frequency if different than OPSS 332, Table 5. (332.08.01)

- Performance grade requirement for RAC. (332.08.07)

- Asphalt cement content specified. (Table 1)

- HIR compaction core. (Table 5)

Any available core data on existing pavement conditions should be included in the bidding documents for information only.

The designer should determine if the following is required and, if so, specify in the Contract Documents:

The designer may specify in a special provision when quality control (QC) test results are to be used for acceptance in place of QA test results.

The designer may consider extending delivery times for samples required on Contracts in remote areas. The designer should be aware that there is a 4 hour delivery requirement for samples and the laboratory should be open to receive them.

For smaller projects, the borderline category for tolerances in Table 1 may not be appropriate. The designer may consider specifying that all work represented by borderline test results shall be deemed rejectable.

The complete tender item description for HIR should include a “type” of HMA according to Table 1 of OPSS 1150 for HIR mixes required to meet Marshall mixes and according to Tables 1 and 2 of OPSS 1151 for HIR mixes required to meet Superpave mixes.

The designer should consider specifying that prior to HIR all materials such as cold mix patching material, crack sealant, and spray patch material shall be removed or that the Contractor shall be responsible for preparing the existing HMA surface by removing all materials such as cold mix patching material, crack sealant, and spray patch material, as the Contractor deems necessary, to heat, hot mill, blend, and place the HIR mix to meet the surface tolerance and surface appearance requirements as specified in the Contract Documents.

For premium mixes, the designer should consider specifying that correcting the existing pavement by cold milling prior to HIR should not result in the existing binder course pavement materials being hot milled and added to the HIR mix.

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

No information provided here.