

B332 - HOT IN-PLACE RECYCLING - OPSS 332

332.1

GENERAL

Use of Hot In-Place Recycled Mix (HIR) is recommended by the Regional Geotechnical Section on a work project specific basis.

The HIR process involves heating and partial depth hot milling the existing asphalt pavement; sizing; mixing with beneficiating hot mix asphalt (HMA) or rejuvenating agent or both; relaying; and compacting the recycled hot bituminous mixture in-place in one single operation.

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 shall not be used to recycle SMA or composite pavements.

HIR must be placed in warm, dry weather; and therefore, HIR contracts should be tendered such that the HIR work can be carried out between May 15<sup>th</sup> and October 15<sup>th</sup>, 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. Refer to CDED B206-3 for design and documentation requirements for excavation for pavement widening.

A properly designed and constructed HIR resurfacing has a minimum life expectancy of approximately 9-10 years on a non-freeway and 8-9 years on a freeway.

Until sufficient cost data is available in the MTO HiCo database, when estimating the cost of the HIR item, it is recommended to use a value 10% lower than the equivalent HMA item (i.e., if specifying 40 mm of HIR that must meet Superpave 12.5FC 1 requirements use a unit cost 10% lower than that of the 40 mm of Superpave 12.5FC 1 square metre item).

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REFERENCES

CDED B206-3, Excavation for Pavement Widening  
 CDED B308, Tack Coat  
 CDED B313-1, Hot Mix Asphalt  
 CDED B510-5, Removal - Pavement Work

332.3

TENDER ITEMS

Hot In-Place Recycled Mix (normal, m<sup>2</sup>, PQP)

332.4

SPECIFICATIONS

The requirements for Hot In-Place Recycling are contained in OPSS 332.

### 332.5 SPECIAL PROVISIONS

Refer to Chapter E of this manual to review the applicable standard special provisions.

### 332.6 STANDARD DRAWINGS - none

### 332.7 DESIGN

#### 332.7.1 Information to be provided to Bidders

- Asphalt core test results and analysis (see Pre-Engineering Section 332.7.3)
- Geotechnical borehole data
- ARAN Pavement Condition Report (in one direction, for the lane on which the ARAN survey was conducted). The ARAN Pavement Condition Report should include:
  - Average International Roughness Index (IRI)
  - Average rut depth
  - Average crossfall
  - Measurements of longitudinal, transverse, and alligator cracking
- Ground Penetrating Radar (GPR), if available
- Estimated quantities of:
  - Crack sealant in linear metres
  - Cold mix in square metres, and
  - Spray patch in square metres, if available.

When the work includes pavement crossfall and/or superelevation correction, cross section templates for the areas to be corrected shall be provided.

#### 332.7.2 Geotechnical Design Considerations

If a pavement crossfall correction  $> 1.0\%$  is required at only a few localized areas, it should be adjusted by patching or milling methods instead of during the HIR operation. Generally, milling should be kept to a minimum to avoid the existing binder course pavement materials being hot milled and added to the HIR mix, since the existing binder course may not always be of the same quality as the existing surface course, and for this reason, HIR is not recommended when crossfall correction is required at more than a few locations.

Tack coat is required prior to HMA paving of HIR surfaces. Refer to CDED B308 for design and documentation requirements for tack coat.

HIR of pavement with crack sealant and/or surface maintenance treatments may result in excess smoke generation. The following guidelines are suggested for addressing sealed and treated pavements:

- Generally, crack sealant and cold mix patches should be removed prior to HIR. A small amount of crack sealant may not affect the HIR. The Regional Geotechnical Section should provide removal recommendations.
- Localized surficial maintenance treatments, such as chip seal and spray patches, greater than 4 m<sup>2</sup> in area should be removed prior to HIR.

In urban areas, the designer should be aware of appurtenance and adjustment requirements, curb heights, and accessibility concerns to accommodate the HIR equipment train and the requirement for traffic detours. At intersections, the main lanes and turn lanes of significant length (greater than 300 m) should be HIR. Different treatments (i.e., removal and replace with acceptable surface course HMA) may be applied to shorter turn tapers, irregularly shaped pavement areas, entrances, etc.

The designer should be aware that the length of the HIR operation may affect traffic management. A 1 kilometre rolling closure is typical for the HIR operation.

While HIR should be limited to pavements with only surficial distresses, if any full depth repairs are required for frost heave and/or distortion corrections, these should be repaired with HMA prior to HIR. To avoid having a new pavement with a patched appearance, HIR through these repairs after they are completed, unless a repair is greater than 100 m long, in which case these large repairs should be skipped during the HIR operation. Full depth repairs are to be managed elsewhere in the contract.

For design purposes, HIR should be compared to the following conventional technique to address non-structural surficial distresses:

- 1) 50 mm HIR vs. mill 30 mm, and place 50 mm surface course
- 2) 40 mm HIR vs. place 40 mm surface course

### 332.7.3 Pre-Engineering Investigation

#### 332.7.3.1 General

This section describes procedures and tests to be carried out during pre-engineering contract investigations on potential Ministry HIR projects.

It is recommended that adequate pre-engineering be carried out to establish existing pavement thicknesses and composition. Ground Penetrating Radar (GPR) is a useful method of providing more frequent measurement of the asphalt thickness during the

pavement investigation phase. Additional investigation should be carried out where pavement composition changes, such as patched areas.

This information is required for the designer to determine whether the existing pavement, on potential projects, meets the minimum thickness requirements, if HIR can be used to meet the acceptance criteria, and to assist the designer in selecting the thickness of HIR.

A field investigation is required to determine the existing pavement condition, crossfall, IRI, distress manifestations, and the presence of crack sealant and/or patches.

#### 332.7.3.2 Selection of Coring Locations

1. A minimum of one sampling location per kilometre plus a minimum of one sampling location wherever the existing surface course is known or suspected of having mixes which are different or have significantly differing properties (i.e. a separate core should be taken for patches that will be incorporated into the HIR mix).
2. It is recommended that a minimum of five 150 mm cores be taken at each sampling location in order to obtain enough material to complete the core testing requirements. Alternatively, more than five smaller cores or a slab of surface course may be taken as long as an equivalent amount of material is obtained at each core location.
3. Cores shall be taken not less than 0.5 m from the edges of the pavement of the main lanes and in areas representative of the overall pavement condition. Sampling locations should be random.
4. Cores should extend to a minimum depth of one lift of HMA below the anticipated HIR depth.
5. Where additional asphalt pavement is required for testing purposes, the additional material shall be obtained from adjacent cores taken at the same locations.
6. Testing of cores should be conducted to determine the requirements of core testing as listed below.

#### 332.7.3.3 Requirements of Core Testing

For each asphalt pavement core the following in-situ quantities should be provided for the depth of the existing asphalt pavement which is to be HIR:

- existing lift thicknesses (LS-294),
- existing aggregate gradation and AC content (LS-282, LS-291, or LS-292),

- actual recovered asphalt cement (RAC) performance grade (LS-284, AASHTO M 320, and AASHTO R 29),
- mass per cubic metre (AASHTO T 166, T 312, LS-264), and
- air voids (LS-265).

The asphalt core test results documentation shall include the location and date of coring.

332.7.3.4 Analysis of Core Data

The following information is given for estimating purposes only.

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

1. The existing aggregate gradation should meet the gradation requirements of a Superpave 12.5, Superpave 12.5FC 1, Superpave 12.5FC 2, 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. Consult with the Bituminous Section as required.
3. Average in-situ air voids of:
  - > 4.5% beneficiating HMA is normally not required,
  - ≤ 4.5% and > 2.0% beneficiating HMA may be required, and
  - ≤ 2.0% 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. As a guideline, the existing pavement properties in each lot (approximately 5 km) should be within 1 Standard Deviation (both on +/- sides) of the specified tolerances for AC content, gradation (payment sieve sizes), etc. (cores taken in patches should be excluded).

For example, consider the following as the first lot of core test results:

Sample Station	DLS	4.75 mm	75 µm	Air Voids	Lift Thickness	AC Content	RAC Performance Grade
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							<b>XX</b>	<b>-YY</b>
1+000	85.2	54.1	6.0	1.1	57.6	5.26	63.1	-25.1
2+000	82.7	49.0	5.4	2.5	39.0	5.00	65.5	-25.5
3+000	77.1	40.5	5.3	1.4	50.0	3.66	55.2	-14.9
4+000	83.2	52.8	5.3	2.6	38.7	5.08	64.2	-30.8
5+000	84.8	47.8	5.0	1.3	31.9	4.81	72.9	-17.5
<b>Average</b>	<b>82.6</b>	<b>48.8</b>	<b>5.4</b>	<b>1.8</b>	<b>43.4</b>	<b>4.76</b>	<b>64.2</b>	<b>-22.8</b>
<b>Standard Deviation</b>	<b>3.25</b>	<b>5.34</b>	<b>0.37</b>	<b>0.71</b>	<b>10.23</b>	<b>0.637</b>	<b>6.32</b>	<b>6.46</b>
<b>Specified Tolerances</b>	<b>40 to 95</b>	<b>40 to 65</b>	<b>2 to 13</b>	<b>2.0 to 5.5</b>	<b>Design Thickness - 10</b>	<b>AC<sub>spec</sub> - 0.2 to AC<sub>spec</sub> + 0.5</b>	<b>≥ XX - 3</b>	<b>≤ -YY + 6</b>

In this example the first lot’s existing pavement conditions can meet the specified tolerances for HIR as explained below:

The DLS sieve’s lot average gradation is 82.6 which is within the 40-95 specified. The 4.75 mm sieve’s average gradation is 48.8 which is within the 40-65 specified. The 75 µm sieve’s average gradation is 5.4 which is within the 2-13 specified.

The air voids lot average is 1.8% which does NOT meet the 2.0-5.5 specified, BUT the average is within 1 standard deviation of the specified tolerances ( $1.8 + 0.71 = 2.51$ ). Therefore, the air voids are close enough for the HIR process with beneficiating HMA to bring them back within the specified tolerances.

The lift thickness lot average is 43.4 mm which would indicate a 40 mm HIR design lift thickness would be appropriate. Individual results should be more than the design thickness - 10 mm ( $40 - 10 = 30$  mm). One or two results below the minimum may still be acceptable with the use of beneficiating HMA. In this example, the lowest value was 31.9 mm, which is still above the minimum 30 mm; however, if the design thickness was 50 mm, then over half the lot (3 cores) would be below the minimum 40 mm, and if 50 mm is required, a grade raise with beneficiating HMA or another strategy other than HIR should be considered.

The AC content lot average is 4.76%, if the AC specified was 4.2 then the lower limit would be 4.0 and the upper limit would be 4.7 and this AC content would NOT be within the specified tolerances, BUT the average is within 1 standard deviation ( $4.76 - 0.637 = 4.123$ ). Therefore, the AC content is close enough for the HIR process with rejuvenating agent or beneficiating HMA to bring it back within the specified tolerances.

The RAC performance grade lot average is 64.2-22.8, if the RAC performance grade specified was 58-28 then the specified tolerances for the high temperature would be  $\geq XX-3$  ( $58 - 3 = 55$ ) and for the low temperature  $\leq -YY+6$  ( $-28 + 6 = -22$ ). Since the high temperature grade (64.2) is higher than the specified 58 it is already acceptable as is. The low temperature grade (-22.8) is less

than the specified -28, BUT greater than the tolerance of -22 and the average is within 1 standard deviation of the specified low temperature ( $-22.8 - 6.46 = -29.3$ ). Therefore, the RAC performance grade is close enough for the HIR process with rejuvenating agent or beneficiating HMA to bring it back within the specified acceptance criteria.

Each lot's average existing pavement properties should be checked, as shown above, to be within 1 standard deviation of the specified tolerances.

When the RAC performance grade of the existing pavement is close to the required performance grade, only small quantities (if any) of rejuvenating agent will be required. The quantity of rejuvenating agent added to the mix decreases the existing air voids proportionally; therefore, the lower the RAC performance grade and air voids in the existing pavement, the more likely beneficiating HMA will be required to get the HIR mix to meet the contract specifications.

### 332.8 COMPUTATION

#### 332.8.1 Source of Information

Project requirements with respect to patch or sealant removal, mix requirements, HIR depths, asphalt core analysis, and treatment of shoulders are recommended in the Pavement Design Report.

#### 332.8.2 Method of Calculation

Hot In-Place Recycled Mix is a Plan Quantity Payment item.

The unit of measurement for HIR is square metres. The computed square metre quantity is the product of the lengths and widths of paving. Base plans, previous contracts, survey data, or other suitable information may be used to calculate quantities.

The item includes the following work: completing the HIR mix design(s) and the supply of rejuvenating agent and/or beneficiating HMA as required for the HIR mix. No quantity calculations are required by the designer for the rejuvenating agent and beneficiating HMA materials.

### 332.9 DOCUMENTATION

#### 332.9.1 Contract Drawings

Paving limits and the thickness of HIR courses, including for shoulders, shall be clearly indicated on the plans and typical sections, as applicable.



Partial depth asphalt removal and HMA thicknesses shall be noted on the drawings for all areas considered inaccessible or impractical for HIR, such as private and commercial entrances, side roads, tapers, ramps, channelization, shoulders, and miscellaneous areas to be paved. Refer to CDED B510-5 and B313-1 for the design and documentation requirements for partial depth asphalt removal and HMA, respectively.

Lane and paved shoulder widths shall be indicated on the plans and typical sections. When pavement widening is required, the existing lane, new lane, and paved shoulder widths shall be indicated. A detail of the widening may be required.

Where crossfall and superelevation are being corrected, the surface course crossfall and superelevation shall be shown on the typical sections. A note should be added to the typical sections stating that crossfall corrections are to be done with the HIR operation.

Where the crossfall and superelevation is being maintained, the crossfall shall be shown as “1.5% – 3.0%” on tangent typical sections and “Existing Superelevation” on superelevation typical sections.

#### 332.9.2 Quantity Sheets

The Quantities-Miscellaneous breakdown sheet shall be used to record quantities.

Each area quantity of HIR is shown on one row. For each area, indicate the start and end chainage in the location column.

Areas that may be inaccessible to the HIR equipment are still included in the HIR quantity. In inaccessible areas, the specification requires removal of the existing pavement and replacement with hot mix, and work is paid for under the HIR item.

#### 332.9.3 Documentation Accuracy

Calculated HIR quantities in square metres are recorded to the nearest whole number. Stations are recorded in whole number metres.

#### 332.9.4 Non-Standard Special Provisions

The following non-standard special provisions shall be included with the Contract Documents:

A non-standard special provision is required detailing the additional sampling, testing, and requirements for RAC (modified version of SSP 111F09 – consult with MERO Bituminous Section).

A non-standard special provision is required detailing the requirements for the materials, equipment, and processes for proportioning and mixing HIR according to the Superpave and SMA mix design methodology (modified version of OPSS.PROV 1151 – consult with MERO Bituminous Section).