CONSTRUCTION SPECIFICATION FOR COLD IN-PLACE RECYCLING

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333.01 SCOPE

This specification covers the requirements for cold in-place recycling of existing hot mix asphalt (HMA) pavement; sizing, adding, and mixing of emulsified asphalt; and spreading and compacting the cold in-place recycled (CIR) mix.

333.01.01 Specification Significance and Use

This specification has been developed for use in provincial- and municipal-oriented Contracts. The administration, testing, and payment policies, procedures, and practices reflected in this specification correspond to those used by many municipalities and the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.
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.

REFERENCES

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

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
OPSS 313 Hot Mix Asphalt - End Result

Ontario Provincial Standard Specifications, Material

OPSS 1103 Emulsified Asphalt

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:
LS-291 Quantitative Extraction of Asphalt Cement and Mechanical Analysis of Extracted Aggregate from Bituminous Paving Mixtures - Ontario Procedure
LS-300 Preparation of Marshall Specimens for Cold In-Place Recycled Mixtures
LS-306 Bulk Relative Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
333.03 DEFINITIONS

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

CCIL means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract.

Cold In-Place Recycled (CIR) Mix means the in-place mixture of existing reclaimed HMA pavement, emulsified asphalt, and water.

Hot Mix Asphalt (HMA) means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract.

Quality Assurance (QA) means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract.

Quality Control (QC) means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract.

Reclaimed Asphalt Pavement (RAP) means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract.

Segregation means as defined in OPSS 310 or OPSS 313, as appropriate to the Contract, and includes the following severities:

a) Slight Segregation means the pavement matrix is in place between the coarse aggregate particles; however, there are slightly more coarse aggregate particles in comparison with the surrounding acceptable mix.

b) Medium Segregation means the pavement has significantly more coarse aggregate particles than the surrounding acceptable mat and usually exhibits some lack of surface matrix.

c) Severe Segregation means the pavement appears very coarse, with coarse aggregate particle against coarse aggregate particle and the pavement has little or no matrix.

333.04 DESIGN AND SUBMISSION REQUIREMENTS

333.04.01 Design Requirements

For mix design purposes, prior to commencing the work, the Contractor shall obtain samples that are representative of the material that is produced during the milling operation. These samples shall be used to establish the design rate of emulsified asphalt as a per cent by mass of the RAP. The design rate of the emulsified asphalt shall be a minimum of 1.2%.

The mix design shall be completed by a laboratory with CCIL Type A certification or equivalent equipped to carry out CIR mix design.

Where the existing pavement significantly changes composition, a separate mix design shall be completed.

Each mix design shall include the following:

a) Information on the type, manufacturer, and supplier of the emulsified asphalt.
b) The design rate of emulsified asphalt.
c) All calculations performed to determine the design rate of emulsified asphalt.
d) The amount of water to be added to the mix.
e) Maximum field rate adjustment allowed to the design rate without adverse affects to mix properties.

### Submission Requirements

333.04.02 Submission Requirements

The mix design shall be submitted to the Contract Administrator a minimum of 7 Days prior to the start of CIR operations.

A new mix design shall be submitted when the emulsified asphalt design rate is adjusted by greater than 0.20%.

Within 7 Days of obtaining a sample to establish the target density, the target density of the CIR mix shall be provided by the Contractor to the Contract Administrator.

### MATERIALS

333.05 MATERIALS

333.05.01 Reclaimed Asphalt Pavement

RAP material shall be 100% passing the 37.5 mm sieve after processing.

333.05.02 Emulsified Asphalt

Emulsified asphalt shall be mixing grade, polymer modified, meet the requirements of OPSS 1103, and be compatible with the process and materials used.

333.05.03 Water

Water shall be clean and free from oil, acid, alkali, organic matter, or other deleterious substances.

333.05.04 Cold In-Place Recycled Mix

The per cent by mass of new emulsified asphalt added to the reclaimed material shall be a minimum of 1.2%. The CIR shall meet the moisture requirements as determined by LS-291.

### EQUIPMENT

333.06 EQUIPMENT

333.06.01 Recycling Train

The recycling train shall include the following:

a) A self-propelled cold milling unit with a cutting drum capable of reclaiming a full lane width of asphalt pavement to the depth specified in the Contract Documents in one pass.

b) A screening and sizing unit capable of processing the RAP so that all reclaimed material passes the 37.5 mm sieve.

c) An aggregate feed system that measures and regulates the mass of RAP being added into the mixing unit prior to the addition of the emulsified asphalt. The scale shall be calibrated to the manufacturer's tolerance at the start of the Contract and when requested by the Contract Administrator.
d) An emulsified asphalt control system equipped with a flow meter calibrated in litres per tonne and a total delivery meter calibrated in litres to continuously maintain the required amount of emulsified asphalt added to within 0.2% by mass of the reclaimed material feed.

e) A means of monitoring and controlling the addition of water.

f) A mixing unit equipped with a device capable of producing a uniform and thoroughly blended CIR mix.

333.06.02 Placing Equipment

Placing of the CIR mix shall be carried out by means of a self-propelled mechanical paver capable of spreading the mix evenly in front of the screed in one continuous pass to the specified crossfall and grade. The paver shall be equipped with distributing augers for the full width to be paved. The paver shall have a vibratory screed capable of vibrating the full width of mix placed.

333.06.03 Compaction Equipment

The Contractor shall select the appropriate compaction equipment to achieve the required compaction.

333.06.04 Drying Unit

The Contractor may elect to use a drying unit specifically designed to provide radiant heat to the CIR mat. Open flame heating shall not be used. The entire heater assembly shall be capable of readily adjusting the intensity of heat on the pavement surface.

333.06.05 Straight Edge

The straight edge shall be 3 m in length, metal, and have a level recessed in its upper edge parallel to the lower edge.

333.06.06 Pilot Vehicle

The pilot vehicle shall be according to the requirements of the OTM, Book 7.

333.07 CONSTRUCTION

333.07.01 General

HMA pavement in areas inaccessible to the reclaiming equipment shall be removed and replaced with acceptable binder course HMA. The HMA shall be placed to the CIR depth specified in the Contract Documents in compacted lift thicknesses between 40 and 75 mm in depth.

The overlap between successive passes of the recycling train shall be a minimum 100 mm.

333.07.02 Cold In-Place Recycling Trial Section

Prior to carrying out CIR on the Contract, the Contractor shall demonstrate to the Contract Administrator the ability to successfully carry out CIR according to this specification by placing a trial section within the Contract limits.

In lieu of a trial section, the Contract Administrator may accept evidence that the Contractor has demonstrated the ability to successfully mix, handle, place, and compact CIR with the same equipment, placing crew, and methodology to meet the Contract requirements for placing CIR on any Contract within the last 12 months.
The trial section shall be one lane width and 500 m in length. The Contractor shall propose the location of the trial section to the Contract Administrator for approval. The Contract Administrator shall be given a minimum of 48 hours notice prior to placing the trial section.

The Contract Administrator shall allow the Contractor to continue the CIR work based on an acceptable visual assessment of the trial. When the CIR is rejected by visual assessment, the Contractor shall repeat additional trial sections until the CIR meets the requirements of this specification.

The Contractor shall be responsible for the repair, removal, or replacement of an unacceptable trial section.

333.07.03 Operational Constraints

The work shall not be carried out when the ambient temperature is less than 10 °C or when the overnight low is forecast to be less than 2 °C. After September 1st, written approval shall be obtained from the Contract Administrator prior to CIR paving. The work shall be carried out when the roadway is clean and free of standing water. CIR shall not proceed in the rain.

When specified in the Contract Documents, all existing crack sealant shall be removed prior to CIR reclaiming operations.

The wearing surface shall not be placed on the CIR mat until the following requirements have been met:

a) The CIR mix has been allowed to cure for a minimum of 14 Days.

b) Immediately prior to placing the wearing surface, the average in situ moisture content of the CIR is 2% or less with no test value greater than 3%.

c) The specified density has been achieved according to the Compaction subsection.

d) All defective areas in the CIR mat have been repaired to the satisfaction of the Contract Administrator.

The tack coat and wearing surface shall be placed within 30 Days of placing the CIR mat, provided the CIR mix meets the requirements of this specification.

All traffic, including construction traffic, shall be kept off the freshly placed CIR mat until it is able to carry traffic without damage. The Contractor shall be responsible for repair of the damaged CIR mat.

333.07.04 Surface Preparation

When specified in the Contract Documents, milling prior to CIR work shall be carried out to achieve the specified crossfall and grade.

All deleterious and loose milled material shall be removed from the milled surfaces at longitudinal and transverse joints after reclaiming operations are completed and before placing the CIR mix.

333.07.05 Mixing

The emulsified asphalt shall be added at the design rate. The rate of addition of emulsified asphalt shall be field adjusted as required to within 0.20% of the design rate to produce a uniformly coated CIR mix that can be compacted to the specified density according to the Compaction subsection.

The Contractor may add water in a controlled manner to facilitate uniform mixing.
333.07.06 Compaction

At the start of production and whenever the existing pavement material significantly changes composition, the target density of the CIR mix shall be established by the Contractor according to LS-300 with material reclaimed from the roadway.

The CIR mix shall be compacted to a minimum of 96% of the target density.

333.07.07 Surface Appearance

The compacted CIR mat shall be smooth and conform to the crossfall and grade specified in the Contract Documents. The surface of the CIR mat shall be of uniform texture and free of segregation, longitudinal streaks, fat spots, oil spills, roller marks, and other defects.

333.07.08 Drying

Prior to the placement of the wearing surface, the Contractor may elect to use a drying unit. Overheating or burning of the CIR shall not be allowed.

333.07.09 Sampling

333.07.09.01 General

Holes resulting from the removal of samples shall be repaired according to the sampling provisions of OPSS 310 or OPSS 313, as appropriate to the Contract, using surface course HMA or other material approved by the Contract Administrator.

333.07.09.02 Cold In-Place Recycling Material

At least 4 Business Days prior to the planned overlay of the CIR mat, the Contractor shall obtain 2 slab samples of the CIR material for each subplot taken at random locations, as directed by the Contract Administrator. One slab sample shall be used to test for moisture content and the other shall be used to test for compaction. Each slab sample shall be dry cut 150 x 150 mm and removed intact from the CIR mat.

The samples shall be packaged in non-absorptive materials to protect sample integrity, sealed in waterproof containers, appropriately labelled, and delivered by the Contractor in good condition to the designated QA testing laboratory specified in the Contract Documents within 48 hours of sampling.

The Contractor shall be permitted to carry out QC sampling and testing of the CIR mat.

333.07.09.03 Emulsified Asphalt

Samples of emulsified asphalt used in the mix shall be taken at the job site from each tanker load of material used on the Contract. Each sample shall be taken either from a sampling spigot on the transfer line, if available, or from the end of the transfer line after a minimum of 4,000 kg has been drawn from the tanker. Each set of samples shall be a minimum of 2 full four-litre containers.

Samples of the emulsified asphalt used in the mix shall be obtained, properly labelled and identified, and delivered within 48 hours of sampling to the designated QA testing laboratory specified in the Contract Documents.

The sample containers supplied by the Contractor shall be new triple tight epoxy lined pails or suitable leak-proof plastic containers. The sample labels shall be obtained from the Contract Administrator.
333.07.10 Traffic Convoy

When specified in the Contract Documents, the Contractor shall convoy traffic according to the OTM, Book 7.

The pilot vehicle shall guide one-way traffic through or around construction. The maximum speed of the convoy shall be 30 km/h. Convoying shall be maintained until such time as the CIR mat is able to carry traffic without damage.

333.07.11 Management of Excess Material

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

333.08 QUALITY ASSURANCE

333.08.01 General

The Contract Administrator shall reject all unacceptable material and all visually defective material, mix, or work according to Table 1. Defective material, mixture, and work shall not be incorporated into the finished work.

Acceptance shall be based on QA testing. QA testing shall be carried out at a laboratory currently certified by CCIL with Type A or Type B certification or AMRL accredited or equivalent laboratory. Acceptance criteria shall be based on the lot mean computed from QA test results for each sublot within the lot.

If the CIR does not meet the requirements of the specification within 30 Days after placing the CIR mat, it shall be deemed unacceptable.

333.08.02 Lot Size

The Contract Administrator will determine the size and location of the lots and sublots after discussion with the Contractor and before CIR production starts. The lot shall typically represent 50,000 m² with 10 equal sublots of 5,000 m² in size.

333.08.03 Surface Tolerance

After compaction, the surface of the CIR mat shall be free from deviations exceeding 6 mm, as measured in any direction with a 3 m straight edge.

333.08.04 Acceptance Criteria for Moisture Content

The moisture content shall be determined according to LS-291. The mean moisture content for each lot shall be less than 2.0% with no sublot moisture content exceeding 3.0%.

CIR mix that does not meet moisture content requirements shall be deemed unacceptable.

333.08.05 Acceptance Criteria for Compaction

The Contract Administrator will determine the acceptability of compaction according to LS-306. Each lot of CIR mix shall be compacted to a minimum mean of 96.0% of the target density established for the mix with no sublot result falling below 95.0% of the target density. CIR mix that is not compacted to the required density shall be deemed unacceptable.
333.08.06 Acceptance of Emulsified Asphalt

The supplied emulsified asphalt samples shall be according to OPSS 1103 for the particular type and grade, when tested according to the test methods specified.

Failure of the sample to conform to any of the material requirements shall be cause for rejection of the material.

The CIR mix that has incorporated emulsified asphalt represented by the failed test result shall be deemed unacceptable.

333.08.07 Repair of Unacceptable Cold In-Place Recycled Mat

CIR mat that is unacceptable shall be repaired as specified in Table 1.

Repairs shall be for the full width of recycling to the depth specified in Table 1.

The HMA required to repair unacceptable CIR shall be placed in compacted lift thickness between 40 to 75 mm.

Reprocessing or using a drying unit to improve the moisture content may be considered as a repair method, upon submission of a proposal by the Contractor and approval by the Contract Administrator.

333.09 MEASUREMENT FOR PAYMENT

333.09.01 Actual Measurement

333.09.01.01 Cold In-Place Recycled Mix

Measurement of CIR mix placed shall be by area in square metres.

333.09.02 Plan Quantity Measurement

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

333.10 BASIS OF PAYMENT

333.10.01 Cold In-Place Recycled Mix - Item

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

HMA required to replace unacceptable CIR material shall be at no extra cost to the Owner.

Emulsified asphalt shall be included in the cold in-place recycled mix item.

Repair of an unacceptable CIR mat shall be carried out at no extra cost to the Owner.

HMA placed in areas inaccessible to the reclaiming equipment shall be included in the cold in-place recycled mix item.

Repair of areas of CIR damaged by traffic shall be completed at no extra cost to the Owner.
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<th>Defect Type</th>
<th>Severity</th>
<th>Required Repair</th>
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<td>Ravelling/Coarse Aggregate Loss</td>
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<td>No action required.</td>
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<td>(Note 1)</td>
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<td></td>
<td>Moderate to Severe</td>
<td>Mill 50 mm and replace with an acceptable binder course HMA.</td>
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<tr>
<td></td>
<td>Very Severe</td>
<td>Remove CIR material to full depth and replace with an acceptable binder course HMA.</td>
</tr>
<tr>
<td>Segregation</td>
<td>Slight to Medium</td>
<td>No action required.</td>
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<tr>
<td>(Note 2)</td>
<td>Severe</td>
<td>Mill 50 mm and replace with an acceptable binder course HMA.</td>
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<td>Moisture content could not be</td>
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<td>Remove CIR material to full depth in the sublot represented by the test and replace with an acceptable binder course HMA.</td>
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Notes:
1. Defect and severity definitions according to SP-024.
2. Defect and severity definitions according to Definitions section of this specification.
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 specification 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

Cold in-place recycling (CIR) is suitable for treating a wide range of pavement distresses. CIR can repair pavements exhibiting age, thermal, fatigue, or reflective cracking and previously recycled pavements and is beneficial in mitigating reflective cracking. CIR is not suitable for pavements with extensive base or subbase problems, pavements containing steel slag, or pavements of insufficient strength.

The designer should specify the following in the Contract Documents:

- Crossfall and grade. (333.07.08)
- Testing laboratory to carry out CIR moisture content and compaction testing. (333.07.10.02)
- Testing laboratory for emulsified asphalt. (333.07.10.03)

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

- Removal of crack sealant prior to CIR operations for extensively sealed pavement. (333.07.03)
- Additional items for milling or padding or both if significant crossfall deficiencies exist. (333.07.04)
- Traffic convoy requirements. (333.07.09)

It is recommended that adequate pre-engineering be carried out on the project and that existing pavement thicknesses and composition be established. Additional investigation should be carried out where pavement composition changes, such as patched areas.

In urban areas, the designer should be aware of appurtenance adjustment requirements, curb heights, and accessibility concerns to accommodate the CIR equipment train and the requirement for traffic detours.

Contract scheduling should allow for CIR and follow-up paving to be completed within the time and temperature operational constraints.

The designer should be aware that the length of CIR paving operation may affect traffic management.

It is recommended to have at least 25 mm of remaining HMA pavement below CIR.

Corrective aggregates may be considered for existing pavements experiencing rutting, shoving, or flushing where the existing bituminous material is suspected to be the cause of these distresses. Appendix-B should be invoked by reference in the Contract Documents if it has been determined that the Contractor may use corrective aggregate.
Appendix 333-A

When sealed transverse cracks are spaced at a frequency of less than 10 m or extensively sealed longitudinal cracks exist, the designer should consider removing that crack sealant prior to the CIR operation.

CIR is typically overlaid with HMA wearing course. Surface treatment, slurry surfacing, or microsurfacing may be considered.

A tack coat is recommended prior to paving HMA wearing course.

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.
Appendix 333-B, Requirements for the Addition of Corrective Aggregate, April 2010
FOR USE IN MUNICIPAL CONTRACTS, WHEN REFERENCED IN THE CONTRACT DOCUMENTS

Note: This is a non-mandatory Additional Information Appendix intended to provide supplementary requirements for the OPS specification in a municipal contract, when the appendix is invoked by the Owner. It is written in mandatory language to permit invoking it by reference in the Contract Documents. If the appendix has not been invoked by reference in the Contract Documents, it does not apply.

Requirements for the Addition of Corrective Aggregate

OPSS 333, Cold In-Place Recycling, is amended as follows:

333.01 SCOPE

The first paragraph is deleted and replaced by the following:

This specification covers the requirements for cold in-place recycling of existing hot mix asphalt (HMA) pavement; addition of corrective aggregate; sizing, adding, and mixing of emulsified asphalt; and spreading and compacting the cold in-place recycled mix.

333.02 REFERENCES

Section 333.02 is amended by the addition of the following to the Ontario Provincial Standard Specifications, Material, list:

OPSS 1003 Aggregates - Hot Mix Asphalt

333.03 DEFINITIONS

Section 335.03 is amended by the addition of the following:

Corrective Aggregate means new aggregate added to the cold in-place recycled mix, if required to meet the mix design requirements.

333.04.01 Design Requirements

Subsection 333.04.01 is amended by the addition of the following:

When the use of corrective aggregate is proposed by the Contractor, a proposal is required detailing the equipment to be used and the process by which the corrective aggregate will be incorporated into the mix. The proposal shall accompany the mix design submission. The mix design shall list the type, source, and quantity of any corrective aggregate and shall include the gradation and physical property test data.

Testing for physical properties of the corrective aggregate shall be performed by a laboratory with CCIL Type D certification or equivalent. Testing for gradation shall be performed by a laboratory with CCIL Type C certification or equivalent. All individual test results shall demonstrate conformance of the aggregates with the requirements of this specification.
Appendix 333-B

333.05 MATERIAL

Section 333.05 is amended by the addition of the following:

333.05.04 Corrective Aggregate

Corrective aggregate shall meet the physical property requirements of OPSS 1003 for Superpave 12.5 binder coarse aggregate and fine aggregate. Corrective aggregate shall be 100% passing the 26.5 mm sieve.

333.09.01 Actual Measurement

Subsection 333.09.01 is amended by the addition of the following:

333.09.01.02 Corrective Aggregate

333.09.01.02.01 By Mass

Measurement of corrective aggregate used in the CIR mix shall be by mass in tonnes.

333.10 BASIS OF PAYMENT

Section 333.10 is amended by the addition of the following:

333.10.02 Corrective Aggregate - Item

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