



**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 active filler if required, adding and mixing emulsified asphalt, and spreading and compacting the cold in-place recycled (CIR) mix.

333.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

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

333.01.02 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.

333.02 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.

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

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt - End Result

Ontario Provincial Standard Specifications, Material

OPSS 1103 Emulsified Asphalt
OPSS 1301 Cementing Materials

Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-200 Penetration of Bituminous Materials
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
LS-602 Sieve Analysis of Aggregates

Ontario Traffic Manual (OTM):
OTM Book 7 - Temporary Conditions

SP-027 Manual for Assessment of Surface Defects of In-Place Recycled Pavement Mats

ASTM International

D6752/D 6752M-11 Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

333.03 DEFINITIONS

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

Active Filler means substances added to the reclaimed existing asphalt pavement that chemically alter the mix properties.

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 313

Quality Assurance (QA) means as defined in OPSS 313.

Reclaimed Asphalt Pavement (RAP) means as defined in OPSS 313.

Target Density means the average bulk relative density for the lot established according to LS-300 by the QA testing laboratory, and used to determine the per cent compaction.

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 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 percent 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 Canadian Council of Independent Laboratories (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 percent by mass of emulsified asphalt in the CIR, referred to as the design rate, and all calculations performed to determine the design rate of emulsified asphalt.
- c) The optimum moisture content and the mix design bulk relative density.
- d) The amount of water to be added to the mix.
- e) Maximum field rate adjustment allowed to the design rate without adverse effects to the mix properties.
- f) Recovered penetration for the binder of the existing pavement according to LS 200.

g) Type, source and quantity of active filler, if required.

333.04.02 Submission Requirements

A copy of the mix design shall be submitted to the Contract Administrator a minimum of 7 Business Days prior to the start of CIR operations. Within 4 Business Days after receiving the mix design, the Contract Administrator shall provide written confirmation of receipt of the submitted mix design documents or of any non-conformance to the contract requirements.

Confirmation of receipt of the mix design documents does not constitute any guarantee that the mix can be produced or constructed or both to Contract requirements, and does not relieve the Contractor of the responsibility for ensuring the specified quality of Materials and workmanship.

A new mix design shall be submitted when the emulsified asphalt design rate is adjusted by greater than 0.20%. Separate or new mix designs shall be submitted if the composition or layer thicknesses of the existing pavement changes significantly. Where more than one mix design is required, the area for which each mix design is to be used shall be clearly identified.

333.05 MATERIALS

333.05.01 Reclaimed Asphalt Pavement

RAP material shall be 100% passing the 37.5 mm sieve, and 95% to 100% passing the 26.5 mm sieve after processing, and shall be measured based on air dried gradation according to the coarse sieving operation of LS-602.

333.05.02 Emulsified Asphalt

Emulsified asphalt shall be polymer modified mixing grade according to 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 Active Filler

When active filler is required, it shall be incorporated into the existing reclaimed asphalt pavement at the application rate specified in the mix design.

When used as active filler, Portland cement shall be according to OPSS 1301. Not more than 1% by mass of Portland cement shall be added to the mix.

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.

- 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 prior to the start of the work 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 capable of producing a uniform and thoroughly blended CIR mix.

333.06.02 Placing Equipment

A mechanical paver capable of spreading the mix evenly in front of the screed in one continuous pass to the specified crossfall and grade shall be used to place the CIR mix. 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

Compaction equipment shall be selected to achieve the required compaction.

333.06.04 Drying Unit

A drying unit specifically designed to provide radiant heat to the CIR mat may be used. 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

Pilot vehicles used to control traffic shall be according to 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 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. Cold in-place recycled mix shall not be placed after September 1st without the written approval from the Contract Administrator. The work shall be carried out when the roadway is clean and free of standing water. The work shall not proceed during periods of rain or when the surface is in a saturated condition.

All traffic, including construction traffic, shall be kept off the freshly placed CIR mat until it is able to carry traffic without damage. Any damage to the CIR mat shall be repaired.

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

- a) The CIR mat has been opened to traffic and allowed to cure for a minimum of 14 Days.
- b) The specified moisture content has been achieved according to the Acceptance Criteria section.
- 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 wearing surface shall be placed within 30 Days of placing the CIR mat. The 30 Day requirement may be waived by the Contract Administrator if the CIR mix does not meet the requirements of this specification and is subject to repair.

333.07.03 Cold In-Place Recycling Trial Section

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

In lieu of a trial section, the Contract Administrator may accept evidence that 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 has been demonstrated on any Contract within the last 12 months.

The trial section shall be one lane width and 500 m in length. The location of the trial section shall be proposed to the Contract Administrator for approval. A minimum of 48 hours notice shall be given to the Contract Administrator prior to placing the trial section.

The Contract Administrator shall allow the CIR work to continue based on an acceptable visual assessment of the trial according to the requirements of the Surface Appearance subsection. When the CIR is rejected by visual assessment, the trial section shall be repaired or removed and replaced until the CIR meets the requirements of the Surface Appearance subsection.

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, and longitudinal and transverse joints after reclaiming operations are completed and before placing CIR mix.

Existing crack sealant shall be removed and disposed of prior to CIR reclaiming operations.

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 and mixed to produce a uniformly coated CIR mix that can be compacted to the specified density. The emulsified asphalt added shall not be less than 1.2%.

Water may be added in a controlled manner to facilitate uniform mixing.

333.07.06 Compaction

The CIR mix shall be compacted according to the requirements of the Acceptance Criteria for Compaction subsection.

333.07.07 Surface Appearance

The compacted CIR mat shall be smooth and constructed 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, raveling, rutting, longitudinal streaks, flushing, 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 Traffic Control with Moving Vehicles

Traffic shall be controlled with moving vehicles according to OTM, Book 7.

The moving vehicles shall guide one-way traffic through or around construction. The maximum speed of the moving vehicles shall be 30 km/h. Traffic control with moving vehicles shall be maintained until such time as the CIR mat is able to carry traffic without damage.

333.07.10 Management of Excess Material

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

333.08 QUALITY ASSURANCE

333.08.01 General

Acceptance of the CIR mix shall be based on the following criteria:

- a) Surface Appearance
- b) Surface Tolerance
- c) Moisture Content
- d) Compaction
- e) RAP Gradation

Work that does not meet the acceptance criteria shall be repaired according to the Repairing and Re-Evaluating subsection.

333.08.02 Sampling

333.08.02.01 Lot Size

The Contract Administrator shall determine the size and location of the lots and sublots after discussion with the Contractor and before CIR production starts. A lot shall typically represent 25,000 m² with 5 equal sublots of 5,000 m² in size.

333.08.02.02 Cold In-Place Recycling Material

Samples of CIR material shall be packaged in non-absorptive materials to protect sample integrity and sealed in waterproof containers. Samples shall be transported in a manner that avoids stacking and extreme temperatures.

333.08.02.02.01 Slabs

At least 4 Business Days prior to the planned overlay of the CIR mat, 2 slab samples of the CIR material shall be obtained from each subplot. The two slab samples shall be located side-by-side and taken at random locations as directed by the Contract Administrator. Each slab sample shall be dry cut 150 mm x 150 mm and removed intact from the CIR mat.

One slab sample shall be used to test for bulk relative density and the other slab sample shall be used to test for moisture content. The result of the moisture content will be used for both the moisture acceptance, and moisture adjustment for compaction calculation according to LS-306.

Additional slab samples for QA acceptance tests shall only be taken after the Contractor has carried out remedial work to improve moisture content and/or compaction in the rejected subplot. The Contractor shall be charged the cost of additional tests.

333.08.02.02.02 Loose Mix Samples

For the purpose of determining the RAP gradation, 30 kg of loose CIR mix samples shall be taken from each of two randomly selected sublots for every lot.

333.08.02.03 Reclaimed Material

At the start of production of each new lot or whenever the existing pavement material significantly changes composition, one 15 kg sample of material reclaimed from the roadway shall be obtained prior to adding emulsion for the purpose of determining the target density for compaction. Samples shall be taken at random locations as directed by the Contract Administrator.

333.08.02.04 Emulsified Asphalt

Samples of emulsified asphalt used in the mix shall be taken at the job site from the tankers according to the Contractor's health and safety plan at a frequency of three sets of samples per Contract randomly taken from three different lots. 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. The Contractor's health and safety plan and procedure for sampling shall be reviewed at the pre-pave meeting.

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.

333.08.03 Acceptance Criteria

333.08.03.01 Surface Appearance

Surface appearance shall be assessed by the Contract Administrator based on visual surveys after the CIR mat has been opened to traffic. The finished CIR surface shall have a uniformly smooth texture and shall meet the surface appearance requirements of ravelling, segregation and rutting as specified in Table 1 prior to placement of HMA overlay.

333.08.03.02 Surface Tolerance

The surface tolerance of any CIR surface shall be such that when tested with a 3 m straight edge placed anywhere on the CIR surface, except across the crown, and in any direction on the surface, there shall not be a gap between the bottom of the straight edge and the surface of the CIR greater than 6 mm.

333.08.03.03 Moisture Content

The QA laboratory shall test one sample from each subplot to determine the moisture content of CIR mix according to LS-291, and the test result of the moisture content shall be rounded to one decimal place according to LS-100. The test result for each subplot shall be used to compute the lot mean for moisture content of CIR mix.

The moisture content of CIR mix acceptance shall be based on the mean moisture content of the lot and the moisture content of the individual sublots. The lot is acceptable if the lot mean moisture content is equal to or less than 2% with no individual subplot's moisture content greater than 3%. The lot is rejectable if the lot mean moisture content of CIR mix is greater than 3%. Any subplot with its moisture content greater than 3% shall be deemed rejectable.

If the lot mean moisture content of CIR mix is less than 3% and greater than 2%, the Contractor may elect to accept a payment reduction or repair for the lot. The payment reduction shall be calculated according to Table 2. If the Contractor elects to repair the lot in lieu of a payment reduction, the lot shall be repaired according to the Repairing and Re-Evaluating subsection.

333.08.03.04 Compaction

The compaction of the CIR mix shall be calculated for each subplot from the bulk relative density determined from slab samples according to LS-306 or ASTM D-6752, and the target density for the lot as follows:

$$\text{Compaction} = (\text{bulk relative density of slab sample} / \text{target density}) \times 100\%$$

where the target density to be used for acceptance purposes shall be calculated for each lot from material reclaimed from the roadway prior to adding emulsion. The target density shall be established according to LS-300.

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 individual subplot's bulk relative density result falling below 95.0% of the target density. CIR that is not compacted to the required density shall be deemed rejectable.

333.08.03.05 Reclaimed Asphalt Pavement Gradation

If the RAP does not meet the gradation requirements, the Contractor shall submit an action plan of remediation to the Contract Administrator for approval within 2 Business Days after the delivery of the QA testing results.

333.08.04 Repairing and Re-Evaluating

CIR mix that is rejectable based on the Acceptance Criteria subsection shall be repaired according to the requirements specified in Table 1.

Repairs shall be for the full lane width. For repairs due to surface appearance defects, the minimum repair length shall be sufficient for the repair to be carried out by the recycling train, or by the paving equipment, whichever is applicable. For other repairs based on the lot and subplot acceptance, the minimum length shall be according to the Repairing and Re-Evaluating clause of OPSS 313 and to the depth specified in Table 1.

The HMA required to repair unacceptable CIR shall be placed in compacted lift thicknesses between 40 and 75 mm. The HMA mix type and design used for repairs shall be approved by the Contract Administrator and shall meet the acceptance requirements for the HMA specified elsewhere in the Contract Documents.

All repairs will be re-evaluated and retested according to the Acceptance Criteria subsection.

When repairs are made to rejectable sublots or those sublots that the Contractor elects to repair due to the non-conformance of the moisture content requirements, the lot shall be re-evaluated and re-decided for payment reduction. The original lot shall be divided into two reconfigured lots in the following way: All acceptable sublots (with moisture content equal to or less than 2%) shall be grouped as one lot and shall receive the full Contract price. The remaining sublots shall be grouped as another lot and shall use the retest results of the repaired sublots to calculate the mean lot moisture content, and shall be accepted either at the full Contract price, or subjected to a payment reduction, or deemed rejectable.

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.

The addition of active filler or other additives to the mix, including any emulsion that is required due to the additives, shall be at no extra cost to the Owner.

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.

Repair, removal, or replacement of an unacceptable trial section shall be completed at no extra cost to the Owner.

333.10.02 Payment Reduction for Moisture Content

When test results show that the moisture content payment factor for the lot is less than 1.000 and the Contractor is not required to or does not elect to repair the lot, the payment reduction for the lot shall be as follows:

$(1.000 - \text{Payment Factor}) \times \text{item price} \times \text{lot quantity}$

For purposes of payment reduction, the term item price means the Contract price of the applicable tender item.

For purposes of re-decision after repairs, the lot quantity is the area of the reconfigured lot.

**TABLE 1
Acceptance Criteria and Repair Requirements for CIR Mix**

Acceptance Criteria	Defect Type	Severity / Criteria	Acceptable / Rejectable	Repair Requirements
Surface Appearance	Ravelling/Coarse Aggregate Loss (Note 1)	Very Slight to Slight	Acceptable	No action required.
		Moderate to Severe	Rejectable	Mill 50 mm and replace with an acceptable binder course HMA (Note 2).
		Very Severe	Rejectable	Remove CIR to full depth and replace with an acceptable binder course HMA (Note 2).
	Segregation (Note 1)	Slight to Medium	Acceptable	No action required.
		Severe	Rejectable	Mill 50 mm and replace with an acceptable binder course HMA (Note 2).
	Rutting (Note 1)	Very Slight to Slight	Acceptable	No action required.
		Moderate to Severe	Rejectable	Mill 50 mm and replace with an acceptable binder course HMA (Note 2).
		Very Severe	Rejectable	Remove CIR to full depth and replace with an acceptable binder course HMA (Note 2).
	Surface Tolerance	Non-conformance for surface tolerance as per the Surface Tolerance subsection of the Acceptance Criteria.	> 6 mm based on 3 m straight edge measurement	Rejectable
Moisture Content	Non-conformance for moisture Content as per the Moisture Content subsection of the Acceptance Criteria.	> 3% for Moisture Content of Lot or Individual Sublot	Rejectable	For rejected sublots, or sublots within the corresponding rejected lot: 1) Use drying unit as specified in the Drying Unit subsection to dry the CIR mat, or 2) Reprocess with a recycling train (Note 2), or 3) Remove CIR material to full depth and replace with an acceptable binder course HMA.
Compaction	Non-conformance for compaction as per the Compaction subsection of the Acceptance Criteria.	< 96% for Compaction of Lot; and < 95% for Compaction of Individual Sublot	Rejectable	For rejected sublots, or sublots within the corresponding rejected lot: 1) Recompact the CIR mat, if required, with reheating process, or 2) Reprocess with a recycling train (Note 2), or 3) Remove CIR material to full depth and replace with an acceptable binder course HMA.
Notes: 1) Defect and severity definitions according to SP-027. 2) Reprocessing with a recycling train may be considered as a repair method, upon submission of a proposal by the Contractor and approved by the Contract Administrator.				

TABLE 2
Moisture Content of CIR Mix Payment Factors

Moisture Content Payment Factors Acceptance Criteria	Classification	Payment Factor, PFT
MC ≤ 2%	Acceptable	1.000
2% < MC ≤ 3%	Payment Reduction	1 – TODRF x (MC - 2)/10
MC > 3%	Rejectable	N/A

Where:

MC = the mean of the lot sample of moisture content of CIR Mix in percent calculated to one decimal place according to LS-100.

PFT = the payment factor for moisture content calculated to three decimal places according to LS-100.

TODRF = Tender Opening Date Reduction Factor according to Table 3.

TABLE 3
Tender Opening Date Reduction Factor

Year of Tender Opening	Tender Opening Date Reduction Factor
2015	0.65
2016	0.8
2017	1.0

Appendix 333-A, November 2015
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 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

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.