Iowa Department of Transportation

MINUTES
OF
IOWA D.O.T. SPECIFICATION COMMITTEE MEETING

November 13, 2008

Members Present:	John Adam	Statewide Operations Bureau
	Tom Reis, Chair	Specifications Section
	Daniel Harness, Secretary	Specifications Section
	Bruce Kuehl	District 6-District Construction
	Gary Novey	Office of Bridges & Structures
	John Smythe	Office of Construction
	Larry Jesse	Office of Local Systems
	Jim Berger	Office of Materials
	Doug McDonald	District 1-Marshalltown RCE
	Dan Redmond	District 4-District Materials
Members Not Present:	Mike Kennerly	Office of Design
	Troy Jerman	Office of Traffic & Safety
	Roger Bierbaum	Office of Contracts
Advisory Members Present:	Lisa Rold	FHWA
Others Present:	Ed Kasper	Office of Contracts
	Mark Bortle	Office of Construction

Tom Reis, Specifications Engineer, opened the meeting. The following items were discussed in accordance with the agenda dated November 6, 2008:

1. Article 2301.04, C, Entrained Air Content.

The Office of Materials requested a change to modify the target air content for entrained air.

2. Article 2528.01, B, Traffic Quality Control.

The Office of Construction requested a change to clarify the requirements for daily traffic control diary and provide a standard format for documentation.

3. Article 2546.02, D, Revetment Stone.
Article 4130.06, Gabion Stone Description.
Article 4130.07, Gabion Stone Gradation.
Article 4130.08. Gabion Stone Quality.

The Office of Materials requested changes to move material requirements from Section 2546 to Section 4130.

4. Article 4110.03, Quality.

The Office of Materials requested a change to using the absolute strength of a sample.

5. Article 4186.02, C, Plywood.

The Office of Materials requested a change to update references to current standards.

6. DS-01XXX, Cold In-Place Recycled Asphalt Pavement.

The Office of Materials requested changes to reflect modifications to Materials I.M. 504.

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: Jim Berger	**Office:** Materials	**Item 1**
Submittal Date: 2008.10.13	**Proposed Effective Date:** April 2009	
Article No.: 2301.04, C **Title:** Entrained Air Content (PCC Pavement)	**Other:**	

Specification Committee Action: Approved as is.

Deferred:	**Not Approved:**	**Approved Date:** 11/13/08	**Effective Date:** 4/21/09

Specification Committee Approved Text: See Specification Section Recommended Text.

Comments: The Office of Materials emphasized they are not actually changing to PWL. Instead, the focus of this revision is to change target air to 8.0%.

Specification Section Recommended Text:

2301.04, C, Entrained Air Content.

Replace the entire article:

Air entrainment shall be accomplished by addition of an approved air entraining agent. The target ~~A~~air content for slip form pavement as determined by Materials I.M. 318~~, will be determined on each day of production as early and as frequently as necessary until the air content is consistently acceptable. The intended air content of finished concrete is 6.0%. Acceptance for entrained air content will be before consolidation.~~ shall be 8.0%, plus or minus 2.0%, when measured on the grade just prior to consolidation. The air content for non slip form paving shall be 7.0% plus or minus 1.5%. The target air content may be adjusted by the Engineer based on random tests of the consolidated concrete behind the paving machine. These additional random tests will be used to consider the need for a target change, and will not be used in the acceptance decision.

~~**1. Slip form projects greater than 7500 square yards (6000 m^2).**~~
~~The target air content will be determined to account for air loss during consolidation of concrete during slip form paving. The difference between before and after the paver air contents for a given location shall be considered the air loss.~~
~~On the first day of paving, air loss and target air content will be established during placement of the first eleven loads of concrete. The procedure will be as follows:~~

~~**a.** Central Batch Plant: the air content before the paver shall be between 8.0% and 12.0% until the target air content has been established.~~

~~**b.** Ready Mixed Concrete: the air content before the paver shall be 7.5% plus 1.5% or minus 1.0%, until target air content has been established.~~

~~Thereafter, the air loss and target air content will be established once per half day paving. The target air content shall be 6.5%, plus the air loss rounded to the next higher 0.5%, with a tolerance of plus or minus 1.5%. A new target air content before the paver will be established if the air loss deviates by more than 0.5% from the last air loss.~~

~~After the first day of paving, the target air content from the previous day will be used until a new target air content is determined.~~

2. Slip form projects less than 7500 square yards (6000 m^2). The air content before the paver shall be 7.5% plus 1.5% or minus 1.0%. At the option of the Engineer, the target air content may be established using the air loss.

The air content for non slip form paving shall be 7.0% plus 1.5% or minus 1.50%.

Comments:

Member's Requested Change (Redline/Strikeout):

C. Entrained Air Content.

Air entrainment shall be accomplished by addition of an approved air entraining agent. The target aAir content as determined by Materials I.M. 318, shall be 8.0%, with a tolerance of plus or minus 2.0% when measured on the grade just prior to consolidation. will be determined on each day of production as early and as frequently as necessary until the air content is consistently acceptable. The intended air content of finished concrete is 6.0%. Acceptance for entrained air content will be before consolidation. The target air content may be adjusted by the Engineer based on random tests of the consolidated concrete behind the paving machine. These additional random tests will be used to consider the need for a target change, and will not be used in the acceptance decision.

1. Slip form projects greater than 7500 square yards (6000 m^2).
The target air content will be determined to account for air loss during consolidation of concrete during slip form paving. The difference between before and after the paver air contents for a given location shall be considered the air loss.
On the first day of paving, air loss and target air content will be established during placement of the first eleven loads of concrete. The procedure will be as follows:

a. Central Batch Plant: the air content before the paver shall be between 8.0% and 12.0% until the target air content has been established.

b. Ready Mixed Concrete: the air content before the paver shall be 7.5% plus 1.5% or minus 1.0%, until target air content has been established.

Thereafter, the air loss and target air content will be established once per half day paving. The target air content shall be 6.5%, plus the air loss rounded to the next higher 0.5%, with a tolerance of plus or minus 1.5%. A new target air content before the paver will be established if the air loss deviates by more than 0.5% from the last air loss.

After the first day of paving, the target air content from the previous day will be used until a new target air content is determined.

2. Slip form projects less than 7500 square yards (6000 m^2). The air content before the paver shall be 7.5% plus 1.5% or minus 1.0%. At the option of the Engineer, the target air content may be established using the air loss.

The air content for non slip form paving shall be 7.0% plus 1.5% or minus 1.50%.

Reason for Revision:

County or City Input Needed (X one)	**Yes**	**No**
Comments:		

Industry Input Needed (X one)			**Yes**	**No**	
Industry Notified:	**Yes** X	**No**	**Industry Concurrence:**	**Yes** X	**No**

Comments: Current process of determining air content using loss has been complicated and interpreted various ways in the field. Industry has expressed an interest to look at percent within limits (PWL) for entrained air content. We have investigated the data based on determining loss and adjusting target air contents. For PWL, a single target value is needed. Typical air loss is between 1 to 2 percent. Based on hardened air results obtained from project cores, the in place air contents average over 7.5%. A target of 8% and assuming a typical loss of 1.5% will achieve adequate in place air content for freeze-thaw protection.

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: John Smythe / Mark Bortle	**Office:** Construction	**Item 2**
Submittal Date: 2008.10.20	**Proposed Effective Date:** April 2009 GS	
Article No.: 2528.01, B **Title:** Traffic Quality Control	**Other:**	

Specification Committee Action: Approved as is.

Deferred:	**Not Approved:**	**Approved Date:** 11/13/08	**Effective Date:** 4/21/09

Specification Committee Approved Text: See Specification Section Recommended Text.

Comments: The Office of Construction explained they established traffic control quality control requirements for contractors several years ago. Part of these requirements includes documenting traffic control. They haven't been specific about the documentation. However, since implementing the documentation requirements, they have seen good and bad examples of documentation. This lead the Office of Construction to develop a standardized form. Industry isn't in favor of a standardized form. They suggested a pre-determined bid item, which would allow the option of withholding payment until documentation is done properly. The Office of Construction noted they are not in favor of a pre-determined bid item because of the variability of the work. Industry would also like to see some sort requirement for how often, and when, documentation is to be turned in. The Office of Construction suggested that how often and when documentation should be turned in could be discussed at the pre-construction meeting.

The Office of Construction noted an additional benefit of the standardized format is documentation of flagger use. This would help when reconciling flagger day payments. The Office of Contracts asked if the documentation would be used to estimate payment for flaggers. The Office of Construction explained payment would still be according to the Specifications. The form would simply document the hours the flaggers are on the site.

The Office of Local Systems asked why the form would have the Contractor's letterhead. The Office of Construction explained that was done in hopes the Contractor would feel a sense of ownership of the form.

The Office of Construction noted the form would reside in the Construction Manual.

Specification Section Recommended Text:

2528.01, B, Traffic Quality Control.

Replace the entire article:

The Contractor shall have a Traffic Control Technician on staff, even though the traffic control portion of the contract may be subcontracted. The Traffic Control Technician shall have attended and passed the exam in an American Traffic Safety Services Association (ATSSA) Traffic Control Technician or IMSA Work Zone Traffic Control training class. This Traffic Control Technician shall be responsible for overall management of the Contractor's quality control program for traffic control.

The Contractor shall perform the following quality control work associated with monitoring and documenting traffic control conditions daily as the project is constructed.

1. Review all traffic control operations for compliance with contract documents and maintain a project traffic control daily diary, in a format provided by the Contracting Authority, which shall be submitted to the Engineer and will become a part of the

Contracting Authority's permanent project records. The Engineer may require submission of completed portions of the daily diary at routine intervals during construction of the project. The diary shall include:

a. listing and station location of traffic control used each day referenced to the appropriate Standard Road Plan, project plan sheet, etc.,
b. all reviews of traffic control devices and operations, whether satisfactory or unsatisfactory, and corrections made,
c. approved changes to the contract document's traffic control,
d. incidentals affecting the efficiency and safety of traffic,
e. weather conditions,
f. a daily list of trained flaggers used, including hours worked ~~on the project~~.

2. Monitor traffic operations and submit proposed Traffic Control Plan changes to the Engineer for approval.

3. Coordinate all changes to the Traffic Control Plan.

4. Coordinate all traffic control operations, including those of subcontractors and suppliers.

~~The Contractor shall have a technician on staff that has attended and passed the exam in an ATSSA Traffic Control Technician or International Municipal Signal Association (IMSA) Work Zone Traffic Control training class. even though the Traffic Control portion of the contract may be subcontracted. This Traffic Control Technician shall be responsible for the overall management of the Contractor's quality control program for traffic control.~~

Comments:

Member's Requested Change: **(Do not use 'Track Changes', or 'Mark-Up'. Use ~~Strikeout~~ and Highlight.)**

B. Traffic Quality Control

The Contractor shall have a traffic control technician on staff, even though the traffic control portion of the contract may be subcontracted. The traffic control technician shall have attended and passed the exam in an ATSSA Traffic Control Technician or International Municipal Signal Association (IMSA) Work Zone Traffic Control training class. This Traffic Control Technician shall be responsible for the overall management of the Contractor's quality control program for traffic control.

The Contractor shall perform the following quality control work associated with monitoring and documenting traffic control conditions daily as the project is constructed.

1. Review all traffic control operations for compliance with contract documents and maintain a project traffic control daily diary, in a format provided by the Contracting Authority, which shall be submitted to the Engineer and will become a part of the Contracting Authority's permanent project records. The Engineer may require submission of completed portions of the daily diary at routine intervals during construction of the project. The diary shall include:

a. listing and station location of traffic control used each day referenced to the appropriate Standard Road Plan, project plan sheet, etc.
b. all reviews of traffic control devices and operations, whether satisfactory or unsatisfactory and corrections made,
c. approved changes to contract document's traffic control,
d. incidentals affecting the efficiency and safety of traffic,
e. weather conditions,

f. a daily list of trained flaggers used, including hours worked ~~on the project~~.

2. Monitor traffic operations and submit proposed Traffic Control Plan changes to the Engineer for approval.

3. Coordinate all changes to the Traffic Control Plan.

4. Coordinate all traffic control operations, including those of subcontractors and suppliers.

~~The Contractor shall have a technician on staff that has attended and passed the exam in an ATSSA Traffic Control Technician or International Municipal Signal Association (IMSA) Work Zone Traffic Control training class. even though the Traffic Control portion of the contract may be subcontracted. This Traffic Control Technician shall be responsible for the overall management of the Contractor's quality control program for traffic control.~~

Reason for Revision: To provide better clarity in the requirements for the daily traffic control diary and to provide a standard diary format for contractors to use.

County or City Input Needed (X one)			**Yes**	**No** X	
Comments:					
Industry Input Needed (X one)			**Yes** X	**No**	
Industry Notified:	**Yes** X	**No**	**Industry Concurrence:**	**Yes**	**No**
Comments:					

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: Jim Berger	**Office:** Materials	**Item 3**
Submittal Date: 2008.10.23	**Proposed Effective Date:** 4/21/2009	
Section No.: 2546.02, D **Title:** Revetment Stone. **Section No.:** 4130 **Title:** Revetment Stone and Erosion Stone.	**Other:**	

Specification Committee Action: Approved with changes as noted.

Deferred:	**Not Approved:**	**Approved Date:** 11/13/08	**Effective Date:** 4/21/09

Specification Committee Approved Text: See Specification Section Recommended Text, with the additional change below.

4130, Revetment Stone and Erosion Stone.

Change the title of the section:

Revetment Stone, ~~and~~ Erosion Stone, and Gabion Stone.

Comments: The Office of Materials noted the title of Section 4130 should be changed to Revetment Stone, Erosion Stone, and Gabion Stone.

Specification Section Recommended Text:

2546.02, D, Revetment Stone.

Replace the title and entire article:

~~**Revetment Stone.**~~
~~Revetment stone for filling baskets shall be broken stone or gravel boulders meeting the following requirements. All stone and boulders for the project shall be from one source or from sources similar in geological origin.~~

~~**1. Durability.**~~
~~Unless otherwise specified, the stone shall be taken from a source which does not exceed 10%, when subjected to the freezing and thawing test, Laboratory Test Method 211, Method A.~~

~~**2. Abrasion.**~~
~~The stone shall be taken from a source which does not exceed 45%, when tested in accord with AASHTO T 96, Grading A or B.~~

~~**3. Size.**~~
~~Unless otherwise specified, the stone or boulders for gabions and mattresses shall be processed so that the sizes range from 4 inches to 8 inches (100 mm to 200 mm) in nominal dimensions, and 3 inches to 5 inches (76.0 mm to 127 mm) is recommended for mattresses.~~

~~Stone sizes shall be inspected visually by a certified aggregate technician.~~

Gabion Stone.
Gabion stone shall meet the requirements of Article 4130.06.

4130.06, Gabion Stone Description.

Add as a new article:

Gabion Stone Description.

Broken stone or gravel boulders meeting the requirements below. Use stone and boulders from sources similar in geological origin.

4130.07, Gabion and Mattress Stone Gradation.

Add as a new article:

Gabion and Mattress Stone Gradation.

Process stone or boulders for gabions and mattresses to sizes ranging from 4 inches to 8 inches (100 mm to 200 mm) in nominal dimensions. Three inches to 5 inches (76.0 mm to 127 mm) is recommended for mattresses.

Have a certified aggregate technician visually inspect stone sizes.

4130.08, Gabion Stone Quality.

Add as a new article:

Gabion Stone Quality.

Meet requirements of Table 4130.08. Sources with Revetment A, B, or E approvals need not meet these requirements.

TABLE 4130.08

Aggregate Quality	Maximum Percent Allowed	Test Method
Alumina A Freeze	0.7 10	Iowa DOT Materials Laboratory Test Method 211, Method A
Abrasion	50	AASHTO T 96
Note: Pass either Alumina or A Freeze for compliance (alumina does not apply to gravel). Perform tests on product crushed to 3/4 inch (19 mm) or 1 inch (25 mm) maximum size.		

Comments:

Member's Requested Change (Redline/Strikeout):

Section 2546. Gabions and Revet Mattresses.

Delete and Replace: D. Revetment Stone with D. Gabion Stone

~~**D. Revetment Stone.**~~

~~Revetment stone for filling **baskets** shall be broken stone or gravel boulders meeting the following requirements. All stone and boulders for the project shall be from one source or from sources similar in geological origin.~~

~~**1. Durability.**~~

~~Unless otherwise specified, the stone shall be taken from a source which does not exceed 10%, when subjected to the freezing and thawing test, Laboratory Test Method 211, Method A.~~

~~**2. Abrasion.**~~

~~The stone shall be taken from a source which does not exceed 45%, when tested in accord with AASHTO~~

~~T 96, Grading A or B.~~

~~**3. Size.**~~
~~Unless otherwise specified, the stone or boulders for gabions and mattresses shall be processed so that the sizes range from 4 inches to 8 inches (100 mm to 200 mm) in nominal dimensions, and 3 inches to 5 inches (76.0 mm to 127 mm) is recommended for mattresses.~~

~~Stone sizes shall be inspected visually by a certified aggregate technician.~~

D. Gabion Stone.
Furnish material meeting the requirements of Article 4130.06.

Section 4130. Revetment Stone and Erosion Stone
Change: Section title
Add: 4130.06 through 4130.08

Section 4130. Revetment Stone, Erosion Stone, and Gabion Stone

4130.06 GABION STONE DESCRIPTION.
Gabion stone for filling baskets shall be broken stone or gravel boulders meeting the following requirements. All stone and boulders for the project shall be from one source or from sources similar in geological origin.

4130.07 GABION STONE GRADATION.
Unless otherwise specified, the stone or boulders for gabions and mattresses shall be processed so that the sizes range from 4 inches to 8 inches (100 mm to 200 mm) in nominal dimensions, and 3 inches to 5 inches (76.0 mm to 127 mm) is recommended for mattresses.

Stone sizes shall be inspected visually by a certified aggregate technician.

4130.08 GABION STONE QUALITY.
Meet the requirements of Table 4130.08-1. Sources with Revetment A, B, or E approvals need not meet these requirements.

Table 4130.08-1: Aggregate Quality (Gabion Stone)

Aggregate Quality	Maximum Percent Allowed	Test Method
Alumina A Freeze	0.7 10	Iowa DOT Materials Laboratory Test Method 211, Method A
Abrasion	50	AASHTO T 96
Note: Pass either Alumina or A Freeze for compliance (alumina does not apply to gravel). Perform tests on product crushed to 3/4 inch (19 mm) or 1 inch (25 mm) maximum size.		

Reason for Revision:

Moving material requirement from 2546 to revetment section 4130. Changing abrasion to match revetment. Adding alumina to match crushed stone specifications. Adding with A, B, or E approvals it is not required to meet test specifications.

County or City Input Needed (X one)	**Yes**	**No** X
Comments:		

Industry Input Needed (X one)			**Yes**	**No** X	
Industry Notified:	**Yes**	**No** X	**Industry Concurrence:**	**Yes**	**No**
Comments: Not a change in specifications.					

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: Jim Berger	**Office:** Materials	**Item 4**
Submittal Date: 2008.10.28	**Proposed Effective Date:** 4/21/2009	
Section No.: 4110 **Title:** Fine Aggregate for PCC	**Other:**	

Specification Committee Action: Approved as is.

Deferred:	**Not Approved:**	**Approved Date:** 11/13/08	**Effective Date:** 4/21/09

Specification Committee Approved Text: See Specification Section Recommended Text.

Comments: None.

Specification Section Recommended Text:

4110.03, Quality.

Replace Table 4110.03:

TABLE 4110.03

Fine Aggregate Quality	Test Limits	Test Method
Shale and Coal	2.0% (maximum)	Materials I.M. 344
Mortar Strength[~~a~~]	~~1.5 (minimum)~~ 6,000 psi (minimum)	Iowa DOT Materials Laboratory Test Method 212
~~Fineness Modulus~~	~~2.75 (minimum)~~	~~Materials I.M. 302~~
~~[a] An annual mortar strength test result of 1.5 or greater is required for continued approval of a source with a fineness modulus less than 2.75.~~		

Comments:

Member's Requested Change (Redline/Strikeout):

Section 4110. Fine Aggregate for Portland Cement Concrete

Change: Mortar Strength ratio from 1.5 to Mortar Strength of 6,000 psi.
Delete: Reference to Fineness Modulus.

Section 4110. Fine Aggregate for Portland Cement Concrete

4110.01 DESCRIPTION.
Natural sands resulting from disintegration of rock through erosional processes. Acquire mineral aggregate from an approved source as described in Materials I.M. 409.

4110.02 GRADATION.
Meet the requirements for Gradation No. 1 of the Aggregate Gradation Table, Article 4109.02.

4110.03 QUALITY.

A. Meet the requirements of Table 4110.03-1:

Table 4110.03-1: Test Limits and Methods

Fine Aggregate Quality	Test Limits	Test Method

Shale and Coal	2.0% (maximum)	Materials I.M. 344
Mortar Strength~~[a]~~	~~1.5 (minimum)~~ 6,000 psi (minimum)	Iowa DOT Materials Laboratory Test Method 212
~~Fineness Modulus~~	~~2.75 (minimum)~~	~~Materials I.M. 302~~
~~[a] An annual mortar strength test result of 1.5 or greater is required for continued approval of a source with a fineness modulus less than 2.75.~~		

B. The Engineer may require additional mortar strength testing for sources where quality changes.

Reason for Revision: With the increasing strength of cements, the relative difference between the sample and the standard has caused an increasing number of fine aggregates to fail the mortar strength ratio test. Going to the "absolute" strength of the sample will resolve this problem. The value of 6,000 psi is based on historic values of the standard strength and a ratio of 1.5 between standard and sample. Fineness modulus will be established by source, with a drop of 0.2 requiring a new mortar strength test. Details will be included with source approval information in Materials IM 409.

County or City Input Needed (X one)			**Yes**	**No** X	
Comments:					
Industry Input Needed (X one)			**Yes**	**No** X	
Industry Notified:	**Yes**	**No** X	**Industry Concurrence:**	**Yes**	**No**

Comments: Not a change in specification, but a reinterpretation of test data to resolve problems with the method.

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: Jim Berger	**Office:** Materials	**Item 5**
Submittal Date: October 31, 2008	**Proposed Effective Date:** April, 2009	
Article No.: 4186.02, C **Title:** Plywood (Sign Panels)	**Other:**	

Specification Committee Action: Approved with changes as noted.

Deferred:	**Not Approved:**	**Approved Date:** 11/13/09	**Effective Date:** 4/21/09

Specification Committee Approved Text:
4186.02, C, Plywood.

Replace the entire article:

~~All softwood plywood shall conform to the latest edition of Production Standard One PS1-83 Group 1, and each panel shall be APA Grade Trademark of the American Plywood Association. The panel shall be BB exterior (Douglas Fir) B grade, plugged core (Douglas Fir). The core gaps shall not exceed 1/2 inch (12.5 mm). This material must be suitable for sign manufacture and the overlay must be compatible with the adhesive of the sheeting. The overlay on both faces must be prepared at the time of manufacture prior to application of sheeting. No marks, blemishes or damage of any kind will be allowed. The 5/8 inch (15.6 mm) thick plywood shall be a high density overlay (HDO) such as Simpson "Highway HDO: or comparable. The 1/2 inch (12.5 mm) thick plywood shall be a medium density overlay (MDO).~~

All softwood plywood shall conform to the latest edition of the National Institute of Standards and Technology Voluntary Product Standard PS 1 for Structural Plywood. Plywood shall be 1/2 inch (12.5 mm) thick and be either medium density overlay (MDO) or high density overlay (HDO). The panels' grades are:

1. Exterior HDO-Industrial B-B, overlaid both sides with a two step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes, or damage of any kind.

   The panel faced veneers shall be a certified hardwood, (tested and certified in accordance to Section 5.8.7 of PS 1 by an International Accreditation Service (IAS) recognized inspection/testing agency) or Douglas fir from Group 1 classification of species. The inner plies shall be Douglas fir and the grade shall be C plugged or better.

2. Exterior MDO-General B-B, overlaid both sides with a two step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes, or damage of any kind.

   The panel faced veneers shall be from a Group 1 classification of species or equivalent, (tested and certified in accordance to Section 5.8.7 of PS 1 by an IAS recognized inspection/testing agency). The inner plies shall be from either Group 1 or Group 2 classification of species and the grade shall be C grade or better.

Comments: The Office of Construction expressed concern that this change may eliminate some material sources. The Office of Materials explained they didn't think it would, but they will check to be sure. The Office of Construction asked what the basis of acceptance is. The Office of Materials explained it is their feeling this would be handled by some type of materials certification. They will look into this issue to be sure. The Office of Construction noted they have had some difficulties tracking

down certification for plywood panels.

The Office of Contracts noted the proposed changes will delete the definitions of MDO and HDO. The Committee agreed these should be added back in to the specification.

Specification Section Recommended Text:

4186.02, C, Plywood.

Replace the entire article:

~~All softwood plywood shall conform to the latest edition of Production Standard One PS1-83 Group 1, and each panel shall be APA Grade-Trademark of the American Plywood Association. The panel shall be BB exterior (Douglas Fir) B grade, plugged core (Douglas Fir). The core gaps shall not exceed 1/2 inch (12.5 mm). This material must be suitable for sign manufacture and the overlay must be compatible with the adhesive of the sheeting. The overlay on both faces must be prepared at the time of manufacture prior to application of sheeting. No marks, blemishes or damage of any kind will be allowed. The 5/8 inch (15.6 mm) thick plywood shall be a high density overlay (HDO) such as Simpson "Highway HDO: or comparable. The 1/2 inch (12.5 mm) thick plywood shall be a medium density overlay (MDO).~~

All softwood plywood shall conform to the latest edition of the National Institute of Standards and Technology Voluntary Product Standard PS 1 for Structural Plywood. Plywood shall be 1/2 inch (12.5 mm) thick. The panels' grades are:

1. Exterior HDO-Industrial B-B, overlaid both sides with a two step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes, or damage of any kind.

   The panel faced veneers shall be a certified hardwood, (tested and certified in accordance to Section 5.8.7 of PS 1 by an International Accreditation Service (IAS) recognized inspection/testing agency) or Douglas fir from Group 1 classification of species. The inner plies shall be Douglas fir and the grade shall be C plugged or better.

2. Exterior MDO-General B-B, overlaid both sides with a two step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes, or damage of any kind.

   The panel faced veneers shall be from a group 1 classification of species or equivalent, (tested and certified in accordance to Section 5.8.7 of PS 1 by an IAS recognized inspection/testing agency). The inner plies shall be from either Group 1 or Group 2 classification of species and the grade shall be C grade or better.

Either grade MDO or HDO may be used.

Comments:

Member's Requested Change: (Do not use 'Track Changes', or 'Mark-Up'. Use ~~Strikeout~~ and Highlight.

4186.02 SIGN PANELS.
Sign panels shall be of sheet aluminum, or galvanized steel, or when specifically specified, flexible roll-up material or plywood. The sign panel shall meet the following requirements:

A. Sheet Aluminum.

Sheet aluminum for Type A signs shall meet requirements of ASTM B 209, Alloy 5052-H38. The aluminum thickness is specified in the contract documents, the nominal thicknesses are 0.063, 0.080, and 0.125 inches (1.5 mm, 2 mm, and 3 mm). If the aluminum thickness is not specified, it shall be 0.080 inches (2 mm) for signs with the longest side of 36 inches (900 mm) or less. For signs with the longest side greater than 36 inches (900 mm), the nominal thickness shall be 0.125 inches (3 mm). These thicknesses are subject to similar tolerances as specified in ASTM B 209 for a sheet having a width equal to the greatest dimension of the sign.

Before application of sheeting, the aluminum surface shall be degreased and etched according to the sheeting manufacturer's recommendations. A conversion coating may be applied to the aluminum in accordance with the sheeting manufacturer's recommendations. Any white rust present on the aluminum prior to application of the sheeting shall be removed according to the sheeting manufacturer's recommendations.

B. Galvanized Steel.
Galvanized steel for Type A signs shall meet requirements of ASTM A 653/A 653M, light commercial coating. The galvanizing shall be phosphatized. For Type A signs with the longest side 30 inches (750 mm) or less, the sheet thickness shall be 0.0785 inch (2 mm); for all other Type A signs, the sheet thickness shall be 0.1233 inch (3.123 mm); both with a minus tolerance of 20%.

C. Plywood.
All softwood plywood shall conform to the latest edition of the National Institute of Standards and Technology Voluntary Product Standard PS 1 for Structural Plywood. Unless specified elsewhere in the contract documents, the plywood shall be ½" thick (12.5mm). The panels grades are:

1. Exterior HDO-Industrial B-B, overlaid both sides with a 2 step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes or damage of any kind.

   The panel faced veneers shall be a certified hardwood, (tested and certified in accordance to Section 5.8.7 of PS 1 by an International Accreditation Service (IAS) recognized inspection/testing agency) or Douglas fir from group 1 classification of species. The inner plies shall be Douglas fir and the grade shall be C plugged or better.

2. Exterior MDO-General B-B, overlaid both sides with a 2 step lay-up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. The overlay shall have no marks, blemishes or damage of any kind.

   The panel faced veneers shall be from a group 1 classification of species or equivalent, (tested and certified in accordance to Section 5.8.7 of PS 1 by an International Accreditation Service (IAS) recognized inspection/testing agency). The inner plies shall be from either Group 1 or Group 2 classification of species and the grade shall be C grade or better.

Unless specified elsewhere in the contract documents, either MDO or HDO listed above may be used.

~~Production Standard One PS1-83 Group 1, and each panel shall be APA Grade-Trademark of the American Plywood Association. The panel shall be BB exterior (Douglas Fir) B grade, plugged core (Douglas Fir). The core gaps shall not exceed 1/2 inch (12.5 mm). This material must be suitable for sign manufacture and the overlay must be compatible with the adhesive of the sheeting. The overlay on both faces must be prepared at the time of manufacture prior to application of sheeting. No marks, blemishes or damage of any kind will be allowed. The 5/8 inch (15.6 mm) thick plywood shall be a high~~

~~density overlay (HDO) such as Simpson "Highway HDO": or comparable. The 1/2 inch (12.5 mm) thick plywood shall be a medium density overlay (MDO).~~					
Reason for Revision: Current Reference to Standards and manufacturer are out of date. The current standard is PS 1-07 and Simpson is now Olympic Panel Products.					
County or City Input Needed (X one)			**Yes**	**No** X	
Comments:					
Industry Input Needed (X one)			**Yes**	**No**	
Industry Notified:	**Yes**	**No**	**Industry Concurrence:**	**Yes**	**No**
Comments: Contacted current Iowa DOT Sign Shop supplier of HDO and MDO for assistance.					

SPECIFICATION REVISION SUBMITTAL FORM

Submitted by: Jim Berger	**Office:** Materials	**Item 6**
Submittal Date: October 19, 2008	**Proposed Effective Date:** January, 2009	
Article No.: DS-01076 **Title:** DEVELOPMENTAL SPECIFICATIONS FOR COLD IN-PLACE RECYCLED ASPHALT PAVEMENT	**Other:**	

Specification Committee Action: Deferred.

Deferred: X	**Not Approved:**	**Approved Date:**	**Effective Date:**

Specification Committee Approved Text:

Comments: The Committee chose to defer this item. There are several issues that need further discussion:

- Remove the option for the type of emulsion the Contractor can use. The designer, not the Contractor, should be choosing which type of emulsion to use.
- Clarify the relationship between CIR curing time and working days. How working days are applied for projects on roads with ADT greater than 2500 vpd can be confusing and needs to be clarified.
- Adjust the time of year to allow CIR. Counties want to narrow the window of time for CIR work to be allowed.
- Provide a definition for a spreader. There is no definition of a spreader to use for placing CIR. What can be used as a spreader needs to be clearly defined.
- Rewrite the specification to be a tiered specification, with one level for primary roads and the other for secondary roads.

The Specifications Section will set up a meeting with the Offices of Construction, Materials, Local Systems, and Contracts, and will include a representative from Iowa County Engineers.

The Office of Construction pointed out that there should be some emphasis on avoiding fabric. Designers should be setting CIR depths to minimize the possibility of encountering fabric. The Office of Construction also noted the fifth sentence of 01XXX.04, C, should be reworded as “Acceptable corrective measures include blading and recompaction of the CIR layer within 24 hours of initial placement, profile milling of CIR layer, or placing an HMA leveling course”. They pointed out it probably isn’t necessary to perform profile milling or to place leveling courses within 24 hours.

Specification Section Recommended Text: See attached Draft DS.

Comments:

Member’s Requested Change: **(Do not use ‘Track Changes’, or ‘Mark-Up’. Use ~~Strikeout~~ and Highlight.**

Reason for Revision: Updates to reflect revised Materials I.M. 504, change to the “cured” moisture content to reflect current practice, and elimination of engineered emulsion.

County or City Input Needed (X one)	**Yes**	**No**
Comments:		

Industry Input Needed (X one)			**Yes**	**No**	
Industry Notified:	**Yes**	**No**	**Industry Concurrence:**	**Yes**	**No**
Comments:					

Draft DS-01XXX
(Replaces DS-01076)

Iowa Department of Transportation

~~****THIS IS A GENERAL REWRITE. PLEASE READ CAREFULLY.****~~

DEVELOPMENTAL SPECIFICATIONS FOR COLD IN-PLACE RECYCLED ASPHALT PAVEMENT

Effective Date
January 21, 2009

THE STANDARD SPECIFICATIONS, SERIES OF 2001, ARE AMENDED BY THE FOLLOWING MODIFICATIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

Replace all of Section 2318 of the Standard Specifications with the following:

01XXX.01 DESCRIPTION.
Cold in-place recycling (CIR) consists of milling the existing asphalt pavement, processing and mixing the recycled asphalt pavement with an asphalt stabilizing agent and water (if required), and placing and compacting this mixture.

01XXX.02 MATERIALS.

A. Asphalt Stabilizing Agent.
Unless otherwise specified in the contract documents, the asphalt stabilizing agent shall, at the Contractor's option, be one of the following:

1. Standard Asphalt Emulsion (HFMS-2s) meeting the requirements of Section 4140 of the Standard Specifications shall be used on all Primary and Interstate projects. CSS-1 emulsion meeting the requirements of Section 4140 of the Standard Specifications may be used in place of HFMS-2s on other projects ~~when the traffic permitted on the CIR layer is less than 500 ADT~~.

2. Foamed Asphalt using PG 52 -34 or PG 46 -34 asphalt binder meeting the requirements of Section 4137 of the Standard Specifications.

~~**3.** Engineered Emulsion meeting the requirements of the mix design.~~

B. Recycled Asphalt Pavement.
The processed RAP is intended to conform to the following gradation. The gradation may be revised with the approval of the Engineer, but the top size of the material shall not exceed 50% of the depth of the compacted recycled mat.

Sieve Size	% Passing
1 1/2 inch (37.5 mm)	98 to 100
1 inch (25 mm)	90 to 100

C. Mix Design.
A mix design process will not be performed for standard asphalt emulsion or foamed asphalt unless otherwise stated in the contract documents. ~~A mix design is required for engineered emulsion.~~ The following application rates per square yard per inch of compacted thickness will be used when no mix design is performed.

Asphalt Stabilizing Agent	**Application Rate (/yd^2/in)**	**(/m^2/25 mm)**
Standard Asphalt Emulsion	0.30 gallons (emulsion)	1.325 L
Foamed Asphalt	0.0011 tons (asphalt binder)	1.175 kg
~~Engineered Emulsion (estimate only)~~	~~0.40 gallons (emulsion)~~	~~1.775 L~~

When a mix design is required, the following provisions shall apply:

~~1. Mix Design using Foamed Asphalt.~~
The ~~c~~Contractor will provide the Engineer with a representative 150 lb (22 kg) bulk sample of the existing pavement surface as directed by the Engineer following the sampling options in ~~Appendix A~~ Materials I.M. 504 and 10 gallons (38 L) of the intended asphalt stabilizing agent. The Engineer will provide the details of the mix design to the Contractor no later than 6 weeks after receiving the samples. The mix design will be performed by the Central Materials Laboratory as per Materials I.M. 504, Appendix A and will establish the amount of asphalt binder to incorporate into the RAP. The mix design will determine the target asphalt temperature and percent of water injected into the asphalt to achieve optimum foaming.

~~2. Mix Design using Engineered Emulsion.~~
~~The Contractor shall submit a mix design to the Engineer and the District Materials Engineer for approval two weeks before the anticipated CIR start date. The mix design shall follow IM 504 Appendix A .~~

01XXX.03 CONSTRUCTION REQUIREMENTS.
Except in specific cases when permitted by the Engineer, the Contractor shall perform CIR between May 1 and October 1.

The Contractor shall not perform recycling operations when the ambient temperature is below 60°F (15°C); when the weather is foggy or rainy; or when weather conditions are such that proper mixing, placing, and compacting the recycled material cannot be accomplished.

A. Equipment.
The Contractor shall furnish a self-propelled machine capable of milling the existing asphalt pavement to the depth shown in the contract documents in one pass. The machine shall be equipped with automatic depth control, maintain a constant cutting depth and width, uniform grade, and uniform slope. It shall also be capable of producing the properly sized RAP or additional screening and crushing will be required.

The Contractor shall furnish equipment capable of mixing the RAP and asphalt stabilizing agent into a homogeneous CIR mixture. The equipment shall meet the requirements of Article 2001.22, F, of the Standard Specifications and provide a positive means, including visual display, for accurately controlling the rate of flow and total delivery of the asphalt stabilizing agent into the mixture in relation to the quantity of RAP being recycled. The asphalt stabilizer application system shall be capable of adjusting for the width of recycling such that overlapped CIR mixture maintains the designed asphalt stabilization content.

When foamed asphalt stabilizing agent is used, the asphalt foaming system shall accurately and uniformly inject the specified percent of water into the hot asphalt binder. The equipment shall be fitted with a test nozzle to provide field samples of foamed asphalt. Tankers supplying the hot asphalt binder shall be equipped with a thermometer to continuously measure the temperature of the asphalt in the bottom third of the tank.

The Contractor shall use a bituminous paver meeting the requirements of Article 2001.19 of the Standard Specifications or a spreader meeting the requirements of Article 2001.13 of the Standard Specifications to place the CIR material. Heating the screed of the bituminous paver will not be permitted.

The rollers for compacting the CIR material shall meet the requirements of Article 2001.05 of the Standard Specifications. As a minimum, the Contractor shall have for use a self-propelled double drum vibratory steel roller and a self-propelled 25 ton (25 Mg) or greater pneumatic tire roller. The vibratory roller may be used in the static or vibratory mode.

B. Preparation.
Prior to initiating the recycling operation, the Contractor shall clear all vegetation and debris within the width of pavement to be recycled in accordance with Article 2212.04, A, of the Standard Specifications.

C. Milling the Existing Pavement.
The Contractor shall mill the existing pavement to the specified constant depth and width in one pass. The RAP shall be processed to the required gradation. When specified in the contract documents or when approved by the Engineer, the pavement surface may be pre-milled to a uniform 2% cross slope. RAP from pre-milling shall be removed from the project.

When the plans note that the milling operation will encounter a paving fabric, the Contractor shall make the necessary adjustments in equipment or operations so that no fabric piece has any dimension exceeding a length of 4 inches (100 mm). The Contractor shall remove RAP containing over-sized pieces of paving fabric.

D. Mixing the Recycled Material.
During recycling operations, the Contractor shall apply the asphalt stabilizing agent to the RAP at the specified application rate. The Engineer may vary the application rate of asphalt stabilizing agent as required by existing pavement conditions. The Contractor shall determine the amount of additional water needed to facilitate uniform mixing with the asphalt stabilizing agent and to achieve a stable pavement layer above the minimum specified density. The water may be added prior to or concurrently with the asphalt stabilizing agent. Adding water to facilitate uniform mixing shall not adversely affect the asphalt stabilizing agent.

E. Placement of the Recycled Material.
The Contractor shall deposit the CIR mixture in a windrow, spreader, paver, or loaded into trucks, without segregation.

The Contractor shall place and finish the CIR mixture in one continuous pass, without segregation. Unless otherwise noted in the contract documents, the surface of the CIR lift shall have a uniform cross-slope of 2%, but at no time shall the lift thickness be less than 2 inches (50 mm). When a pick-up machine is used to feed the windrow into the paver hopper, the pick-up machine shall be capable of picking up the entire windrow to the underlying material.

F. Compaction and Density.
The field density for Interstate and Primary Roads shall be a minimum of 94% of laboratory density based on the dry weight of compacted material in accordance with ~~Appendix A~~ Materials I.M. 504. The field density for all other roads shall be a minimum of 92%.

The Contractor shall perform initial rolling with a pneumatic tired roller. The Contractor shall perform final rolling to eliminate pneumatic tire marks by using steel wheel rollers, either in static or vibratory mode.

The Contractor shall discontinue any type of rolling that results in cracking, movement, or other types

of pavement distress until such time that the problem can be resolved.

If there is a significant change in mix proportions, weather conditions, or other controlling factors the Engineer may require construction of test strips to check target density.

G. Opening the CIR Layer to Traffic.
After compaction is complete, the Contractor will determine when the CIR layer is stable to open to traffic. ~~After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. Excessive loose particles that may develop on the pavement surface shall be removed by power brooming.~~

~~**H. Placement of Surface Course.**~~
~~Any subsequent HMA overlay or surface treatment will not be allowed until the moisture content of the CIR layer is no more than 0.3% above the residual moisture content or 1.5%, which ever is greater. The Engineer may adjust this drying period depending on field conditions.~~

On projects with less than 2500 ADT, the Contractor has 14 calendar days after the CIR layer is complete and initially achieves the allowable moisture content to place the first lift of HMA overlay or specified surface treatment. Any damage to the CIR layer after the 14 calendar days shall be corrected at the Contractor's expense.

On roadways ~~projects~~ with more than 2500 ADT, the Contractor has 10 working days after the CIR layer initially achieves the allowable moisture content to place the first lift of HMA overlay or specified surface treatment. This working day limitation applies separately for each day of CIR rehabilitation. Any damage to the CIR layer after the 10 working days shall be corrected at the Contractor's expense.

H. Placement of Surface Course.
Any subsequent HMA overlay or surface treatment will not be allowed until the moisture content of the CIR layer is no more than 0.3% above the residual moisture content or 2.0%, which ever is greater. The Engineer may adjust this drying period depending on field conditions.

01XXX.04 QUALITY CONTROL
The Contractor shall be responsible for quality control of the materials and CIR process. The Contractor shall test the items listed below at the frequency listed in Materials I.M. 204. All samples shall be taken and delivered by the Contractor to the District Materials Laboratory in accordance with ~~Appendix A~~ Materials I.M. 504. Each day of CIR operation shall be defined as a lot for quality control sampling and testing.

A. Asphalt Stabilizing Agent.
The asphalt stabilizing agent shall be sampled and tested according to Materials I.M. 204.
The asphalt stabilization agent shall be applied at the target application rate within ± 0.06 gallon per square yard per inch (0.25 L/m^2/25 mm) for standard ~~and engineered~~ emulsion and within ~~(~~± 0.000165 tons per square yard per inch (0.175 kg/m^2/25 mm) for foamed asphalt~~) of the target application rate~~.

B. Binder Temperature using Foamed Asphalt.
When foamed asphalt is used, the asphalt binder shall be maintained at a temperature within ± 20°F (10°C) of 310°F (155°C) or the optimum temperature established by the mix design. The injection water shall be maintained at the target ± 0.5 percent. The foaming characteristics of each new tanker load will be verified by measuring a sample from the equipment's test nozzle.

C. Profile and Cross-Slope Testing.
Bumps and dips in the profile greater than 1 inch (25 mm) in 25 feet (7.6 m) shall be corrected. Cross-slope of the compacted CIR mat shall be within 0.4% of the desired slope. When directed by the Engineer, the Contractor shall measure the profile of the center of each lane of the compacted

CIR mat with a profilograph. The Contractor will be paid $400 per lane-mile ($250/lane-km) for profiling the length directed by the Engineer. Acceptable corrective measures include profile milling or blading and recompaction within 24 hours of the initial placement or HMA leveling course. Corrective measures shall be at the Contractor's expense.

D. Moisture and Density Tests.
The Contractor shall perform nuclear gauge moisture and density tests in accordance with ~~Appendix A~~ Materials I.M. 504 within 24 hours of completing each lot at locations determined by the Engineer. During each lot of CIR production, the Contractor shall furnish a 40 pound (18 kg) sample sealed in plastic of loose CIR mixture from a location determined by the Engineer and deliver the sample as soon as possible after sampling to the District Materials Laboratory daily for density determination. The Quality Index for density does not apply. Sublots that do not achieve the minimum required density shall be recompacted within 2 calendar days after the CIR layer was placed to meet the target density.

01XXX.05 METHOD OF MEASUREMENT.

A. Cold In-Place Recycled Asphalt Pavement.
The Engineer will compute the area in square yards (square meters) from the measured longitudinal length of pavement and the width of pavement specified in the contract documents.

B. Asphalt Stabilizing Agent.
The Engineer will measure the Asphalt Stabilizing Agent in gallons (liters) at 60°F (15°C) for standard ~~or engineered~~ emulsion, or tons (megagrams) for asphalt binder, through a calibrated pump used for metering the total delivery of the agent or through delivery ticket quantity.

01XXX.06 BASIS OF PAYMENT.

A. Cold In-Place Recycled Asphalt Pavement.
The Contractor will be paid the contract unit price per square yard (square meter) for Cold In-Place Recycled Asphalt Pavement. This payment shall be full compensation for all labor, material including mixing water, and equipment necessary for milling, mixing, spreading, placing, shaping, and compaction of the completed Cold In-Place Recycled Asphalt Pavement.

B. Asphalt Stabilizing Agent.
The Contractor will be paid the contract unit price per gallon (liter) or ton (megagram) for Asphalt Stabilizing Agent. This payment shall be full compensation for all labor, materials, and equipment necessary for furnishing the stabilizing agent.

Appendix A – Instructions for Cold In-Place Recycled Asphalt Pavement

GENERAL

Cold in-place recycling (CIR) is a method of rehabilitating the existing asphalt pavement surface. As an "in-place" technology, all work takes place on the roadway using the existing asphalt pavement. Generally, material is not wasted or removed. The existing asphalt surface material is cold milled to the specified depth, sized to the specified gradation (maximum particle size), mixed with the specified asphalt stabilizing agents, and placed back on the pavement to the specified width, depth, profile, and cross-slope. This is accomplished in a continuous single-pass operation with the appropriate equipment. The CIR layer is compacted to the required density with rubber-tired and steel-wheeled rollers and can be opened to traffic the same day in most cases. As part of the project, the CIR layer is covered with a new HMA surface course or thin asphalt surface treatment.

This rehabilitation process is normally applied to projects with low volume traffic (i.e., under 2000 vpd) and a structurally adequate pavement section. Projects with insufficient subgrade support should not be candidates for this type of rehabilitation. Projects with higher traffic volumes should do an engineering analysis to determine if this rehabilitation strategy can be successfully applied.

MATERIAL SAMPLING FOR MIX DESIGN

STABILIZING AGENT

The stabilizing agent from the proposed supplier is required for the mix design. A 10-gallon (38 L) sample is needed to prepare the replicates for the range of application rates.

EXISTING PAVEMENT

Samples for mix design testing should be obtained from at least 3 locations. Significant mixture differences in the pavement to be recycled may require separate samples. Samples for mix design obtained from the milled RAP are the most representative, but are rarely possible when the mix designs are performed. If RAP samples are obtained by milling, mill a minimum of 50 feet (15 m) of project length at each sample location. Other methods of sampling for mix design include coring or air-hammer patch areas. All samples shall represent the entire depth of CIR processing.

DEVELOPING THE MIX DESIGN

STANDARD EMULSION

A mix design is not required for CIR with standard emulsion. The production starts at 0.3 gallons of emulsion per square yard per inch (1.325 l/m^2/25 mm) of CIR compacted thickness. The Engineer may adjust the asphalt stabilizing agent application rate in the field to improve stability or minimize cracking.

FOAMED ASPHALT

The mix design of CIR with foamed asphalt requires a laboratory capable of generating controlled quantities of foamed asphalt. The mix design determines the proper application rate of foamed asphalt to achieve stability under dry and saturated conditions. Indirect tensile testing is used to measure the CIR mixture strength.

The mix design with foamed asphalt is performed by the Iowa DOT Central Asphalt Lab. The current mix design procedure is described in this appendix.

ENGINEERED EMULSION

The mix design of CIR with engineered emulsion requires close coordination with the emulsion supplier to formulate the residual asphalt binder to satisfy the mix design criteria. The mix design determines the emulsion properties and the application rate for the emulsion that satisfy the mix design criteria. A series of tests are used to measure strength and low temperature flexibility.

Procedures for the mix design with engineered emulsion are described in this appendix.

FIELD CONTROL OF ASPHALT STABILIZING AGENT

CALIBRATE AND MONITOR STABILIZING AGENT RATE OF FLOW
The contactor shall provide a positive means of accurately metering the rate of flow and total delivery of the asphalt stabilizing agent. The Engineer should verify the rate of application with production yield checks during construction.

The contractor may use the delivery pump as one of the options to determine total gallons of stabilizing agent used on the project. Pump accuracy is determined by comparing a metered volume or weight, correcting for temperature, against a known volume or weight. The pump must consistently deliver with in ± 1.5% of the required gallons (liters). If the contractor elects to use delivery ticket quantities and production yield, calibration of the pump would not be necessary.

The production yield is determined by comparing the quantity of asphalt stabilizing agent used to the quantity required for the square yards per inch (square meters per centimeter) of compacted thickness as measured. Production yield shall be with in the specified tolerance of the target application rate. The application rate specifies the quantity of standard emulsion, foamed asphalt, or engineered emulsion added to the RAP volume. Use Form #CIR-1, Yield Check to verify the rate of application by yield check.

If the standard emulsion is diluted, the target application rate must be adjusted by the amount of emulsion dilution. Dilution is not normally performed for CIR applications because it adds excess water to the CIR mixture.

ADJUSTMENT OF STABILIZING AGENT CONTENT
The Engineer must approve any revision in the asphalt stabilizing agent content. Changes in the content, particularly a reduction, may have a significant impact on the long term performance of the CIR layer. The Engineer and Contractor should consider adjustments to the CIR operations before reducing the asphalt stabilizing agent content.

STABILIZING AGENT SAMPLING
A one-quart (one-liter) sample of stabilizing agent shall be obtained each day. The sample from the first day and one each week shall be forwarded to the District Materials Engineer for testing. The other samples shall be retained for submission in the event of a failing test. The District Materials Laboratory will determine the percent residual binder of the emulsion sample. The Central Materials Laboratory may conduct further qualifying tests as required in Materials I.M. 204.

The sample should be taken from the supply tanker. A plastic bottle must be used to sample emulsions and a metal tin must be used for hot asphalt binder (foamed asphalt application).

FIELD CONTROL OF CIR MIXTURE

MIXTURE SAMPLING
Sample loose CIR mixture from the roadway using sampling methods described in Materials I.M. 322. One 30 pound (15 kg) sample placed in an airtight bag or container will be required per day. Each sample must be taken from the roadway after the RAP and stabilizing agent have been mixed and placed by the screed and before rolling.

The sample shall be promptly delivered to the District Materials Laboratory for density determination. Additional samples should be taken when a significant change in the RAP or CIR mixture occurs.

LABORATORY TESTING PROCEDURE
1. Remove a representative 1000 g sample to determine the moisture content of the mixture. Dry the entire sample to a constant dry mass in an oven at a temperature not to exceed 275°F (135°C). Record all weight measurements to the nearest 0.5 g.

Moisture content will be calculated using the following formula:

$$\%\,\text{Moisture} = \frac{(\text{Wet Sample Mass} - \text{Dry Sample Mass})}{\text{Dry Sample Mass}} \times 100$$

Example: Given: Wet Sample Mass = 1017.0 g
Given: Dry Sample Mass = 985.5 g

$$\%\ \text{Moisture} = \frac{(1017.0 - 985.5)}{985.5} \times 100 = 3.2\%$$

2. Split the remainder of the bulk sample and prepare a 4000 g gyratory specimen for 6-inch (150 mm) gyratory molds from each split sample. If the measured moisture content is below 3.5%, increase the moisture content in the sample to 4.0% before compaction. Molds shall be at room temperature. Do not use paper disks. Use plastic disks, wax paper disks, or coat the base and head plate with a thin layer of light oil. Compact each sample to 25 gyrations. Determine the bulk wet density of the compacted specimen as follows.

3. Pre-weigh the gyratory mold with the base plate. Determine the mass of each mold to the nearest 0.5 g. Charge the mold with the CIR mixture and record the total mass to the nearest 0.5 g. Determine the mass of the specimen by subtracting the mass of the mold and base plate. After compaction, remove the specimen from the mold and measure the height to the nearest 0.1 mm using a dial indicator or suitable caliper. Take a minimum of four measurements, compute the average of the measurements, and round the average to the nearest 0.5 mm.

If the specimen is too tender to handle or distorts when removed from the mold, the height of the specimen may be recorded from the gyratory compactor at the completion of the compaction process.

4. Compute the laboratory wet density using the following equation.

$$\text{Laboratory Wet Density (kg/m}^3) = \frac{\text{Specimen Mass (g)}}{\text{Specimen Height (mm)}} \times 56.588$$

$$\text{Laboratory Wet Density (lb/ft}^3) = \text{metric wet density (kg/m}^3) \times 0.062436$$

5. Compute the laboratory dry density using the following equation.

$$\text{Laboratory Dry Density (lb/ft}^3 \text{ or kg/m}^3) = \frac{\text{Laboratory Wet Density}}{(100 + \text{Percent Moisture})} \times 100$$

NOTE: Variations in laboratory dry density of more than 3 pounds per cubic foot (50 kg/m^3) between successive samples shall be investigated promptly. Testing of additional samples should be included in the investigation.

FIELD DENSITY TESTING PROCEDURE
The project inspection personnel shall select and mark the field density test locations. Each day of CIR production shall be divided into approximately equal sublots. A random location in each sublot shall be selected for moisture and density testing.

The Contractor will determine the in-place density and moisture using a nuclear gauge in direct transmission mode at the maximum allowable probe depth in accordance with IM 334. The nuclear gauge moisture measurements shall be adjusted by the correction factor below to account for the asphalt binder in the mixture. The dry density and percent of lab density of each test location is determined using the following equations. Report both values to one decimal place. Sublots that do not achieve the specified minimum percent density should be re-rolled immediately and re-tested. The optimum condition

for re-rolling is when the CIR layer is warm (typically in the afternoon).

Field Compacted Dry Density = Gauge Wet Density – Gauge Moisture + Correction Factor

$$\text{Percent Laboratory Density} = \frac{\text{Field Compacted Dry Density}}{\text{Laboratory Gyratory Dry Density}} \times 100$$

Example:

Field Compacted Gauge Wet Density	2090.6	=	130.5
Gauge Moisture	-168.2	=	-10.5
Correction Factor	+120.2	=	7.5
Field Compacted Dry Density	2042.6 kg/m³	=	127.5 lb./ft.³

DETERMINE THE CORRECTION FACTOR

During the first 2 working days, the Contractor will sample approximately 1000 g of CIR mixture at each density test location (minimum of 10 locations) to determine the in-place moisture content. Each sample shall be properly sealed, transported to the Contractor's laboratory, and measured for moisture content. Use the paired nuclear gauge moisture content measurements and in-place (laboratory) moisture content measurements to determine the correction factor. Compute the actual in-place moisture for each of the sampled test locations using the following equation.

$$\text{Actual In place Moisture (lb/ft}^3\text{ or kg/m}^3) = \frac{(\text{Laboratory \% Moisture}) \times (\text{Nuclear Guage Wet Density})}{\text{Laboratory \% Moisture} + 100}$$

Example (for one set of paired values)

Nuclear Gauge Wet Density = 2090.6 kg/m³ (130.5 lb/ft³)
Laboratory % Moisture = 2.3%

$$\text{Actual In place Moisture} = \frac{(2.3) \times (2090.6)}{(2.3 + 100)} = \frac{4808.38}{102.3} = 47 \text{kg/m}^3 = \frac{(2.3) \times (130.5)}{(2.3 + 100)} = \frac{300.2}{102.3} = 2.9 \text{lb/ft}^3$$

Compute the average of the actual in-place moisture contents for the paired tests and compute the average of the nuclear gauge moisture readings for the same moisture sample locations. Then compute the correction factor using the following equation.

Correction Factor = Avg Gauge Moisture - Avg Actual Moisture

Example:

Average of Gauge Moisture	177.8	11.1
Average of Actual In-Place Moisture	- 57.7	- 3.6
Correction Factor:	120.1 kg/m³	7.5 lb./ft.³

Use Form #CIR-2, Determination of Moisture Correction Factor for showing the determination of a correction factor. This correction factor may seem large. It represents the asphalt binder in the CIR mixture. The nuclear gauge measures both asphalt binder and water in the moisture reading.

NOTE: Any significant change in the characteristics or components of the asphalt pavement being recycled requires a new correction factor.

PROFILE AND CROSS-SLOPE TESTING

The Engineer will perform an onsite inspection to determine if the profile and cross-slope of the finished CIR layer is acceptable. If the Engineer and Contractor cannot agree on locations that have unsatisfactory profile, the Engineer can direct the Contractor to run a profiler on the sections in question. The results of the profile measurement that do not comply with the specified limits shall be corrected by

the Contractor to the satisfaction of the Engineer.

DETERMINE RESIDUAL MOISTURE CONTENT OF THE PAVEMENT PRIOR TO CIR

Before the Contractor can place the HMA overlay or thin asphalt surface treatment over the CIR, the moisture content of the CIR layer must drop to one of two specified levels, 1.5% or 0.3% above residual moisture. The criteria for 0.3% above residual moisture recognizes the impact of the in-situ moisture content of the pavement structure in a given location. If the residual moisture content is above 1.5%, that section of CIR layer may never achieve the standard 1.5% criteria.

To use the 0.3% above residual moisture criteria, the Engineer and Contractor should sample and test the asphalt pavement prior to initiating the CIR production. The samples should be taken at locations that represent the different drainage characteristics over the length of the project. For example, cut sections and fill sections may have different residual moisture in the top 3 to 4 inches (75 to 100 mm) of the asphalt pavement.

The samples should be taken during normal pavement conditions, not immediately after a rain event. Postpone sampling until 5 calendar days after a rain.

Each sample must be cut dry. No wet coring. Dry sawing and impact air-hammers should be used. The sample should represent the proposed depth of CIR rehabilitation. Immediately bag and seal the samples and send them to the District Materials Lab to determine the residual moisture content.

DETERMINE IN-PLACE MOISTURE CONTENT OF FINISHED CIR LAYER

The in-place moisture content must comply with specifications prior to applying a subsequent HMA surface or thin asphalt surface treatment. Two sample locations should be tested from each day of completed CIR to determine the moisture content of the CIR layer. Inclement weather or project conditions may require additional samples representing questionable areas to determine acceptable moisture levels.

Moisture content of the material may be determined by one of the following methods.

1) Use the same nuclear gauge that was used for density determination taking into account the moisture correction factor for asphalt content. The following equation will convert the nuclear gauge readings to percent moisture.

$$\%\,\text{Moisture} = \frac{\text{guage moisture (lb/ft}^3\text{ or kg/m}^3\text{)} - \text{correction factor (lb/ft}^3\text{ or kg/m}^3\text{)}}{\text{guage wet density (lb/ft}^3\text{ or kg/m}^3\text{)} - \text{guage moisture (lb/ft}^3\text{ or kg/m}^3\text{)} + \text{correction factor (lb/ft}^3\text{ or kg/m}^3\text{)}} \times 100$$

2) Using a different nuclear gauge and establishing a new correction factor using the procedure previously noted under roadway testing.

3)

4) Extract 1000 g of material from the sample location. Dry the entire sample to a constant dry mass in an oven at a temperature not to exceed 275ºF (135ºC) or on a hot plate at a low temperature setting.

TIMELY OVERLAY OF CIR LAYER

Many CIR layers are opened to traffic before the HMA overlay or chip seal are placed. This places the CIR layer at risk of raveling and the pavement structure at risk of base failure if traffic and climate conditions are unfavorable. The owner agency accepts this risk when the CIR layer is open to traffic. The specifications establish a reasonable period of time for the Contractor to begin placing the overlay during which the owner agency assumes the risk. After this period, the Contractor becomes liable for any damage before the HMA overlay is placed.

The period of time is dependent on the level of traffic using the route. Most CIR projects are covered under the lower traffic criteria. The Contractor is given a reasonable period of time to coordinate the start of the HMA overlay after the entire CIR layer is complete. Under the higher traffic criteria, the Contractor is expected to recognize the additional effort required to coordinate the CIR and HMA overlay.

FIELD REPORT

Report daily results on Form #CIR-3, Daily Cold-In-Place Asphalt Recycling Report. All CIR forms can be found in the Asphalt Section of the Iowa DOT Web Page (www.dot.state.ia.us/materials/acc.htm).

MIX DESIGN METHOD FOR CIR WITH FOAMED ASPHALT

The mix design for CIR with foamed asphalt is performed by the Iowa DOT Central Laboratory. The primary steps in the mix design process are:

- Determine the optimum foaming characteristics of the asphalt binder.
- Determine the optimum moisture content of the RAP for compaction.
- Prepare, compact, and cure CIR mixture over a range of foamed asphalt contents
- Determine the optimum foamed asphalt content for the CIR mixture.

1. DETERMINE THE OPTIMUM FOAMING CHARACTERISTICS

By foaming the asphalt binder, the viscosity of the asphalt is significantly reduced to permit uniform mixing with cold RAP material. The ability to foam asphalt is controlled by the asphalt binder temperature and the amount of water injected into the asphalt. These values generally range from 280 to 320ºF (135 to 160ºC) and 1.5 to 3.5% injected water. The foamed is measured by the expansion ratio and half-life. The foam expansion ratio will increase (5 times to 15 times) as the amount of water injected increases. The half-life of the foam decreases (15 seconds to 5 seconds) as the amount of water injected increases. These conflicting conditions are merged to select the best foam properties for the project. An expansion ratio of 10 and half-life of 10 seconds are suitable for most CIR projects.

The specification sets the temperature and injection water at values that are acceptable for most binders used for CIR in Iowa when a mix design is not performed.

2. DETERMINE THE OPTIMUM COMPACTION MOISTURE

CIR mixture is compacted to a maximum density through the lubricating affect of the free moisture in the mixture. This is not the moisture injected into the asphalt binder to create foam. To determine the optimum compaction moisture, a group of RAP samples are compacted with different moisture contents. The resulting dry densities are plotted to determine the optimum moisture required for compaction. Mix designs prepared over the last several years indicate that the moisture required to achieve maximum RAP density is approximately 4 percent.

Once the optimum moisture content is determined, the value is adjusted down slightly to account for the foamed asphalt added to the mixture

3. PREPARE MIXTURES

The bulk sample of RAP may require additional processing to achieve a gradation that passes the 1 inch (25 mm) sieve. The RAP is dried in open pans at room temperature, sieved into 3 size fractions (+3/8 inch, +1/8 inch, pan)(+9.5 mm, +2.36 mm, pan), and re-blended to achieve uniform samples.

Prepare a blending chart to determine what amounts of foamed asphalt will be added to the RAP. A minimum of three foamed asphalt contents should be selected. The preferred contents are 1.5%, 2.0%, 2.5%, and 3.0%.

Each batch should have sufficient mixture to compact three 4 inch (100 mm) gyratory samples. The dry RAP sample and compaction water are added to the mixing bowl and mixed for 45 to 60 seconds. The foamed asphalt is sprayed into the damp RAP while the mixer continues to mix the sample. Continue mixing for an additional 60 seconds.

4. COMPACT AND CURE MIXTURES

The gyratory compactor is used to compact each sample to 25 gyrations. Extrude the specimen and place it in the oven to cure at 105ºF (40ºC) for 72 hours. Remove the specimens from the oven and allow them to cool to room temperature.

5. TEST MIXTURES

Measure the volume and mass of each specimen and determine the density. Sort the specimens into

equal sublots based on height and density for further testing.

Dry condition the samples of one sublot in an oven at 77ºF (25ºC) for 2 hours. The other sublot of specimens are placed in a 77ºF (25ºC) water bath for 20 minutes, vacuum saturated (50mm Hg) for 50 minutes, and then allowed to rest in the 77ºF (25ºC) bath for an additional 10 minutes.

Perform the indirect tensile test (IDT) and calculate the average IDT strength for each sublot. Plot the average IDT wet and dry strength for each foamed asphalt content.

6. MIX DESIGN REPORT

The mix design report will provide the results for optimum foam characteristics, optimum compaction moisture content, and optimum foamed asphalt content. Specific report values include:

- Asphalt binder temperature for foaming (ºF or ºC)
- Percent injection water for foaming (% of asphalt by weight)
- Optimum compaction moisture content (% of dry RAP by weight)
- Optimum asphalt foam content (% of dry RAP by weight)

MIX DESIGN METHOD FOR CIR WITH ENGINEERED EMULSION

The mix design for CIR with engineered emulsion is performed by the Contractor. The primary steps in the mix design process are:

- Process, dry, sieve, and blend the RAP.
- Select the engineered emulsion.
- Prepare, compact, and cure CIR mixture over a range of emulsion contents.
- Determine the engineered emulsion content for the CIR mixture.

1. PREPARE THE RAP SAMPLE

The bulk sample of RAP may require additional crushing to meet the gradation band shown. The RAP is dried in open pans at room temperature, sieved into a minimum of 3 size fractions (+3/8 inch, +1/8 inch, pan)(+9.5 mm, +2.36 mm, pan), and re-blended to achieve uniform samples.

Sieve Size	**%passing**
1.5 inch (37.5 mm)	100
1.0 inch (25 mm)	100
3/4 inch (19 mm)	85-95
No. 4 (4.75 mm)	40-55
No. 30 (600 µm)	5-15
No. 200 (75 µm)	0.5-3

2. SELECT THE ENGINEERED EMULSION

Standard asphalt binder grades used for asphalt emulsions may not have appropriate characteristics to achieve the desired CIR mixture properties. By trial and error, the designer must select the base asphalt grade for the emulsion.

3. PREPARE MIXTURES
Prepare a blending chart to determine what amounts of engineered emulsion will be added to the RAP. A minimum of three emulsion contents should be selected. The preferred contents are 2.0%, 2.5%, 3.0% and 3.5%.

In addition to the engineered emulsion, 1.5% water is added to represent the water used in the milling process.

The dry RAP sample and 1.5% water are added to the mixing bowl and mixed for 45-60 seconds. The engineered emulsion is added to the damp RAP while the mixer continues to mix the sample. Mixing continues for an additional 60 seconds. A set of three specimens can be prepared in each batch.

4. COMPACT AND CURE MIXTURES
Specimens shall be compacted immediately after mixing. Do not use paper disks. Specimens shall be compacted with a gyratory compactor in a 4-inch (100 mm) mold at 1.25 degree angle, 87 psi (600 kPa) ram pressure, and 30 gyrations. The mold shall not be heated. Extrude specimens from molds immediately after compaction. Place each specimen in a small container to account for material loss from the specimens during curing.

Cure compacted specimens in 140ºF (60ºC) forced draft oven for 48 hours. After curing, cool specimens at ambient temperature for 12 hours.

5. TEST MIXTURES

A. Determine bulk specific gravity (density) of each compacted (cured and cooled) specimen according to ASTM D 2726 or equivalent; however, the mass of the specimen in water (measurement C) should be recorded after 1 minute of submersion.

B. Determine specimen heights according to ASTM D 3549 or equivalent. Alternatively, the height can be obtained from the gyratory compactor readout.

C. Sort the specimens into equal sublots based on height and density for further testing.

D. For the three specimens of one sublot, determine corrected Marshall stability by ASTM D 1559 Part 5 at 100ºF (40ºC) after 2 hour temperature conditioning in a forced draft oven. This testing shall be performed at the same time that the moisture-conditioned specimens are tested.

E. For the three specimens from the other sublot, vacuum saturate to 55% to 75%, soak in a 75ºF (25ºC) water bath for 23 hours, followed by a 1 hour soak at 100ºF (40ºC). Determine corrected Marshall stability.

F. Compute the retained strength as the average moisture conditioned Marshall stability strength divided by the average dry Marshall stability strength.

G. Perform the thermal cracking test for critical cold temperature. The temperature is based on FHWA LTPPBind software for 50% reliability at 3 inches (75 mm) below the pavement surface. The required temperature for the specification is –20ºC. Perform the indirect tensile testing according to AASHTO T 322 with the following exceptions:

1) Specimens shall be 6 inches (150 mm) in diameter and at least 4 1/2 inches (115 mm) in height and compacted to the design density and emulsion content determined from the Marshall Stability Testing. Trial specimens are needed to establish the number of gyrations for compacting the 6-inch (150 mm) specimens. Test specimens shall be cured at 140ºF (60°C) for 72 hours. After curing, two specimens shall be cut from each compacted specimen to 2 inches (50 mm) in height.

2) Measure the bulk specific gravity of each cut specimen.

~~3) Test two specimens at each of three test temperatures (-20ºC, -10ºC, 0ºC).~~

~~4) The tensile strength test shall be carried out on each specimen directly after the tensile creep test at the same temperature as the creep test.~~

~~5) The critical cracking temperature is defined as the intersection of the calculated pavement thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the results of the average tensile strength at the three temperatures).~~

~~**H.** Perform the raveling test. The apparatus used for the raveling test is a modified A-120 Hobart mixer and abrasion head (including hose) used in the Wet Track Abrasion of Slurry Surfaces Test (International Slurry Seal Association; ISSA TB-100). The rotation speed for the raveling test is not modified from ISSA TB-100. The ring weight is removed from the abrasion head for the raveling test below. The weight (mass) of the abrasion head and hose in contact with the specimen should be 1.3 pounds ± 0.5 ounce (600 g ± 15 g). The prepared sample must be able to be secured under the abrasion head, and centered for accurate result, allowing for free movement vertically of the abrasion head. The device used for securing and centering the sample must allow a minimum of 3/8 inch (10 mm) of the sample to be available for abrasion. The Hobart mixer will need to be modified to allow the sample to fit properly for abrasion. The modification may be accomplished by adjusting the abrasion head height, or the height of the secured sample. A Raveling Test Adapter can be purchased through Precision Machine and Welding, Salina, KS (785) 823-8760. Please reference the Hobart Model number A-120 when ordering. The C-100 and N-50 Models are not acceptable for this test procedure due to differences in size and speed of rotation.~~

~~1) Prepare two samples at the design moisture content and emulsion content. The size of each sample should be sufficient to meet the compacted specimen dimensions described below. (note: 6 pounds (2.7 kg) is an approximate weight (mass) to meet the criteria).~~

~~2) After mixing, place the mixture into a 6 inches (150 mm) gyratory compaction mold and compacted to 20 gyrations. The compacted specimen height shall be 2 3/4 inches ± 1/4 inch (70 mm ± 5 mm).~~

~~3) Extrude the samples from the compaction mold and placed on a flat pan to cure at a temperature of 50ºF +/- 2ºF (10ºC +/- 1ºC) for 4 hours ± 5 minutes.~~

~~4) The specimens shall be weighed after curing, just prior to testing.~~

~~5) The specimens shall be placed on the raveling test apparatus. Care should be taken that the specimen is centered and well supported. The area of the hose in contact with the specimen should not have been previously used. It is allowable to rotate the hose to an unworn section for testing. The abrasion head (with hose) shall be free to move vertically downward a minimum of 1/4 inch (5 mm) if abrasion allows.~~

~~6) The samples shall be abraded for 15 minutes and immediately weighed.~~

~~7) The percent raveling loss shall be determined as follows:~~

$$\text{Raveling Loss} = \frac{(\text{Weight Before Test} - \text{Weight After Abrasion})}{\text{Weight Before Test}} \times 100$$

~~8) The average of the two specimens shall be reported as the Percent Raveling Loss. There should not be a difference of 0.5% Raveling Loss between the two test specimens for proper precision. A difference of > 0.5% will require the test to be repeated. If both of the samples have a Raveling Loss of > 10% the numbers shall be averaged and the precision rule will be waived.~~

I. Determine if the selected engineered emulsion within the emulsion content range tested meets the following properties. If not, repeat the design with another engineered emulsion.

Test	**Criteria**	**Purpose**
Marshall stability	1,000 lb. (567 kg) min.	Stability under traffic
Retained strength	70% min.	Ability to withstand moisture damage
Thermal Cracking	-20ºC max.	Resist low temperature cracking
Raveling Test	2% max.	Raveling Resistance

6. MIX DESIGN REPORT

The mix design report will provide the following results at the optimum engineered emulsion content:

- Engineered emulsion base asphalt PG grade
- RAP gradation
- Mixture dry density (lb/ft^3 or kg/m^3)
- Marshall stability (lb or kg)
- Percent retained strength (%)
- Critical low temperature (C)
- Percent raveling loss (%)