Mix and Thickness Design for Cold in-Place Recycling (CIR)

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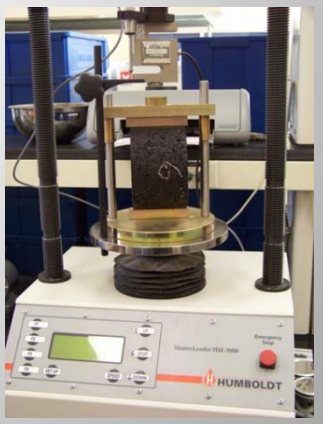
Outline

- Purpose of mix design
- Sampling
- Mix design tests and emulsions
- Pavement design
- Summary and conclusions

Purpose of Mix Design

- Determine emulsion content – provide guidance on low and high contents for construction
  - Impact on project cost
- Determine emulsion properties to meet mix and job requirements
- Look for problem materials and ways to correct for them



Sampling

- Ideally, sample locations are determined by construction and maintenance records or in-place testing (FWD, GPR)
- Samples should represent the width and length of the project to provide an overall “picture” of layer thickness values

Sampling

- Cores may identify thin areas that are insufficient for CIR or where new material could be added
- Other testing, such as DCP, can be performed at the time of coring to evaluate the aggregate base and subgrade for strength and train support

Sampling

- Overall quantity depends on specification and job requirements

- Bottom line – The mix design must plan on variability in materials and thicknesses

Mix design – material preparation and evaluation

- Saw-cut material that will not be used
- Look for signs of stripping, fabric, delamination, etc.
  - Don’t leave stripped layers in place
- Excessive thickness of chip seals may give lower strength
  - High binder content

Mix design – material preparation and evaluation

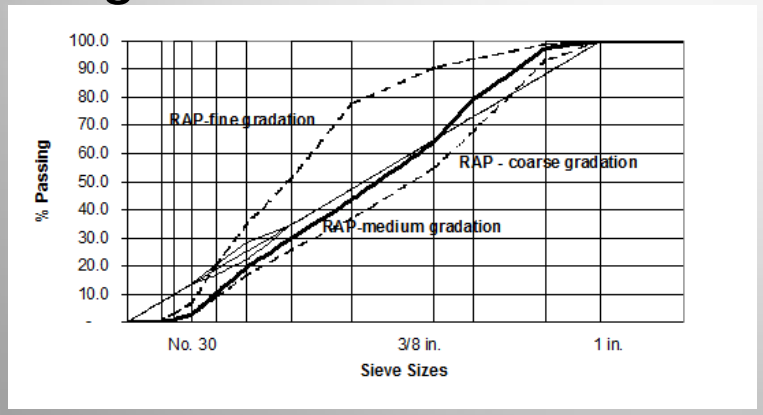
- Round aggregates may give lower strength
- Consider lime or cement for stripping or new aggregate for strength
- Recovery of asphalt
  - Gradation
  - Penetration and PG grading

Mix design – key tests

CIR	Purpose
• Grinder / crusher	➢ Simulate milling
• Mixer	➢ Simulate mixing
• Raveling test	➢ Adequate setting
• Marshall stability	➢ Long-term strength
• Retained strength	➢ Key performance indicator
• Thermal crack	➢ Non-load cracking

Mix design – grinder or crusher to simulate milling

- Miniature lab milling machine or jaw crusher to simulate expected field gradations



or

Mix design – mixing

- Recommend using a mechanical mixer to better simulate mixing that occurs in field equipment

Mix design – compaction and curing

- Superpave gyratory compactor. Some agencies specify Marshall compaction.
- Cure at 60˚ C from 16 to 48 hours (except raveling) after compaction

Mix design – raveling test

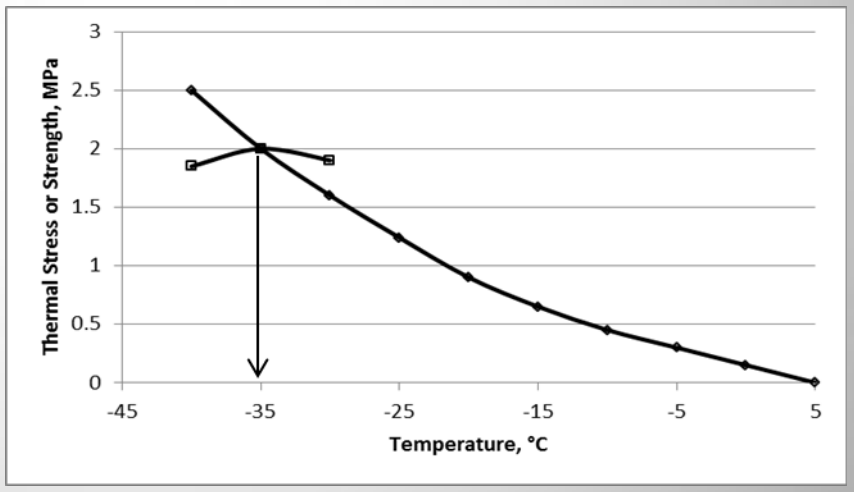
- Indicator of emulsion breaking and setting properties
- California considering three temperatures
- Criteria being considered – 5% max. (tentative)

Mix design – Marshall stability and retained stability

- 1,250 pounds Marshall stability at 40C
- 70% retained stability after vacuum saturation
  - Key performance indicator

Mix design – Thermal cracking

- Not an issue for Bay Area
  - Considered for high altitudes and cold climates
- AASHTO T-322



Mix design – summary

Test	**Result**
Gradation	Report
Asphalt content	Report
Air voids	Report – Typically 9 to 14%
Raveling test	5% max. (tentative, TBD)
Marshall stability at 40C	1,250 lbs min.
Retained stability	70% minimum
Emulsion	In order to meet mix and project requirements

Mix design – typical emulsion rates

Typical emulsion quantities for CIR

- 1.5 to 3.5% or higher CSS-1/1h (special)
- Depends on how “active” the asphalt in the RAP is
- Ratio of emulsion residue to cement or lime of 1.8 (minimum) – if used

Mix design – summary

- HMA industry tests have been adapted for CIR mix designs (except raveling)
- CIR acts like a slightly lower modulus HMA material

Pavement design – surface courses

- WMA / HMA binder and wearing courses
- Rubberized asphalt concrete
- Ultra-thin bonded wearing course
- Surface treatments – micro surfacing or chip seal, etc.
- Dense-graded cold mixes

The recycled layer must be covered by at least a bituminous treatment (i.e. micro surfacing or chip seal). The specific treatment needed will depend on pavement design and ride expectations.

Pavement design

- The pavement structure – depth of recycling and overlay thickness – are primarily influenced by:
  - Subgrade type and properties
  - Aggregate base or stabilized base thickness, type, and condition
  - Deflection measurements
  - Additive properties used in recycling
  - Traffic – especially trucks
  - Design life

Pavement design

- Caltrans Flexible Pavement Rehabilitation Manual
  - Section 4-40: Cold Recycled Asphalt Concrete Pavement
  - Deflection – Dynaflect – is primary method of design
  - Tolerable deflection at surface (TDS) based on TI
  - If Dynaflect D_{80} > TDS, rehab is needed
  - Deflection at milled depth (DM) is determined
  - Percent reduction in deflection at milled depth (PRM) determined

Pavement design

- Caltrans Flexible Pavement Rehabilitation Manual
  - GE is determined from PRM and TI
  - Thickness saved as compared to DGAC should be at least 0.10 foot
  - Gravel factor G_f for asphalt concrete is 1.9 (rehab)
  - G_f for CIR is 1.7 (1.5 Caltrans manual)

Pavement design - example

- Caltrans Flexible Pavement Rehabilitation Manual
  - Mill depth planned 0.30 ft
  - GE needed is determined to be 0.82 ft
  - GE of CIR = (0.30 ft) (1.7) = 0.51 ft
  - GE of DGAC = 0.82 – 0.51 = 0.31 ft
  - Thickness of DGAC = 0.31 / 1.9 = 0.16 ft
  - Rounded to 0.20 ft

Summary

- Proper sampling is critical
- Test methods are in place to ensure a successful project, determine the binder content, and the need for additives
- Consider a G_f of 1.7 for CIR

Resources

Valuable resources if more information is needed…

- ARRA Basic Asphalt Recycling Manual
- Caltrans Flexible Pavement Rehabilitation Manual
- Recycling and Reclamation of Asphalt Pavements Using In-Place Methods, NCHRP Synthesis 421, 2011
- Cold In-Place Recycling and Full Depth Recycling with Asphalt Products, Illinois Center for Transportation, Series No. 09-036, March 2009
- Cold In-Place Recycling in New York State, Contract 6764F-2, New York State DOT, July 2010
- Recycling seminars
- www.arra.org

Questions?

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