# Design Criteria and Testing for Cold In-Place Recycling

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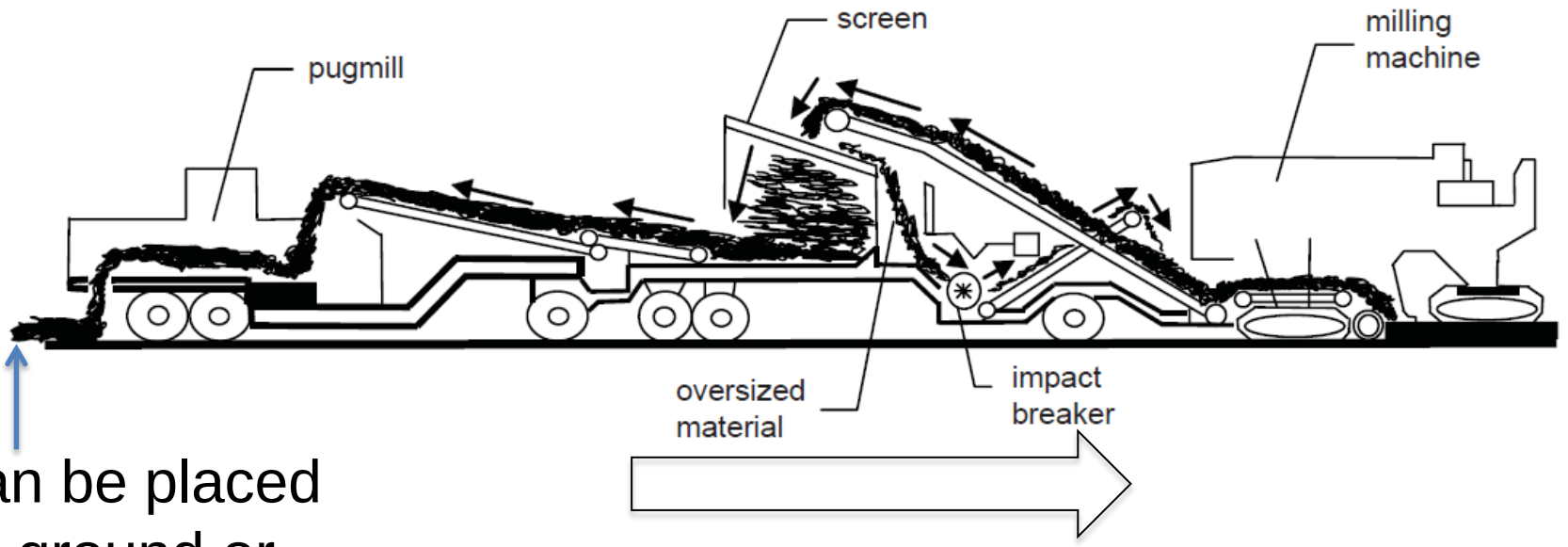
# Presentation Topics

- CIR description
- Project selection criteria for CIR
- Mix design
- Pavement design

# CIR Description

- Typical treatment depth of 2 to 4 inches
- Train of equipment (tanker trucks, milling machines, crushing and screening units, mixers, a paver, and rollers)
- An additive or combination of additives (asphalt emulsion, lime, fly ash, cement) mixing with 100% RAP
- Resulting recycled pavement usually opened to traffic at the end of the work day

# CIR Description




Can be placed on ground or directly in paver hopper

*Diagram: Center for Transportation Research and Education, June 2007, Iowa State University*

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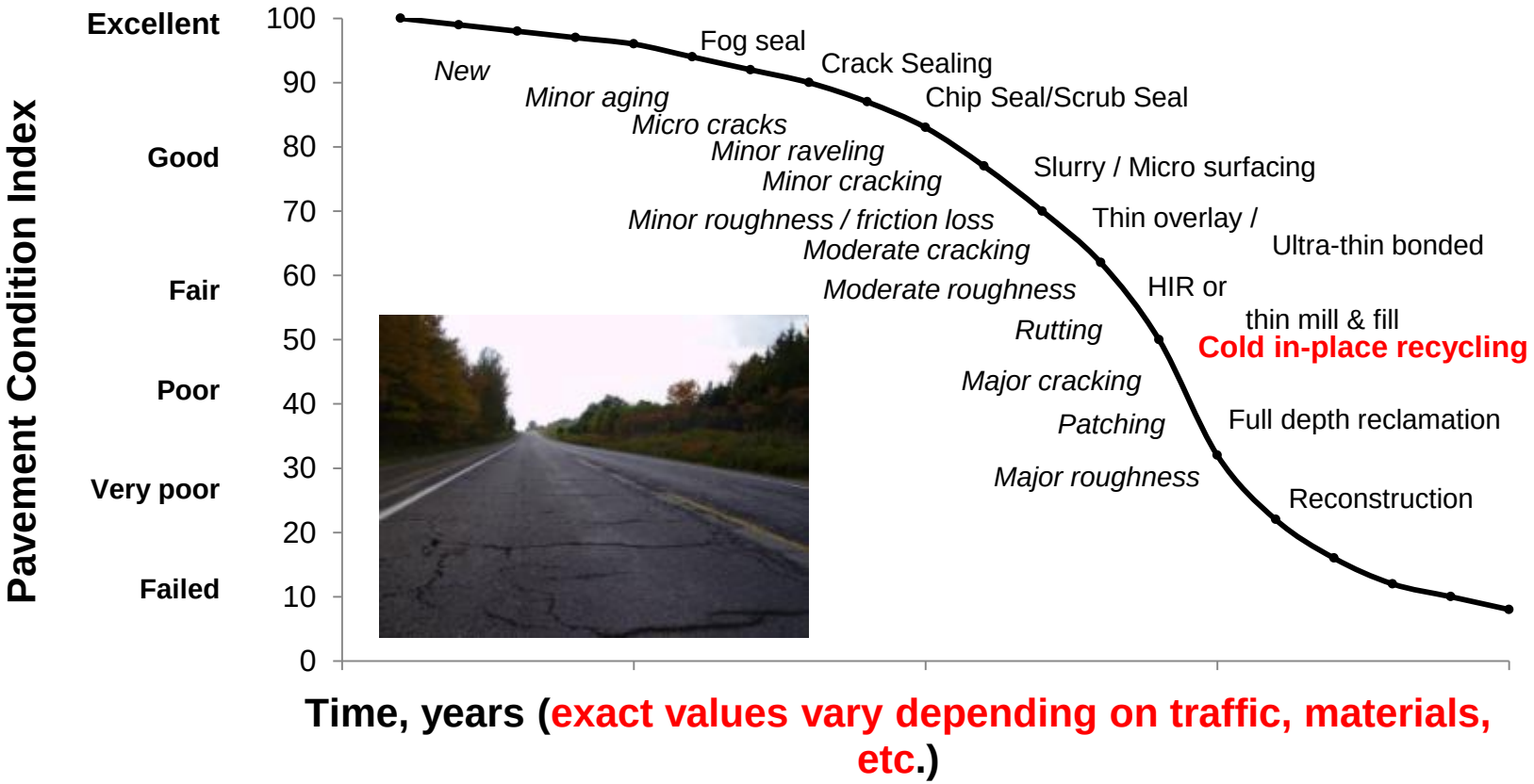
# Project selection criteria

## Generalized pavement deterioration curve



# Project selection criteria

- Highways, county roads, city streets, airports
- Any asphalt-surfaced road, including composite pavements, with adequate thickness for the process
- Pavements with functional or minor structural distresses
- Treats the bituminous layer but not the base or subgrade

# Project selection

- Minor structural upgrades for current or future traffic
- Good surface drainage and internal drainage
- Up to 20-year service life, or more, with preventative maintenance
- Generally an alternative to mill and fill

# Challenges and limitations

- Steep grades are processed down-hill
- Longitudinal profile problems
- Tight curves
- Manholes and other utilities require special handling

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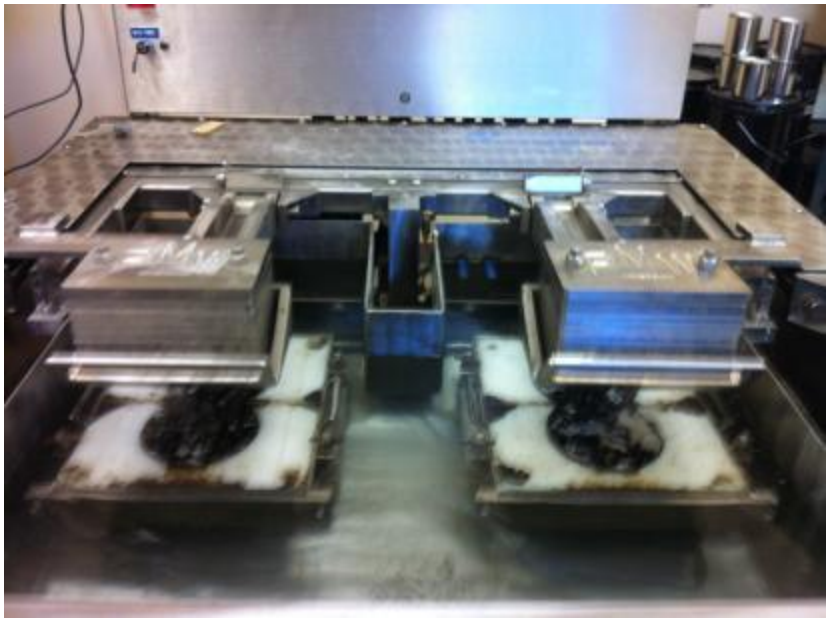
# Purpose of Mix Design

- Determine emulsion content –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

# Mix Design

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



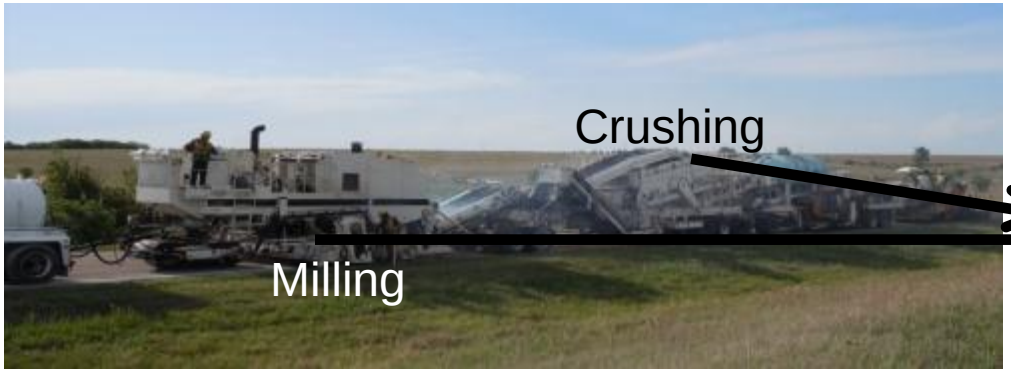
# Sampling and Preparation

- Samples to represent length and width
- Ensure uniformity or design around variability
- Look for paving fabrics
- Look for stripping or delaminated layers

# Mix design – key tests

| | |
|---|---|
| • Grinder / crusher | ➢ Simulate milling |
| • Early-cure strength | ➢ Adequate setting |
| • Marshall stability or tensile strength | ➢ Long-term strength |
| • Retained strength | ➢ Key performance indicator |
| • Hamburg WT | ➢ Alt. strength or retained |
| • Thermal crack | ➢ Non-load cracking |

# Mix design – grinder or crusher





- Miniature lab milling machine or jaw crusher to simulate expected field gradations
- Alternate – field milling if same equipment as job

and / or

# Mix design – mixing

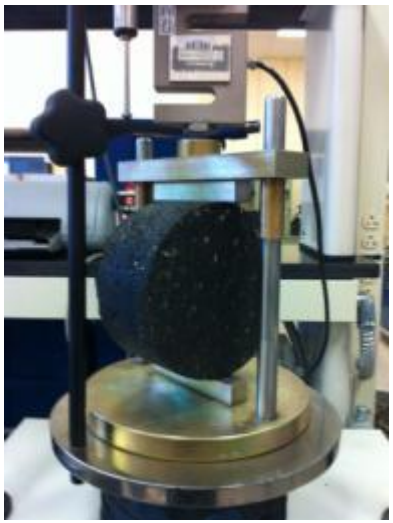
- Use a mechanical mixer to better simulate mixing that occurs in field equipment

# Compaction and curing

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

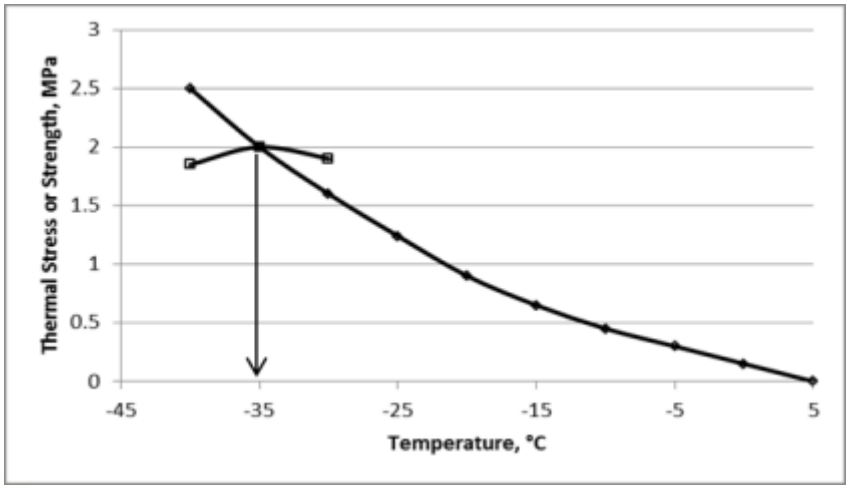
# Strength and Retained Strength

- Marshall strength (40°C) or indirect tensile strength (25°C)
- 70% retained stability after vacuum saturation and soak



# Mix design – Thermal cracking

- AASHTO T-322
- To meet the low temperature requirements for the project




# Mix design – typical emulsion rates

Typical emulsion quantities for CIR

- 1.5 to 3.5% or higher CSS-1/1h (special) and 1 to 3% HFMS-2
- Depends on how “active” the asphalt in the RAP is
- Ratio of emulsion residue to cement or lime of 1.8 or 2.0 (minimum) – if used

# Mix design

While there is no nationally accepted mix design procedure yet for CIR, engineered mx design procedures used by many agencies have given more confidence in the process.

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# Pavement design – surface courses over CIR

- 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

# Pavement Design for Rehab

- Basic equation: $SN_{OL} = SN_f – SN_{eff}$
  - $SN_f$ - AASHTO Sec. II, Fig. 3.1 nomograph
    - Soil modulus by testing (sampling) or FWD
  - $SN_{eff}$ – 2 options
    - From deflection data (FWD - recommended)
    - From condition data

# $SN_{eff}$ from Deflection Data

- Falling weight deflectometer (FWD) is one common device
- Estimate soil modulus
- Quantify variability along road

# $SN_{eff}$ from Condition Data

- $SN_{eff} = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$
  - $D_1$, $D_2$, $D_3$ = Thickness values of existing layers
  - $a_1$, $a_2$, $a_3$ = Layer coefficients corresponding to the current condition
  - $m_2$, $m_3$ = Drainage coefficients corresponding to the current condition

# Overlay Thickness

- $SN_{OL} = SN_f – SN_{eff}$
- Overlay $SN_{OL} = D_{OL}\ a_{OL}$
- $D_{OL} = (SN_f – SN_{eff}) / a_{OL}$

# How to apply equation for CIR?

- $SN_{OL+CIR} = SN_f - SN_{eff}$
  - CIR will remove part of the asphalt layer and its structural contribution
    - CIR coefficient ranges from 0.28 to 0.35 (0.30 is typical)
  - $SN_f$ is calculated the same way as for overlays
  - $SN_{eff}$ should consider the following:

# Pavement Design

$SN_{OL+CIR} = SN_f - SN_{eff}$

- $SN_{OL+CIR} = a_{OL}D_{OL} + a_{CIR}D_{CIR}$ (Solve for overlay thickness, keeping CIR thickness fixed)
- $SN_f$ = AASHTO Sec. II, Fig. 3.1
- $SN_{eff} = a_{AC}D_{AC} + a_2D_2m_2 + a_3D_3m_3$ (condition data, etc.)

NCHRP study for CIR using MEPDG

# Summary

- Representative sampling and laboratory material processing is critical
- Test methods are in place to ensure a successful project, determine the binder content, and the need for additives
- A coefficient for CIR as high as 0.35, but more like 0.30, can be considered with proper mix design and construction procedures in place

# Resources

Valuable resources if more information is needed…

- ARRA Basic Asphalt Recycling Manual
- Recycling and Reclamation of Asphalt Pavements Using In-Place Methods, NCHRP Synthesis 421, 2011
- 1993 Guide for Design of Pavement Structures, AASHTO
- ARRA / FHWA recycling seminars
- www.arra.org

# Thank You!

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