Best Practices for In-Place Recycling

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Industry Segments

- *Cold Planing*
- *Hot In-place Recycling*
- *Cold Recycling*
  - *Cold In-place Recycling*
  - *Cold Central Plant Recycling*
- *Full Depth Reclamation*

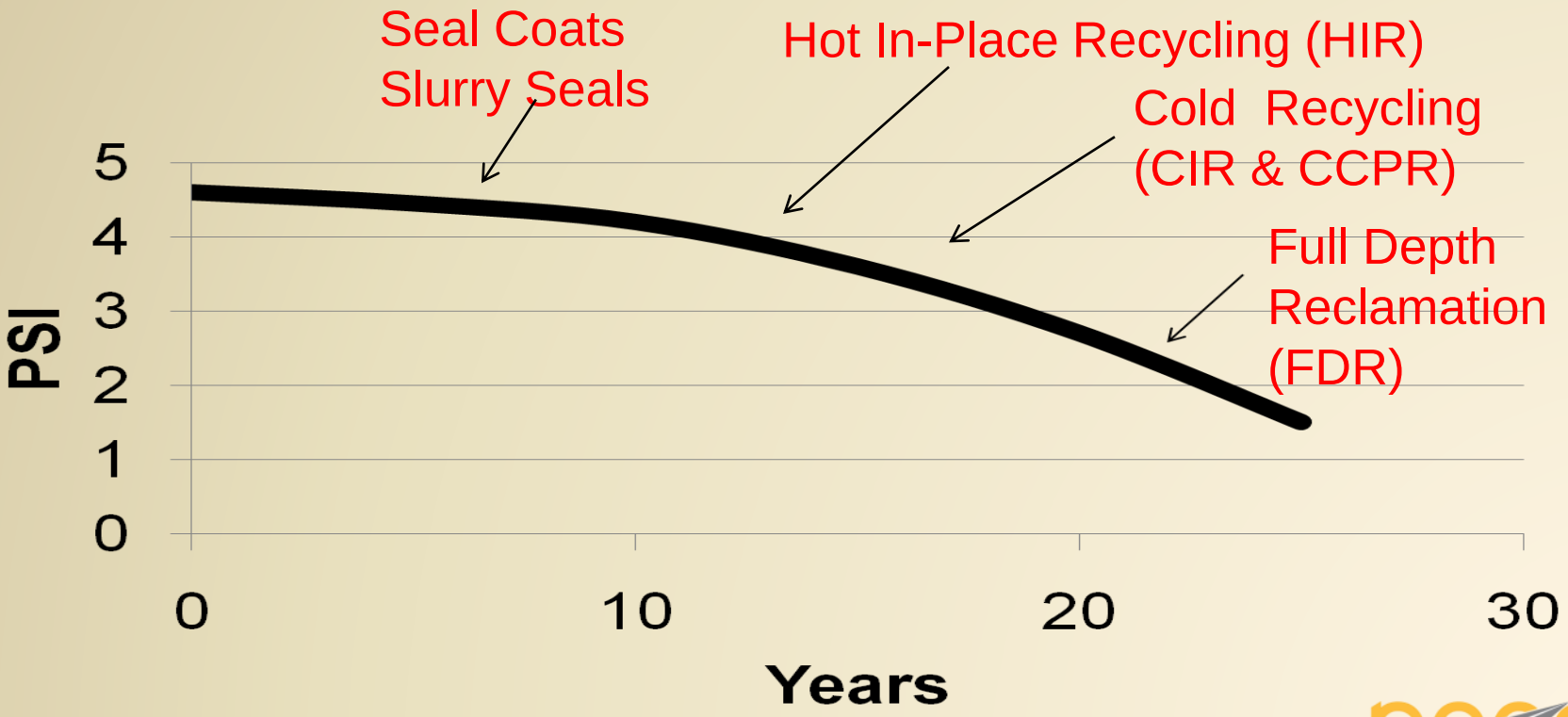
Recycling & Reclaiming Strategies

M&R	Strategy	Method	CP	HIR	CR	FDR
Construction	New					
	Reconstruction		X			X
Rehabilitation	Major		X		X*	X
	Structural Overlay		X	X*	X*	X*
	Minor		X	X	X	
Maintenance	Preventative	PP	X	X	X	
	Routine		X			
	Corrective		X	X	X	
	Catastrophic		X			

*With HMA Overlay

PP = Pavement Preservation

Pavement Management



Cold Planing

- Surface or grade preparation for other rehabilitation techniques
- Temporary driving surface
- Improving ride quality
- Micro Milling
  - Permanent driving surface
  - Improving ride

Hot In-place Recycling

HIR uses heat to soften the existing asphalt cement, mills or scarifies the pavement, adds rejuvenating agent and additives (if desired), relays and compacts the pavement in one continuous process.

Surface Recycling

Heating, reworking and rejuvenating top 1-2 inches of existing asphalt pavement in preparation of wearing surface.

Surface Remixing

Heating, reworking, and rejuvenating the top 1 to 2 inches of an existing asphalt pavement, adding new aggregate and/or admix and mixing the newly recycled mix material in a pugmill or mixing drum prior to laying, either as a binder or surface course.

Surface Repaving

Heating, reworking and rejuvenating the top 1-2 inches of an existing asphalt pavement and simultaneously applying an overlay resulting in a single, thermally bonded layer

Types of Cold Recycling

- Cold Central Plant Recycling (CCPR)

- Cold In-Place Recycling (CIR)

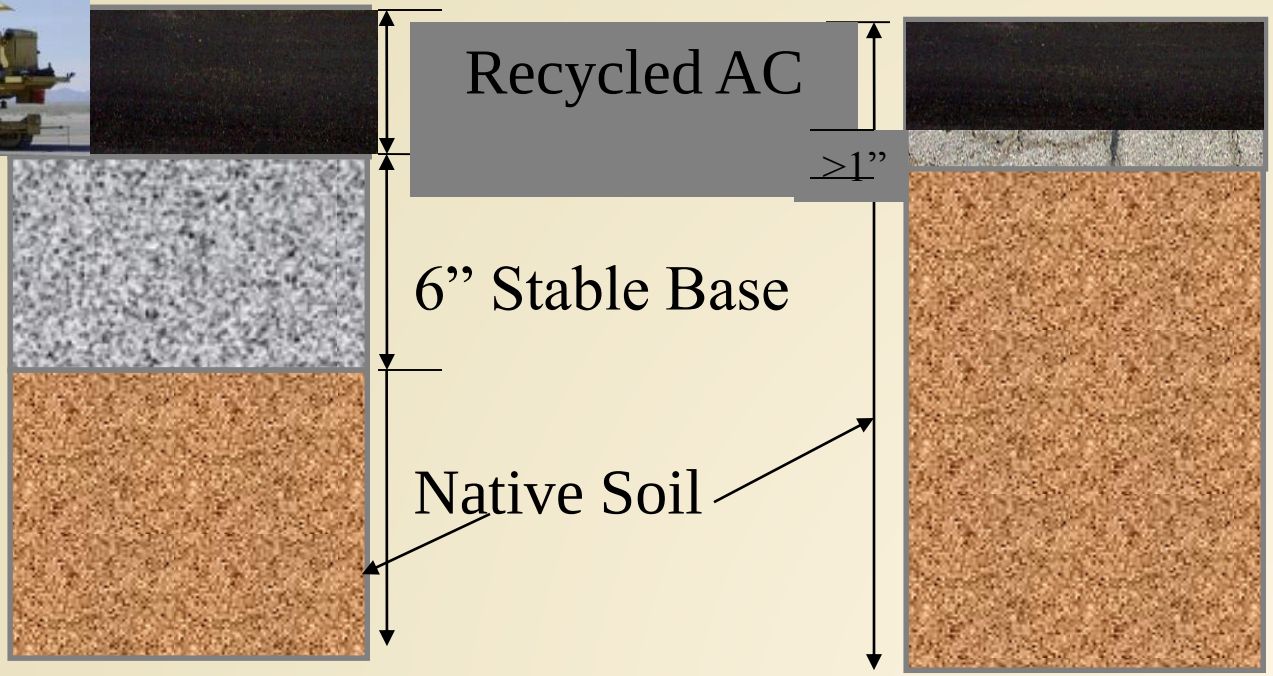
Cold Central Plant Recycling

A viable alternative when stockpiles of high quality RAP are available or when it is not possible to in-place recycle the pavement. May be used immediately or stockpiled

Cold In-Place Recycling

Recycle AC to:

- Stable Base
- Within 1” of less Supportive Material



Types CIR Trains

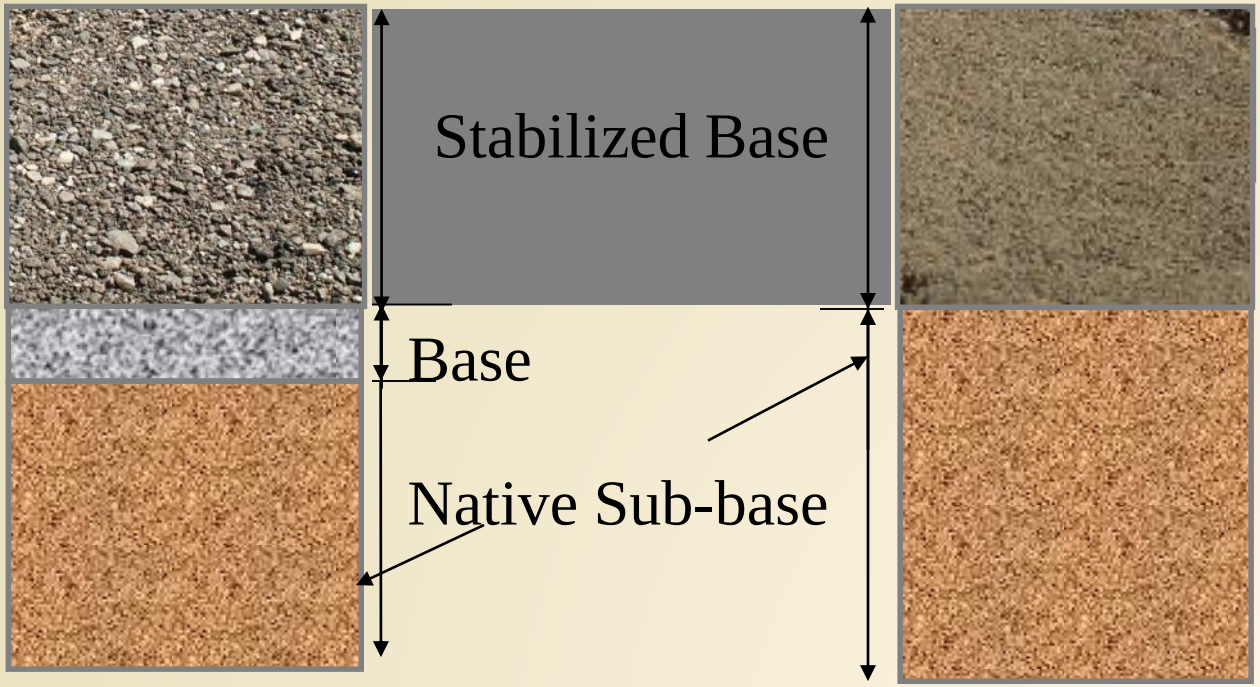
CR – Placement & Compaction

Traditional Asphalt Pavers Used →

Heavy (22-25 ton) pneumatic roller(s) and 10-12 ton vibratory steel wheel roller(s)

Full Depth Reclamation

Improves existing materials in-place to provide greater structural support and reduction of imported material.



4 Types of FDR

- Pulverization
- Mechanical Stabilization
  - Addition of RAP or Aggregate
- Bituminous Stabilization
  - Foamed or Emulsified Asphalt
- Chemical Stabilization
  - Cement
  - Lime
  - Type C Fly Ash

Recent Performance Studies

- ***NCHRP 9-51*** Material Properties of Cold In-Place Recycled and Full-Depth Reclamation Asphalt Concrete for Pavement Design – Nearing Completion.
- Virginia DOT I-81 In-Place Pavement Recycling Project, FHWA/VCTIR 15-R1
- VDOT Test Sections at NCAT Test Track, Sections N3,N4, S12

Keys to a Successful/Quality In-place Recycling Project?

- Proper Site Selection – Right Method, Right Road, Right Time
- Good Communication and Education
- Good Specifications

Specification Issues ARRA Faces

- Most Specifications In Use Were Generated By:
  - Contractors, Material Suppliers and Equipment Manufacturers
  - Geared to Their Own Specific Equipment, Materials or Techniques
- Unlimited Number of Environmental Conditions, Existing Materials and Traffic Levels Throughout North America
- There are Few Tests or Performance Parameters on ARRA Techniques
- Engineers Like Measures and Metrics. Not “Just Trust Me”

Specification Issues ARRA Faces

- Few issues with the hot processes such as hot in-place recycling
- Majority of issues are with the cold processes
- All must address issue of working with in-place materials
- Cold processes are time dependent (emulsions, foamed asphalt, cementitious materials) affects compacting field samples and coring
- Cold processes use water making field density measurements difficult

Compaction Monitoring

- HIR uses conventional HMA procedures
- With CIR and CCPR, ARRA recommends using a target density based on a rolling pattern and specifying heavy compaction equipment. (Intelligent Compaction)
- It can take weeks to months to recover an intact core
- FDR tends to use a field compacted Proctor to measure percent compaction along with a field moisture content.

Verification of Field Mix Properties

- Same as HMA for HIR
- For CR & FDR, sample age and temperature can have pronounced affect on measured mix properties
- Sealing uncompacted samples in containers does not appreciably help
- Must specify maximum compaction delay and sample temperature
- Usually requires compaction on-site

Results QA Testing on CIR

Test	No Delay	Delay
Lab Molded Voids	13.3%	20.6%
Dry Tensile Strength	74.5 psi	72.1 psi
Wet Tensile Strength	55.9 psi	64.9 psi
TSR	0.75	0.90
E* 20 C, 1 Hz	456,000 psi	355,000 psi

NCHRP Project 9-62: Quality Assurance and Specifications for In-Place Recycled Pavements Constructed Using Asphalt Based Recycling Agents - Anticipated

- Main objective of this research is to develop a rapid field-based test(s) for recycled asphalt pavement materials to guide contractors' quality while providing the transportation agency a basis for acceptance and time to trafficking/surfacing.
- Also develop guide specifications.

ARRA Best Practice Guidelines

- **Series 100 Construction Best Practice Guidelines**
  - Suggested Specification Language
- **Series 200 Project Sampling & Mix Design Guidelines**
- **Series 300 QC Guidelines**
  - Recommended Quality Control Checks and Remediation Actions
- **Series 400 Project Selection Guidelines**
  - New FHWA Tech Brief
- All Provide User Notes for More Information

Status of ARRA Guidelines

		100 Series Const.	200 Series Mix Design	300 Series Quality Control	400 Series Project Selection
Cold Planing	Milling	X			
	Micro Milling	X			
Cold Recycling	Cold Central Plant	X	X	X	X
	Cold In-Place	X	X	X	X
Full Depth Reclamation	Bituminous	X	X	X	X
	Cementitious	X	X	X	X
	Lime	X	X	X	X

X Available X Under Development

AASHTO CR Emulsion Mix Designs
Working Through Approval Process

Standard Specification for

Materials for Cold Recycled Mixtures with Emulsified Asphalt

AASHTO Designation: MP xxx-17[1]
Technical Section: 2a

X1.1.1. Release: Group 3 (Month yyyy)

Standard Practice for

Emulsified Asphalt Content Cold Recycled Mixture Design

AASHTO Designation: PP xxx-17[1]
Technical Section: 2a

X1.1.1. Release: Group 3 (Month yyyy)

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Asphalt Recycling & Reclaiming Association's n has been to promote the recycling of existing roadway materials throug methodologies, to preserve limited natural resources and reduce costs. N ith politics, social issues, anti-terrorism policies and procedures, or the ertain – America needs its highways. Everyone acknowledges that soon to be maintained, preserved, and rehabilitated, and that the methods repre e least expensive, longest lasting alternatives for stretching available do

SAVE THE DATE

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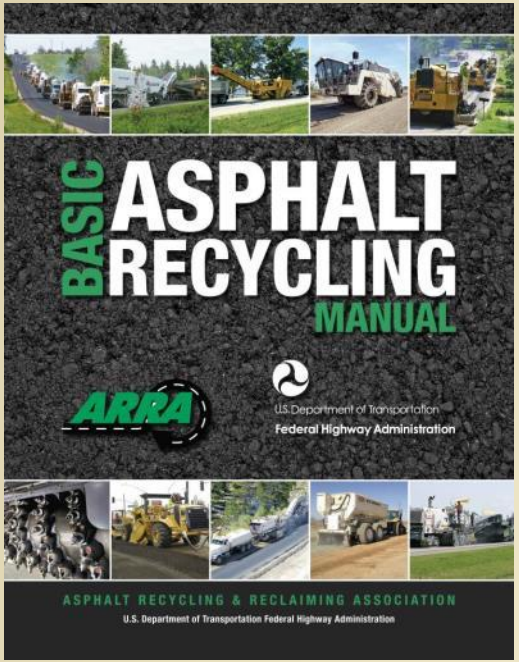
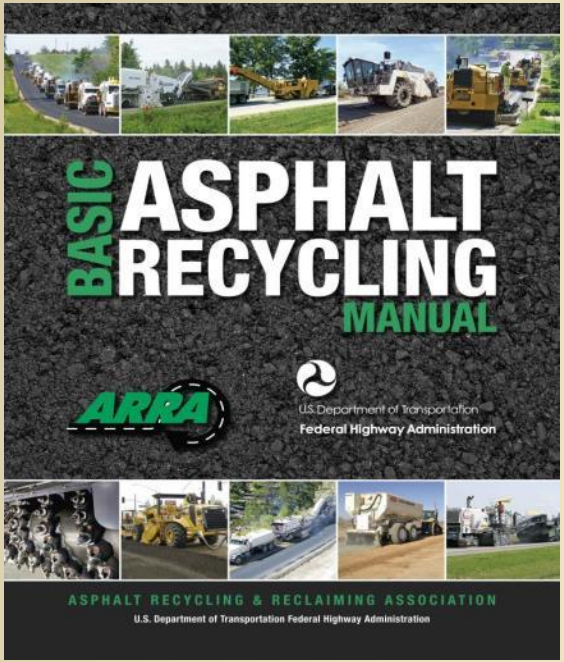
BARM II



FHWA –HIF-14-001

- **Sections on:**
- **Cold Planing**
- **Hot In-place Recycling**
- **Cold Recycling**
- **Full Depth Reclamation**

BARM II



For Each Part - Chapters on:

- Detailed Project Analysis
- Mix Design
- Construction
- Project Specifications and Inspection

HIR Applicability

Table 6-1: HIR Applicability

Condition		Surface Recycling	Remixing	Repaving
Surface Defects	Raveling	Yes	Yes	Yes
	Pot Holes	Yes	Yes	Yes
	Bleeding	No	Possible, see note a	Possible, see note b
	Skid Resistance	No	Possible, see note a	Yes
Deformations	Shoulder Drop Off	No	No	No
	Rutting - Wear	Yes	Yes	Yes
	Rutting - Mix Instability	No	Possible, see note a & c	Possible, see note d
	Rutting - Deep Structural	No	No	No
	Corrugations	Yes	Yes	Yes
	Shoving	No	Possible, see note a & c	Possible, see note d
Load Associated Cracking	Fatigue - Bottom Up	No	No	No
	Fatigue - Top Down	Possible, see note e	Possible, see note e	Possible, see note e
	Edge	Possible, see note b & f	Possible, see note b & f	Possible, see note b & f
	Slippage	Possible, see note g	Possible, see note g	Possible, see note g
Non-load Associated Cracking	Block	Yes	Yes	Yes
	Longitudinal	Yes	Yes	Yes
	Transverse	Yes, see note d	Yes, see note d	Yes, see note d
	Reflective	Yes, see note d	Yes, see note d	Yes, see note d
Combined Cracking	Joint Reflection	Possible, see note b	Possible, see note b	Possible, see note b
	Discontinuity	Possible, see note b	Possible, see note b	Possible, see note b
Base/Subgrade Deficiencies	Swells, Bumps, Sags Depressions	Unlikely, see note b	Unlikely, see note b	Unlikely, see note b
Roughness	Ride Quality	Yes	Yes	Yes
Other Criteria	All Levels of Traffic	Yes, see note h	Yes, see note h	Yes, see note h
	Rural	Yes	Yes	Yes
	Urban	Yes, see note i	Yes, see note i	Yes, see note i
	Stripping	Possible, see note c & d	Possible, see note c & d	Possible, see note c & d
	Poor Drainage	No, see note j	No, see note j	No, see note j

Notes: a) Can be corrected with additives such as admixture or new aggregate. b) May not correct but will mitigate. c) Needs to be verified by a mix design. d) Determine severity and depth of existing layers that are affected. May not correct but will mitigate. e) Ensure that structural requirements can be met. An asphalt overlay may be needed. f) Need to provide shoulder confinement after HIR. g) Treatment depth should exceed slippage plane. h) As long as proper pavement structural design is undertaken as part of the process to ensure that the effects of future traffic are taken into account. i) Geometric constraints may influence the type of recycling units used. j) Poor drainage must be improved for HIR, or any other pavement treatment, to ensure adequate performance.

- Table 6-1 describes which HIR sub-discipline addresses which pavement distresses
- Notes clarify if address, mitigate other actions required

CR Applicability

Table 10-1: CR Applicability

Condition		CR Applicability
Surface Defects	Raveling	Yes
	Pot Holes	Yes
	Bleeding	Yes
	Skid Resistance	Yes
Deformations	Shoulder Drop Off	No
	Rutting - Wear	Yes
	Rutting - Mix Instability	Possible, see note a
	Rutting - Deep Structural	Possible, see note b
	Corrugations	Yes
	Shoving	Possible, see note a
Load Associated Cracking	Fatigue - Bottom Up	Possible, see note c
	Fatigue - Top Down	Possible, see note c
	Edge	Possible, see note d
	Slippage	Possible, see note e
Non-load Associated Cracking	Block	Yes
	Longitudinal	Yes
	Transverse	Yes
	Reflective	Yes
Combined Cracking	Joint Reflective	Possible, see note f
	Discontinuity	Yes
Base/Subgrade Deficiencies	Swells, Bumps, Sags Depressions	Possible, see note g
Roughness	Ride Quality	Yes
Other Criteria	All Levels of Traffic	Yes, see note h
	Rural	Yes
	Urban	Yes, see note i
	Stripping	Possible, see note a
	Poor Drainage	No, see note j

Notes: a) Can be corrected with additives such as cement, lime and new aggregate. Needs to be verified by a mix design. b) Not with CIR but can be addressed with CCPR and correction of the underlying materials. c) Ensure that structural requirements can be met. CR in conjunction with an asphalt overlay may be needed. d) Need to provide shoulder confinement after CR. e) As long as treatment depth exceeds the slippage plane. f) May not correct but will mitigate. g) Can be addressed with CCPR and correction of the underlying materials. CIR may not correct but may mitigate. h) As long as proper pavement structural design is undertaken as part of the process to ensure that the effects of future traffic are taken into account and if the CR mixture is designed to have sufficient early and long term strength. Additives (cement or lime) may be necessary to improve early strength gain. i) Geometric constraints may influence the type of recycling units used or whether CIR or CCPR is used. j) Poor drainage must be improved for CR, or any other pavement treatment, to ensure adequate performance.

- Same information for CR as HIR
- Notes clarify if address, mitigate other actions required

FDR Stabilizing Agent Selection Guide

Table 15-1: Stabilizing Agent[1] Selection Guide for FDR Mixtures Including RAP

Material Type - Including RAP	Well Graded Gravel	Poorly Graded Gravel	Silty Gravel	Clayey Gravel	Well Graded Sand	Poorly Graded Sand	Silty Sand	Clayey Sand	Silt, Silt with Sand	Lean Clay	Organic Silt/Organic Lean Clay	Elastic Silt	Fat Clay, Fat Clay with Sand
USCS[2]	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH
AASHTO[3]	A-1-a	A-1-a	A-1-b	A-1-b A-2-6	A-1-b	A-3 or A-1-b	A-2-4 or A-2-5	A-2-6 or A-2-7	A-4 or A-5	A-6	A-4	A-5 or A-7-5	A-7-6
Emulsified Asphalt SE > 30 or PI < 6 and P_{200} 5 to 20 %	X	X	X	X	X	X	X						
Foamed Asphalt PI < 10 and P_{200} 5 to 20%	X		X	X	X		X						
Cement, CKD or Self-Cementing Class C Fly Ash PI < 20 SO_4 < 3000 ppm	X	X	X	X	X	X	X	X	X	X			
Lime/LKD PI > 20 and P_{200} > 25% SO_4 < 3000 ppm								X		X		X	X

TC3 Web Based Courses on HIR, CR & FDR Hosted by AASHTO Free at Checkout

Module 1: Introduction to Cold In-Place Recycling

The presentation is available as an attachment from the paperclip icon in the bottom right-hand part of the screen.

TC3 Training Resources

- ***Hot In-place Recycling (HIR): ID 2590***
  - *https://training.transportation.org/item_details.aspx?ID=2590*
- ***Inspector Training for Cold In-place Recycling (CIR): ID 2509***
  - *https://training.transportation.org/item_details.aspx?ID=2509*
- ***Full Depth Reclamation (FDR): ID 2593***
  - *https://training.transportation.org/item_details.aspx?ID=2593*

Additional Training Classes

- ARRA Cold Milling & In-Place Recycling Workshops
- NHI 131050 Asphalt Pavement In-Place Recycling
  - 2 brief web based training modules
  - 2-day Instructor-led classroom

The Asphalt Recycling & Reclaiming Association's

Cold Milling & In-Place Recycling Workshops

Need additional information on In-Place Recycling? Have a limited travel budget or unable to cross state lines for training? ARRA is developing a series of 1-day workshops that we can bring to your agency focusing on:

- Cold Planing
- Hot In-Place Recycling
- Cold Recycling (Both in-place and central plant)
- Full Depth Reclamation

These Workshops can be tailored to meet your specific needs and can cover all, a portion, or an individual ARRA discipline. Course content for the in-place recycling disciplines will cover:

1. Overview of the disciple or disciplines
2. Project selection criteria
3. Mix design procedures
4. Pavement/Thickness design procedures
5. Construction best practices
6. Quality Assurance and Specifications

Workshop content is based on the Second Edition of ARRA's *Basic Asphalt Recycling Manual* and ARRA's *Best Practice Guidelines*, which were developed with input from FHWA.

To learn more or to schedule a Workshop contact:
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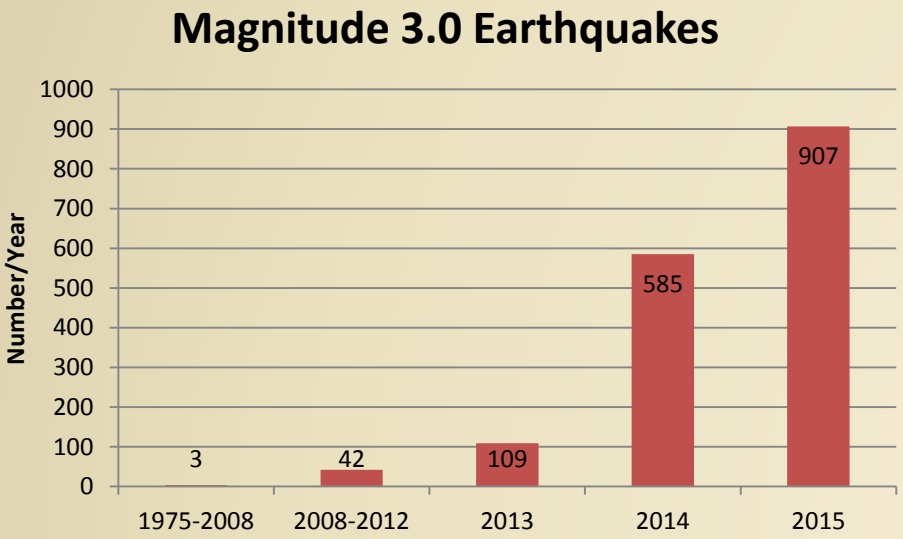
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