



# Performance Based Specifications For In-place Recycling of Pavements

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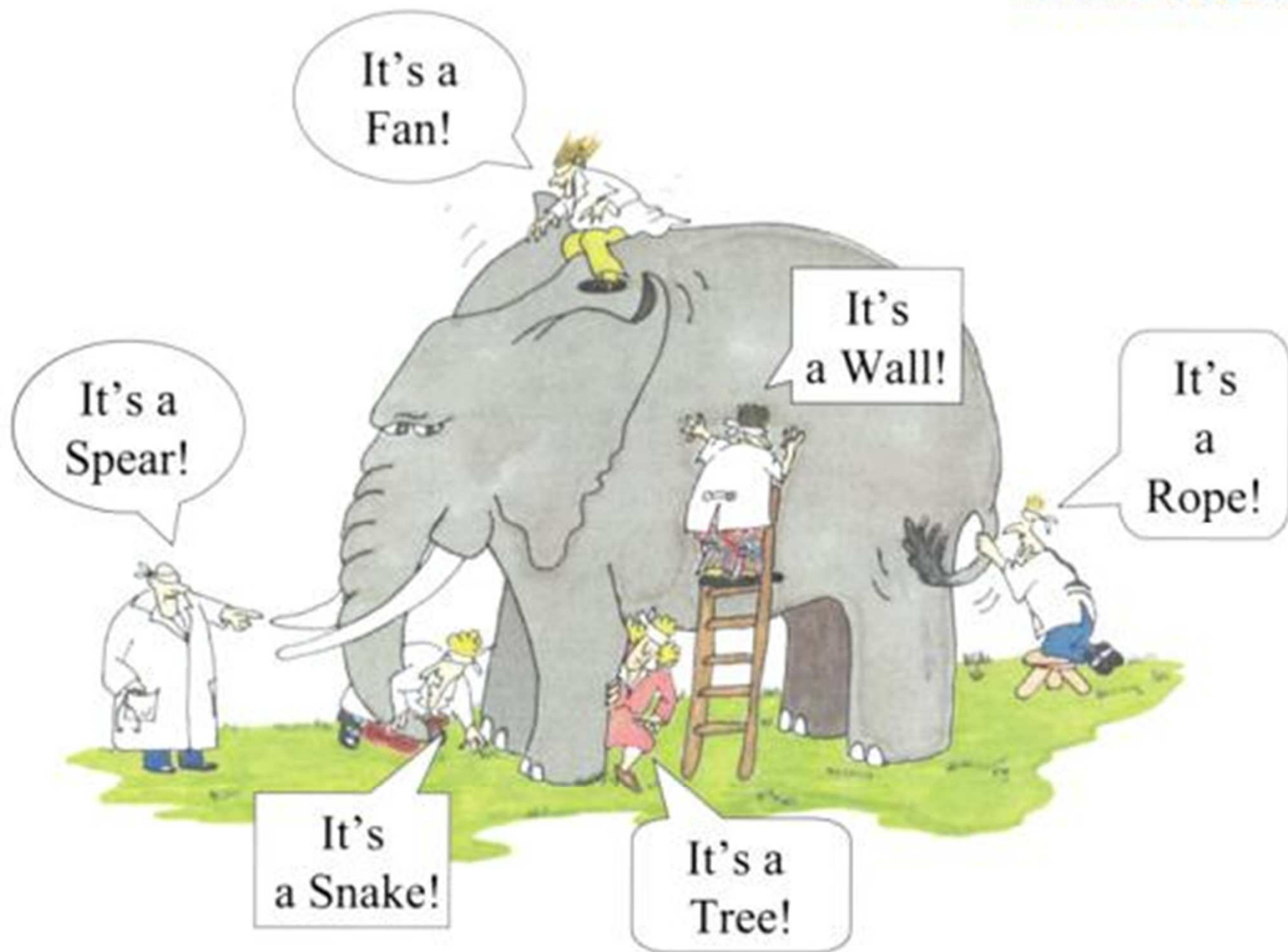
**Southeastern States Regional  
In-place Recycling Conference**

# Performance Based Specifications? In Recycling - What a Joke

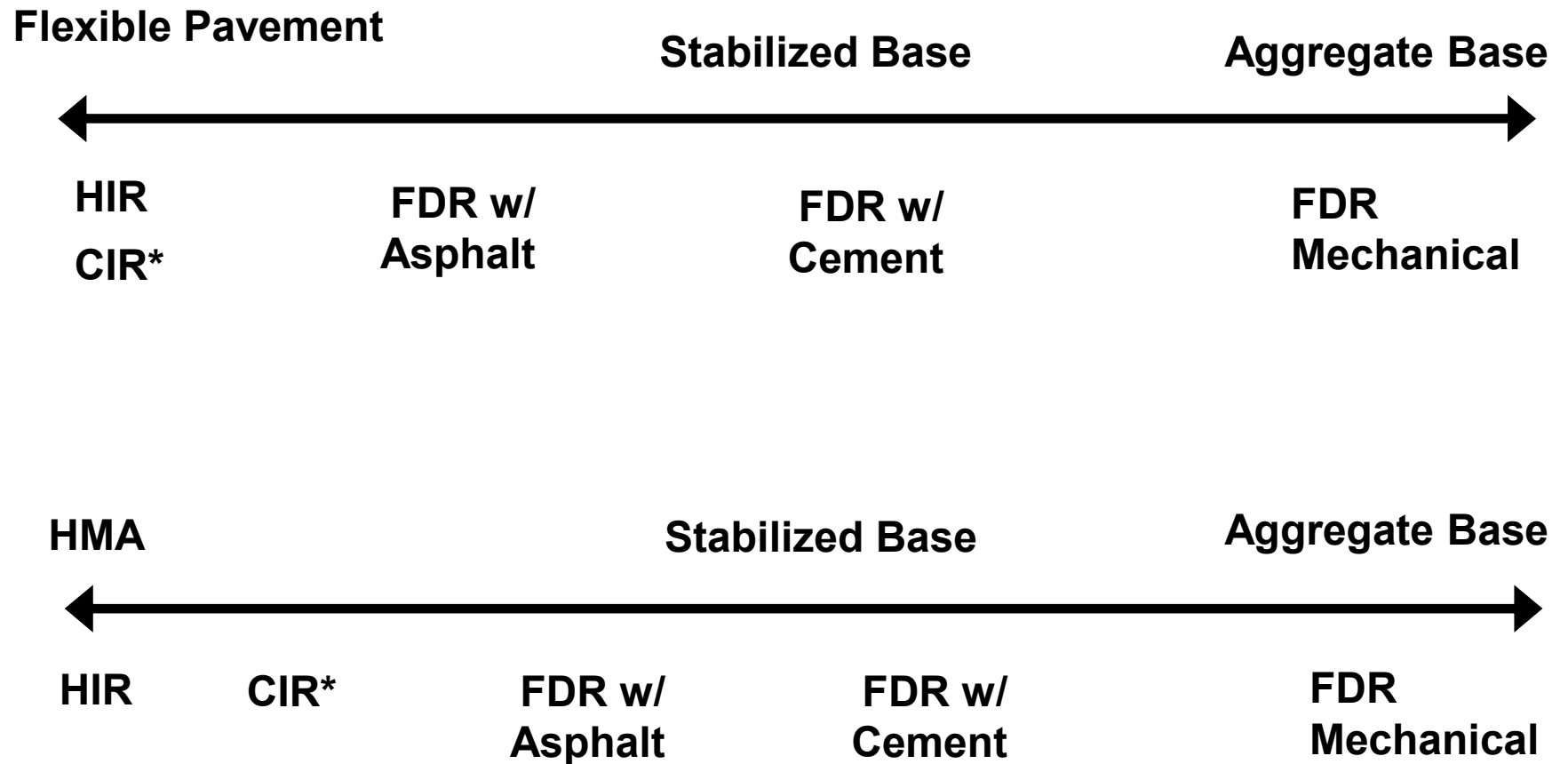
- NCHRP Synthesis 42 I

Type of Specification	HIR	CIR	FDR
Method	Often	Often	Frequently
End Result	Sometimes	Sometimes	Frequently
Performance	Sometimes	Sometimes	Often
Warranty	Sometimes	Sometimes	Often

- We Will Look at Common Specifications
- But First Perspective

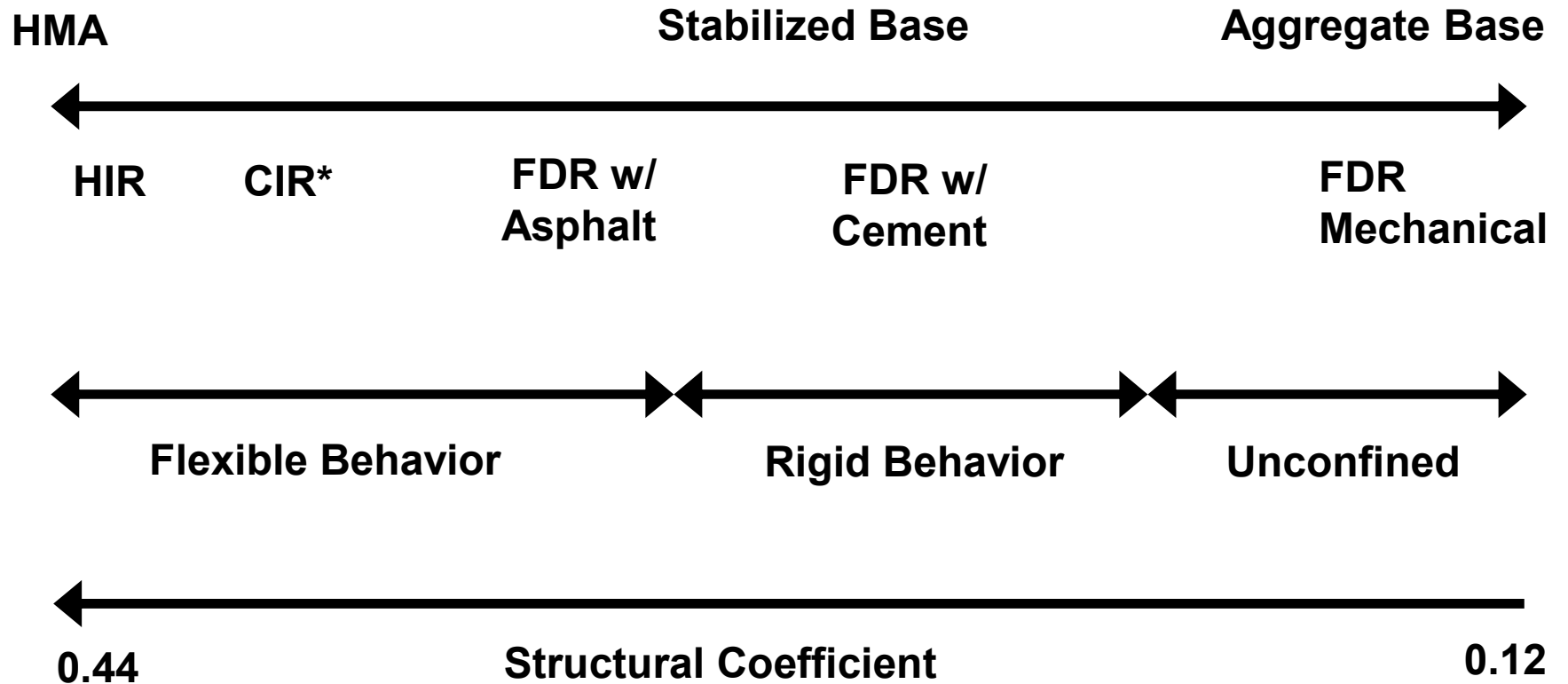


# Understand the Animal

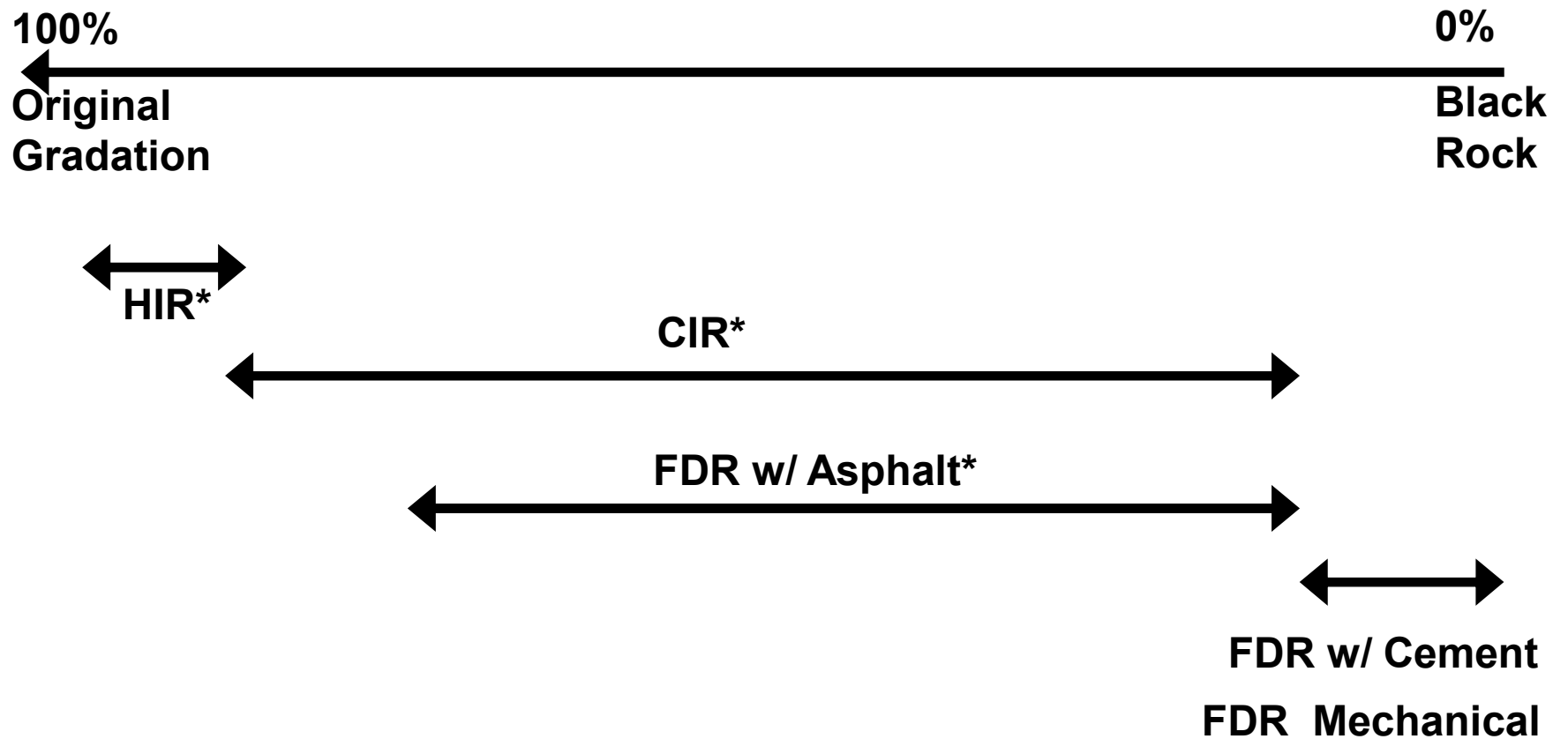


\*When Fully Cured. Could Be Weeks to Months.

# How Do We Model?



# Binder Activation



\*Depends on Existing Viscosity and New Binder or Rejuvenator.



# In-place Recycling And Reclaiming Methods

- In-place Asphalt Recycling
  - Hot In-place Recycling (HIR)
  - Cold In-place Recycling (CIR)
  - Cold Central Plant Recycling (CCPR)
- Full Depth Reclamation (FDR)
  - Pulverization (Aggregate Base Standards)
  - Mechanical Stabilization (Aggregate Base Standards)
  - Chemical Stabilization (PCA, Fly Ash, ARRA Etc...)
  - Asphalt Stabilization (Wirtgen Manual, CIR Approximation)

# What Recycling Specification Sections Are Typically Included

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- Description
- Materials
- Mix Design
- Construction Quality
- Equipment
- Climatic Conditions
- Measurement/Payment



# Specification / Information Review Per Epps

## Not Intended to List All for All

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- Arizona
- British Columbia
- California
- Colorado
- Iowa
- Kansas
- Nevada
- New Mexico
- Ohio
- Pennsylvania
- South Dakota
- Utah
- Vermont
- Washington
- Ontario
- FHWA
- ARRA
- PCCAS
- NCHRP Synthesis 421

# What is Cold In-Place Recycling?

Distressed converted to New pavement using a train of equipment that:

- **Mills deteriorated pavement**
  - **Reclaimed asphalt pavement (RAP)**
- **Crushes RAP to gradation**
- **Mixes with recycling agent**
- **Re-Paves recycled mix**
- **Compacts to specified density**
- **Readies for surface treatment**



# Summary of Pavement Conditions that can be addressed by Cold In-Place Recycling

<b>Ruts</b>	<b>&lt; 3/4 in</b>	✓	<b>Ride - Poor</b>	✓
			<b>Poor Drainage</b>	no
			<b>Snow Plow Use</b>	✓
<b>Crack</b>	<b>Fatigue</b>	? <sup>1</sup>	<b>Low Skid Resistance</b>	✓
	<b>Longitudinal</b>	✓	<b>Asphalt Rubber</b>	
	<b>Transverse</b>	✓	<b>Type O or Type G</b>	?
	<b>Block</b>	✓	<b>Terminal Blend</b>	✓
			<b>Stripping Pavement</b>	? <sup>2</sup>
			<b>Paving Fabrics</b>	? <sup>3</sup>
<b>Surface</b>	<b>Dry</b>	✓	<b>Structural Deficiency</b>	no
	<b>Flushing</b>	✓	<b>Base Failure</b>	no
	<b>Bleeding</b>	✓		
	<b>Variable</b>	✓		
<b>Raveling</b>		✓	<b>Questions?</b>	
<b>Potholes</b>		✓	1. Provided not base, subgrade or unstable mix related.	
<b>Texture - Rough</b>		✓	2. Depends on severity. May be able to add antistrip additive.	
			3. No problem if properly installed. If not, logistical issue with additional costs for disposal.	



**Not All Recycling Done in Remote Areas  
City of Beverly Hills**

# Intersection in City of Beverly Hills



# CIR Materials - Binders

<b>State</b>	<b>Asphalt Binder</b>
<b>Arizona</b>	<b>HFE-XXP</b>
<b>California</b>	<b>Emulsified RA</b>
<b>Colorado</b>	<b>HFE (Polymer) / emulsified RA</b>
<b>Iowa</b>	<b>Contractor select</b>
<b>Kansas</b>	<b>Emulsified asphalt / asphalt RA</b>
<b>Nevada</b>	<b>CMS-2S</b>
<b>New Mexico</b>	<b>HFE-150P</b>
<b>Ontario</b>	<b>Emulsified asphalt/ asphalt foam</b>
<b>Pennsylvania</b>	<b>MS, CMS, SS, CSS, HMFS / polymer grades</b>
<b>South Dakota</b>	<b>Emulsified asphalt</b>

# CIR Materials - Additives

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<b>State</b>	<b>Additive</b>
<b>California</b>	<b>0.5% to 1.0% cement (3:1 limit)</b>
<b>Nevada</b>	<b>1.5% quicklime slurry</b>
<b>New Mexico</b>	<b>1.5% hydrated lime slurry</b>
<b>Utah</b>	<b>1.5% quicklime slurry</b>

# Mix Design

<b>State</b>	<b>Method</b>
<b>Arizona</b>	<b>Contractor performed</b>
<b>ARRA</b>	<b>Gyratory compactor, indirect tensile test, retained stability, raveling test, existing binder content and penetration</b>
<b>California</b>	<b>Gyratory compactor, Marshall stability, retained stability, raveling test and existing binder (adding viscosity and/or penetration and multiple test temperatures)</b>
<b>Iowa</b>	<b>Gyratory compactor, Marshall stability, retained stability, raveling test</b>
<b>Nevada</b>	<b>None</b>



# Quality - Gradation

State	% Passing		
	1 ½-in	1 ¼-in	1-in
Arizona		100	
California			100
Colorado		100	
Nevada	100	100 (some)	
New Mexico		100	90 - 100
South Dakota		100	95
Utah	100		

# Quality – In-Place Density

<b>State</b>	<b>Density Requirement</b>
<b>Arizona</b>	<b>Specified in plans</b>
<b>California</b>	<b>95 to 105% of max density on test strip. Breakover Curve</b>
<b>Colorado</b>	<b>100% of field mixed/lab compact</b>
<b>Nevada</b>	<b>Breakover Curve</b>
<b>New Mexico</b>	<b>96% of field mixed/lab compact</b>
<b>South Dakota</b>	<b>97% of target density</b>
<b>Utah</b>	<b>96% of field mixed/lab compact</b>

**Nuclear Gauge Operator's Worksheet  
For Control Strip Density - Part 1**

Material Type CIR - 4"  
 Lift & Pad Number \_\_\_\_\_  
 Width of Spread \_\_\_\_\_  
 Project No. \_\_\_\_\_

Contract No. EXAMPLE  
 Date \_\_\_\_\_  
 Station/Location \_\_\_\_\_  
 Gauge SN \_\_\_\_\_

**Tests During Rolling**

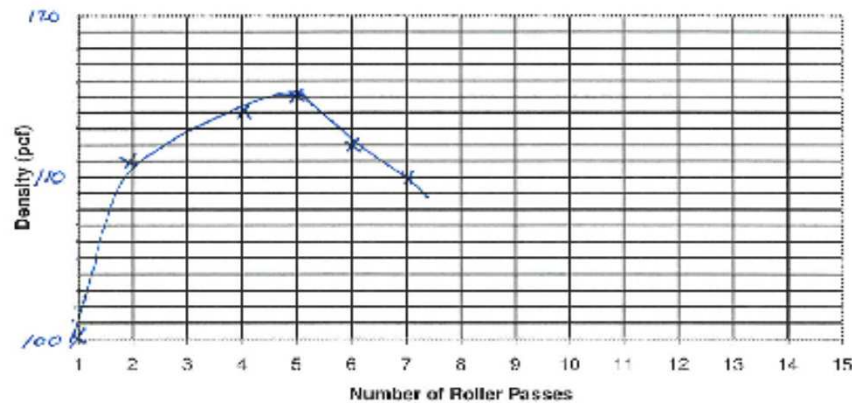
Type & No. of Roller Passes	1 <u>STATIC STEEL</u>			2 <u>VIB STEEL</u>			3 <u>VIB STEEL</u>		
Site Number	1	2	3	1	2	3	1	2	3
Density (pcf)	A								
	B								
"Moisture" Reading									
Average Test Site Density									
Average Density	<u>101</u>			<u>111</u>					

*stair  
cracking*

Type & No. of Roller Passes	4 <u>Pneumatic</u>			5 <u>Pneumatic</u>			6 <u>Pneumatic</u>		
Site Number	1	2	3	1	2	3	1	2	3
Density (pcf)	A								
	B								
"Moisture" Reading									
Average Test Site Density									
Average Density	<u>113</u>			<u>115</u>			<u>112</u>		

Type & No. of Roller Passes	7 <u>Steel Static</u>			8			9		
Site Number	1	2	3	1	2	3	1	2	3
Density (pcf)	A								
	B								
"Moisture" Reading									
Average Test Site Density									
Average Density	<u>110</u>								

**Density vs. Number of Roller Passes**



# Quality – Surface Tolerance / Smoothness

<b>State</b>	<b>Smoothness Requirement</b>
<b>Arizona</b>	<b>1/4-in longitudinal</b>
<b>California</b>	<b>1/4-in transverse. Profilograph to HMA Standards (Being Changed)</b>
<b>Colorado</b>	<b>3/16-in transverse &amp; 3/16-in longitudinal</b>
<b>Nevada</b>	<b>1/4-in transverse &amp; 1/4-in longitudinal</b>
<b>New Mexico</b>	<b>1/4-in transverse</b>
<b>South Dakota</b>	<b>0.04-ft transverse</b>
<b>Utah</b>	<b>3/8-in transverse</b>

**Smoothness Held for Warranty Period  
is Performance For Permanent  
Deformation and Raveling**

## Equipment (Typical)

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- ❖ **Self propelled machine 12-ft in width min.**
- ❖ **Capability to crush and screen material**
- ❖ **Capable of processing and spreading material in one pass**
- ❖ **Capable of producing homogeneous material**
- ❖ **One pneumatic roller at least 25-tons**
- ❖ **One double drum roller at least 10-tons**
- ❖ **Rotary broom on site**

## Climatic Conditions – Do Not Construct

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- ❖ **Ambient air temperature**
  - ❖ ex. below 45 to 65°F
- ❖ **Pavement temperature below**
  - ❖ ex. below 50 to 70°F
- ❖ **Over night temperature at or below freezing**
- ❖ **Weather is rainy or foggy**
- ❖ **When proper mixing, spreading and compaction cannot be accomplished**
- ❖ **Between specific months**
  - ❖ ex. October 1 to April 30

## Climatic Conditions – Curing Conditions

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- ❖ **No vehicles on material until 2-hrs have passed**
- ❖ **Surface treatment/wearing course placed when moisture content is below a certain point**
  - ❖ **Free moisture content – below 1.0 to 1.5%**
  - ❖ **Total moisture content – below 1.5 to 3.0%**
- ❖ **Wearing course must be placed within a certain timeframe**
  - ❖ **Between 3 - to 30-days**

## Measurement / Payment

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- ❖ **Payment based on square yard or unit price per station**
- ❖ **Payment may include bituminous materials on a volume or weight basis**



## Typical Contract Items - CIR with Emulsified Recycling Agent

ITEM NO.	ITEM CODE	ITEM DESCRIPTION	UNIT OF MEASURE	ESTIMATED QUANTITY
1	074016	CONSTRUCTION SITE MANAGEMENT	LS	LUMP SUM
2	074019	PREPARE STORM WATER POLLUTION PREVENTION PLAN	LS	LUMP SUM
3 (S)	120090	CONSTRUCTION AREA SIGNS	LS	LUMP SUM
4 (S)	120100	TRAFFIC CONTROL SYSTEM	LS	LUMP SUM
5 (S)	128650	PORTABLE CHANGEABLE MESSAGE SIGN	LS	LUMP SUM
6 (S)	150662	REMOVE METAL BEAM GUARD RAILING	N	65
7	150771	REMOVE ASPHALT CONCRETE DIKE	N	1,180
8 (S)	151572	RECONSTRUCT METAL BEAM GUARD RAILING	N	1,830
9 (S)	153103	COLD PLANE ASPHALT CONCRETE PAVEMENT	M2	570
10	198007	IMPORTED MATERIAL (SHOULDER BACKING)	TONN	470
11	390095	REPLACE ASPHALT CONCRETE SURFACING	M3	87
12	390102	ASPHALT CONCRETE (TYPE A)	TONN	3,860
13	394044	PLACE ASPHALT CONCRETE DIKE (TYPE C)	N	19
14	394046	PLACE ASPHALT CONCRETE DIKE (TYPE D)	N	160
15	394048	PLACE ASPHALT CONCRETE DIKE (TYPE E)	N	230
16	394049	PLACE ASPHALT CONCRETE DIKE (TYPE F)	N	790
17	011871	EMULSIFIED RECYCLING AGENT	TONN	220
18	011872	COLD IN-PLACE RECYCLING ADDITIVE	TONN	54
19	011873	COLD IN-PLACE RECYCLING	M2	45,000
20	820107	DELINEATOR (CLASS 1)	EA	280
21	820151	OBJECT MARKER (TYPE L-1)	EA	3
22 (S)	011874	END CAP (TYPE C)	EA	5
23 (S)	839581	END ANCHOR ASSEMBLY (TYPE SFT)	EA	5
24 (S)	839584	ALTERNATIVE IN-LINE TERMINAL SYSTEM	EA	2
25 (S)	839585	ALTERNATIVE FLARED TERMINAL SYSTEM	EA	3
26 (S)	840561	100 MM THERMOPLASTIC TRAFFIC STRIPE	N	24,500
27 (S)	840570	100 MM THERMOPLASTIC TRAFFIC STRIPE (BROKEN 10.98 M - 3.66 M)	N	550
28 (S)	850111	PAVEMENT MARKER (RETROREFLECTIVE)	EA	1,680

CIR  
CIR  
CIR

# What is HIR?

Distressed converted to New pavement using a train of equipment that:

- **Heats** deteriorated pavement surface
- **Mills** Reclaimed asphalt pavement (RAP)
- **Mixes** with rejuvenating agent, emulsion and/or possibly new HMA
- **Re-Paves** recycled mix
- **Compacts** to specified density





# Hot In-Place Recycling

- Three methods
  - Surface recycling
  - Remixing
  - Repaving
- Typical depth: 0.6 to 2.0 in (Some up to 3.0 in)
- RAP mixed with rejuvenating additives or recycle emulsion
- Admix - Additional hot mix AC may be added
- Relaid and compacted
- Immediate opening to traffic
- Applicable for all traffic levels



## HIR Construction

- Eliminates distress in upper portion of pavement
- Restores existing asphalt mix to desired mix composition or strength
- Recycled mix may serve as wearing course
- Provides modest amount of strengthening

# Materials - Binders

<b>State</b>	<b>Asphalt Binder</b>
<b>British Columbia</b>	<b>Emulsified recycling agent / Recycling agent</b>
<b>Colorado</b>	<b>Asphalt rejuvenating agent</b>
<b>New Mexico</b>	<b>Emulsified recycling agent (blend meet PG binder grade)</b>
<b>Ontario</b>	<b>Select material to provide blend that meets 50 to 80 pen</b>
<b>Utah</b>	<b>Emulsified recycling agent</b>
<b>Washington</b>	<b>Emulsified recycling agent / PG 58-22</b>

# Mix Design

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<b>State</b>	<b>Method</b>
<b>Kansas</b>	<b>Air voids, TSR, rutting resistance, thermal cracking</b>
<b>New Mexico</b>	<b>Must meet specifications for HMA – Section 423</b>
<b>Ohio</b>	<b>Marshall stability, penetration</b>
<b>Washington</b>	<b>Superpave, air voids</b>

# Quality – In-Place Density

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<b>State</b>	<b>Density Requirement</b>
<b>British Columbia</b>	<b>97% of lab density</b>
<b>Colorado</b>	<b>92 to 96% of maximum theoretical</b>
<b>New Mexico</b>	<b>92 to 98% of maximum theoretical</b>
<b>Ontario</b>	<b>Lab compacted air voids between 2.5% and 5.5% (75b Marshall)</b>

# Quality – Surface Tolerance

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<b>State</b>	<b>Surface Tolerance</b>
<b>Colorado</b>	<b>Profile Index – dependent upon roadway traffic volume</b>
<b>New Mexico</b>	<b>1/8-in transverse 1/8-in longitudinal</b>



## Equipment (Typical)

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- ❖ **Remove all material from pavement surface - broom**
- ❖ **Self propelled**
- ❖ **Enclosed combustion area**
- ❖ **No open flame in direct contact with pavement**
- ❖ **Capable of heating pavement to desired temperature**
- ❖ **Capable of scarifying the heated pavement to the desired depth**

# Equipment (Typical)

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- ❖ **Requirements on laydown temperature of material**
  - ❖ **Typ. Min. 190°F to 230°F**
  - ❖ **Typ. Max. 300°F to 315°F**
- ❖ **Scarification does not break the aggregate particles**
- ❖ **Heating does not char the asphalt surface**
- ❖ **Uniformly distribute material**
- ❖ **Rolling operation must obtain the desired pavement density**

## Climatic Conditions – Do Not Construct

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- ❖ **Ambient air temperature**
  - ❖ ex. below 40 to 50°F
- ❖ **Pavement temperature below**
  - ❖ ex. below 50°F
- ❖ **When roadway surface is wet**
- ❖ **Weather conditions prevent proper placement**
- ❖ **Between specific months**
  - ❖ ex. October 16 to May 14

## Measurement / Payment

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- ❖ **Payment based on square yard or unit price per station**
- ❖ **Payment may include rejuvenator/recycle emulsion and/or admix on a volume or weight basis**

# Where Do We Go From Here?

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- Consistency in Specifications Across All Areas
  - ARRA Working on Suggested Guidelines
- CIR – End Result Specifications that Better Model Actual Performance
  - e.g. Dynamic Modulus with Confinement and Temperature
- HIR – Better HMA Modeling and Binder Interactions
- Design Build – Warranty Specifications

# Thank You – Questions?



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