NOVA SCOTIA ASPHALT USER PRODUCER ASSOCIATION

2nd Annual Seminar

FULL AND PARTIAL DEPTH RECYCLING APPLICATIONS – a Contractors Perspective

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Presentation Summary

- Nova Scotia's Experience with In-Place Recycling
- Evolution of Full Depth Reclamation to In-Place Recycling
- Recycling Techniques being used today in NS
- Project Selection Considerations
- Design issues and QA/QC
- Environmental Benefits

Nova Scotia's Recycling Experience

- NSTIR first used bituminous stabilization on a Partial depth project in *1997*
- Have recently utilized both full and partial depth bituminous stabilization in addition to cement stabilization
- NSTIR have completed over 400 kms in the last 12 years

- HRM has been recycling since *1998* and have recently completed both partial and full depth bituminous stabilization.
- HRM has completed over lane 14 km

Both agencies have committed to providing Sustainable Transportation Networks

FULL DEPTH RECLAMATION EVOLUTION OF AN INDUSTRY

- Began with pulverizing existing roadways
- Evolved into In-Place Stabilization
- Pulverize first pass, Stabilize to desired depth with binders;
  - **Mechanical binders** can include virgin granulars or RAP
  - **Chemical binders** include portland cement, calcium chloride, lime, flyash and water.
  - **Bituminous binders** include expanded or foamed asphalt and asphalt emulsions.

In-Place Recycling now includes Partial Depth applications

FDR - EVOLUTION OF AN INDUSTRY

FDR

FDR Chemical Stabilization

FDR Bituminous Stabilization

Paver Laid Bituminous Stab

Recycling Techniques Being Used in Nova Scotia

- Pulverization – Full Depth Reclamation (FDR)
- Full Depth Reclamation with Expanded Asphalt
- Partial Depth Reclamation with Expanded Asphalt or Emulsified Asphalt Stabilization
- Full Depth Reclamation with Portland Cement
- Conventional Mill and Pave

FULL DEPTH RECLAMTION

- A Reconstruction technique that recycles bituminous pavements on site by:
- Pulverizing the existing pavement and,
- Mixing the processed material with the underlying granular base
- Grading and compacting

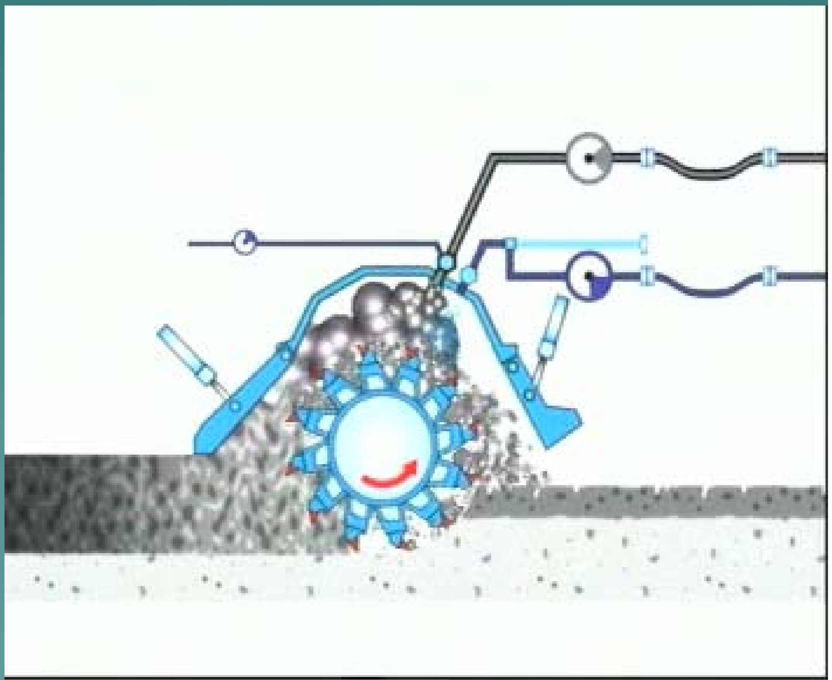
Pulverizing - Full Depth Reclamation

FULL DEPTH RECLAMTION with EXPANDED ASPHALT

- In-Place full depth reclamation of the existing HMA and underlying granular base, then
- Stabilization of reclaimed material by adding expanded (foamed) asphalt, and additives if required then
- Grading/Placing and compacting
- A surface wearing course is required, generally, 1 – 2 lifts of Hot Mix

Original Full Depth Expanded Asphalt Technology

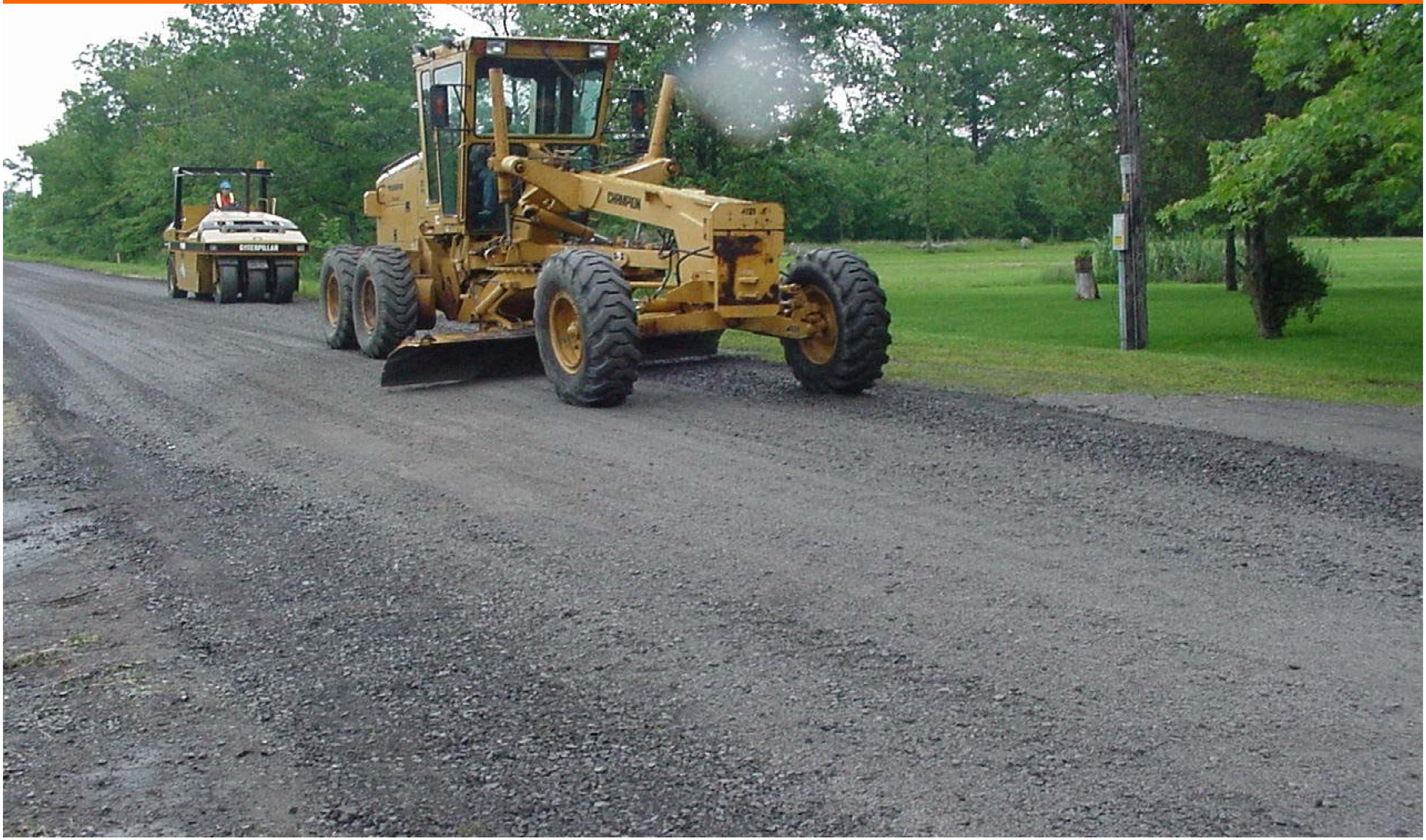
Modified Pulverizer with Expansion Bar



Full Depth Expanded in to the underlying granular layer

Full Depth Expanded Asphalt

Full Depth Expanded Asphalt Grader-Laid



Full Depth Paver Laid Expanded Asphalt

Generally 3 step process

But can also be done without pre-pulverize

1. Pre-pulverize the pavement layer and underlying granulars and any required additives (aggregate, lime, etc.) to specified depth

Shoulder material can be incorporated to achieve widening

Full Depth Paver Laid Expanded

2. After Pre-Pulverizing - grade and compact to required widths and cross falls

Full Depth Paver Laid Expanded

3. Process (expand) and place with paver to specified depth / width, compact and place wearing surface

Rural Project – 4.85 m (16') wide lanes

Full Depth Paver Laid Expanded

Trunk 12, Rural Project – 200 mm thick FD EA

Compaction

Compaction can commence immediately behind the paver. No concerns with temperature

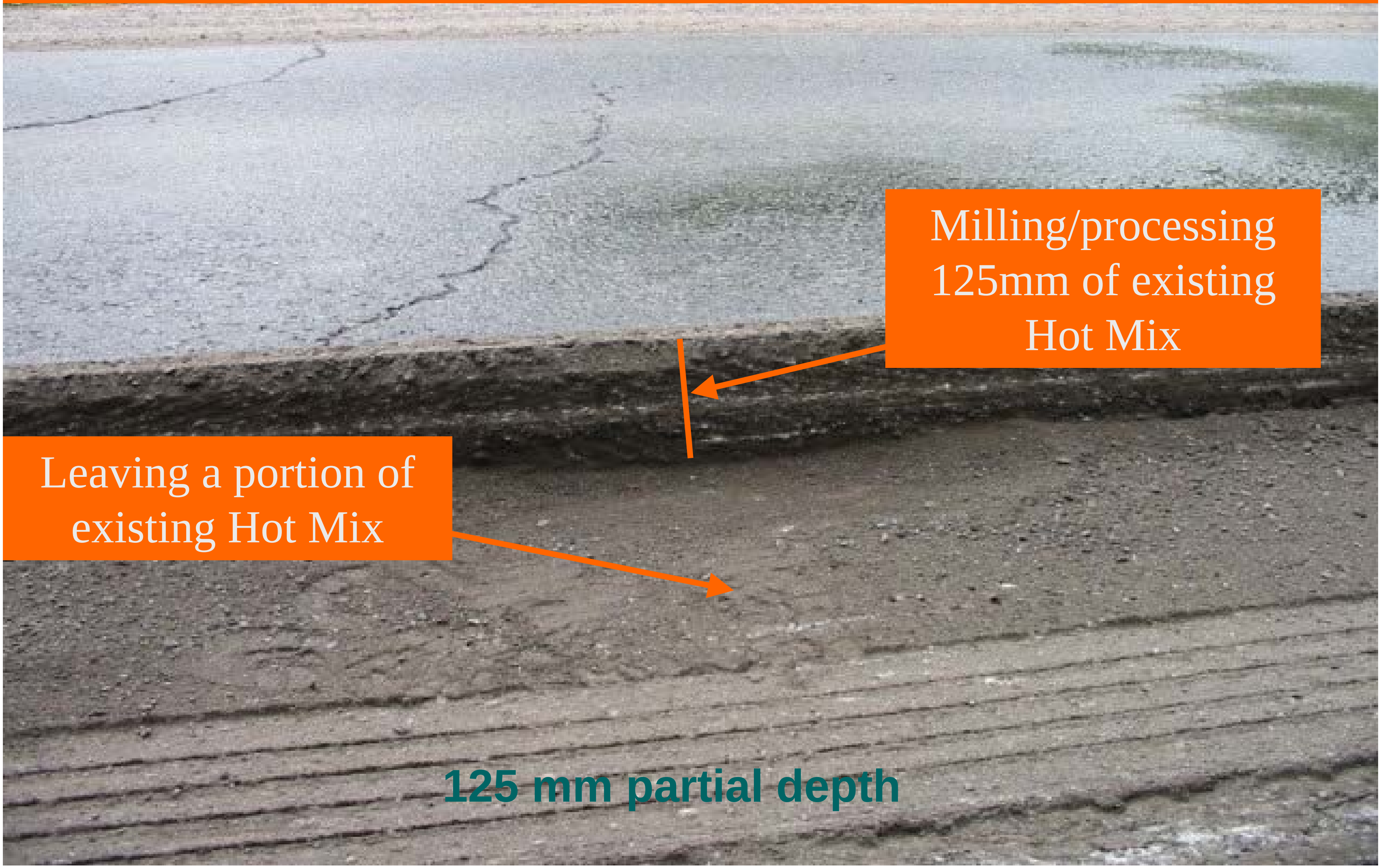
Partial Depth Reclamation with Expanded Asphalt or Emulsified Asphalt Stabilization

- **Partial Depth Reclamation is a In-Place Recycling process that grinds up the existing asphalt pavement, sizes it, mixes in new bituminous binder and water, then**
- **Places the cold recycled bituminous mixture with a conventional paver in one continuous operation**
- **The binder is typically an off the rack PGAC or an emulsified asphalt**

Partial Depth Paver Laid Expanded

Partial Depth Paver Laid Expanded

Partial Depth Rural Project



Partial Depth Paver Laid Expanded

Granton Abercrombie Road, 2008

100 mm depth

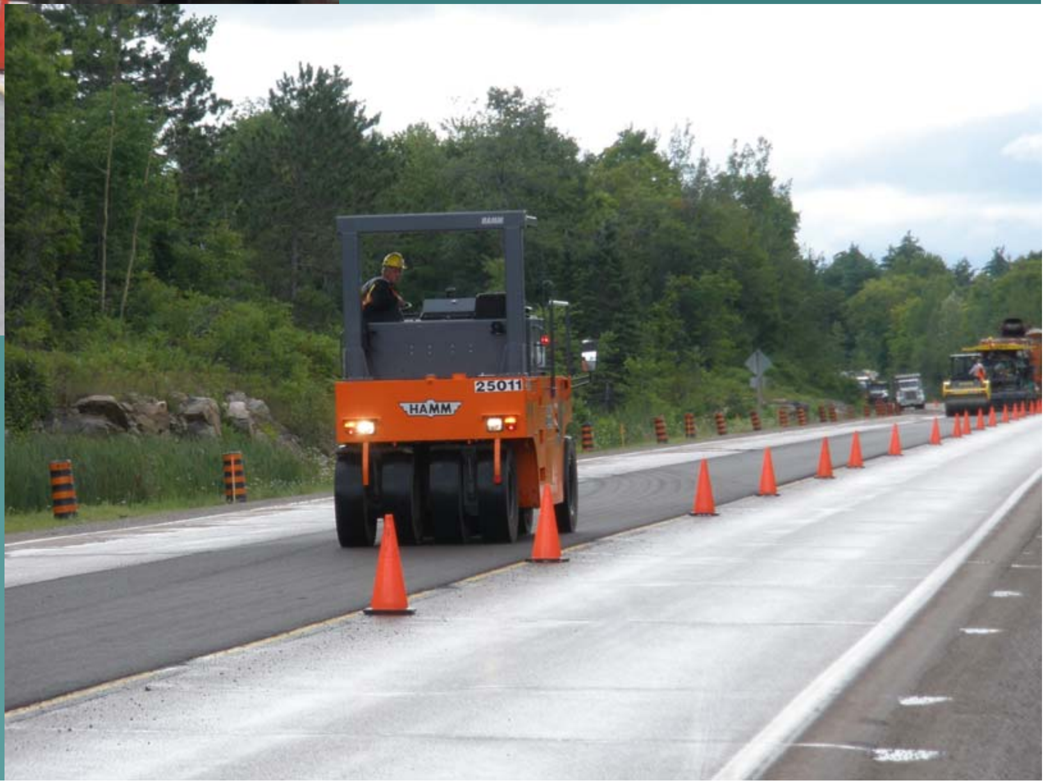
Partial Depth Paver Laid Expanded

Compaction

Steel Breakdown

Rubber Tire Inter

Steel Finish



Same compaction equipment as Hot Mix

Paver Laid Components

Full Depth Reclamation with Portland Cement

- In-Place full depth reclamation of the existing HMA and underlying granular base, then
- Stabilization of reclaimed material by adding required portland cement and re-pulverizing and then
- Grading, compacting and curing including pre-cracking 24 -48 hours from initial compaction

Initial Pulverizing
Full Depth Reclamation

Add Cement, dry process

Add Cement – Slurry form

Stabilization with Cement, then grade, compact and cure

Blending of Cement, followed by grader and compaction

DESIGN CONSIDERATIONS for IN-PLACE RECYCLING

OBJECTIVE

- **Surface rehabilitation**
- **Structural reinforcement**

TYPES OF BINDER

- **Bituminous binders**
- **Chemical (hydraulic) binders**
- **Combination of both**

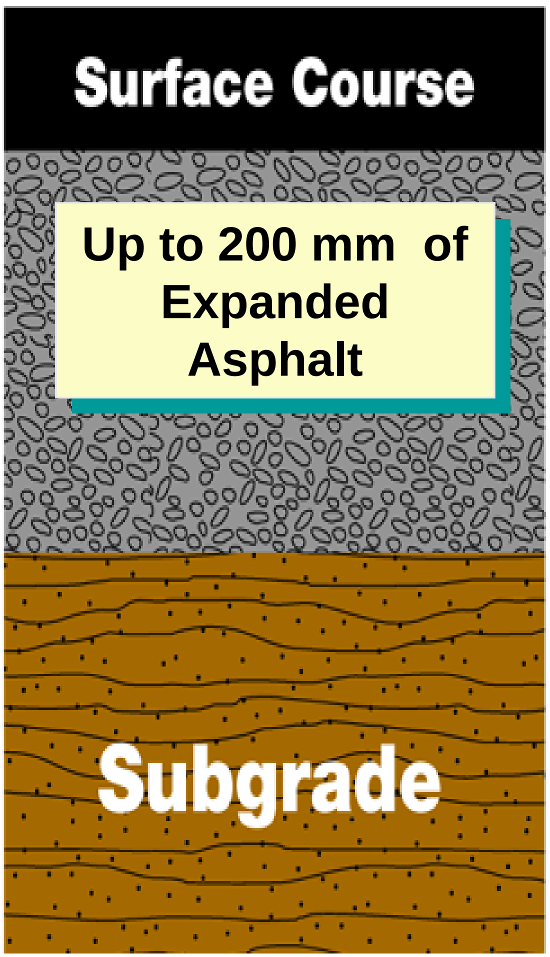
Blend of In-Place Materials – Full Depth

- **Ratio of bituminous and granular**

Comparison on types of Recycling

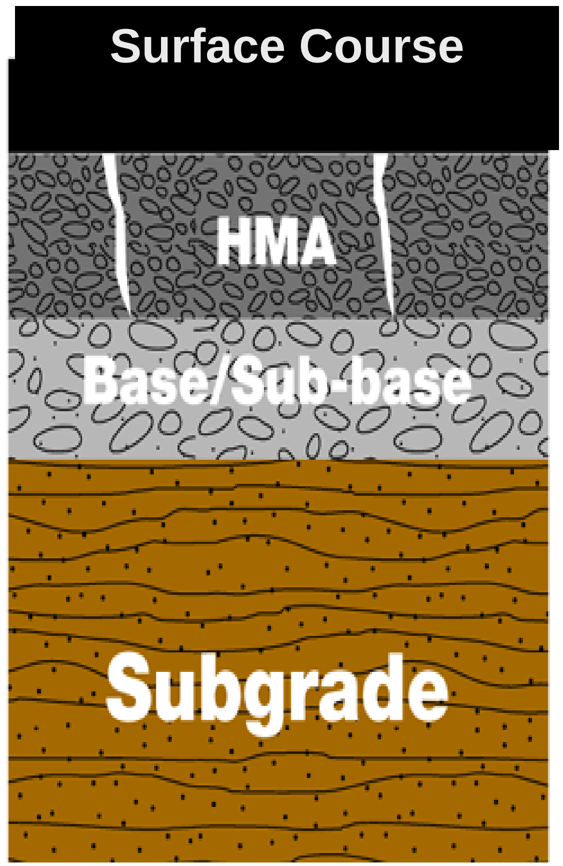
FULL DEPTH Expanded Asphalt

Paver/Pulverizer

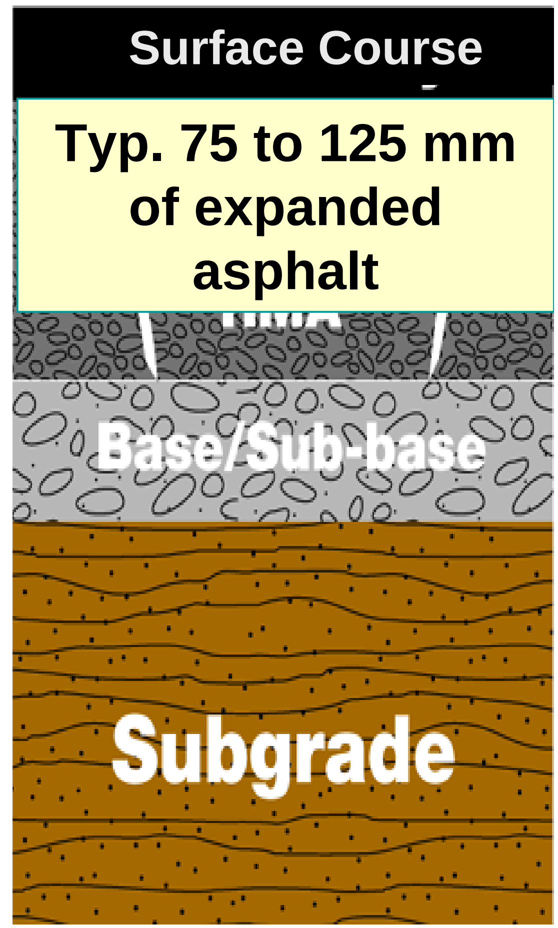


Mill

and Pave



Partial Depth Recycling with Paver



Project Selection Considerations

Characteristics Binder Selection Full or Partial	Bituminous binder treatments			Hydraulic binder treatment	Composite binder treatment
	Partial depth treatment	Partial or Full Depth Treatment	Full depth treatment		Partial or Full Depth Treatment
Objective	Surface Rehabilitation		Structural Reinforcement		Surface Rehabilitation or Structural Reinforcement
Principle	Recycling of bituminous surface layers	Reclamation and stabilization of the full thickness of bituminous surface layers including some or a proportion of the underlying granular material		Creation of a new pavement material using the in-situ material	
In-place materials	Bituminous material only	40 to 80 mm of bituminous material plus some underlying granular material	75 to 150 mm of bituminous material and 75 to 150 mm of underlying granular material		Bituminous material with or without underlying granular material
Type of binder	Bituminous binder emulsified or foamed or rejuvenating binder	Bituminous binder emulsified or foamed		Cement or other pozzolanic binders	Blend of bituminous and hydraulic binders
Added binder content	0.8 to 1.5 % residual binder	1.3 to 2.0 % residual binder	1.8 to 4.0 % residual binder	3 to 6 % hydraulic binder	1.5 to 7 % composite binder
Depth of treatment	60 to 120 mm		125 to 200 mm	200 to 300 mm	75 to 300 mm

Source: Technical Guide, Cold In-situ Recycling, July 2003. France

Candidate Selection based on Pavement Distress, Ride and Strength

PAVEMENT DISTRESS MODE	CANDIDATE REHABILITATION TECHNIQUES						
	MILL AND PAVE	IN-PLACE RECYCLING	THIN HOT MIX OVERLAY	THICK HOT MIX OVERLAY	FDR PULVERIZE	Combination Treatments	Reconstruction
Raveling	Yellow	Cyan	Green	Yellow	Red	Green	Red
Potholes	Red	Green	Yellow	Cyan	Yellow	Green	Red
Bleeding	Cyan	Cyan	Red	Yellow	Cyan	Green	Red
Skid Resistance	Cyan	Cyan	Green	Yellow	Yellow	Green	Red
Shoulder Drop Off	Cyan	Red	Red	Red	Red	Red	Green
Rutting	Cyan	Green	Red	Yellow	Yellow	Green	Yellow
Corrugations	Cyan	Green	Red	Yellow	Yellow	Green	Yellow
Shoving	Cyan	Green	Red	Yellow	Yellow	Green	Yellow
Fatigue Cracking	Red	Green	Red	Green	Green	Green	Green
Edge Cracking	Red	Yellow	Red	Yellow	Green	Green	Green
Slippage Cracking	Red	Green	Red	Yellow	Cyan	Green	Cyan
Block Cracking	Red	Green	Red	Yellow	Green	Green	Cyan
Longitudinal Cracking	Red	Green	Red	Yellow	Cyan	Green	Cyan
Transverse Cracking	Red	Green	Red	Yellow	Green	Green	Cyan
Reflection Cracking	Red	Green	Red	Yellow	Green	Green	Cyan
Discontinuity Cracking	Red	Green	Red	Yellow	Green	Green	Cyan
Swells	Yellow	Cyan	Yellow	Green	Cyan	Green	Yellow
Bumps	Yellow	Cyan	Yellow	Green	Cyan	Green	Yellow
Sags	Yellow	Cyan	Yellow	Green	Cyan	Green	Yellow
Depressions	Yellow	Cyan	Yellow	Green	Cyan	Green	Yellow
Ride Quality	Yellow	Green	Yellow	Green	Red	Green	Red
Strength	Red	Cyan	Red	Green	Green	Green	Green

Green	Green	Cyan		Yellow	Red	Red
Most	Appropriate				Least	Appropriate

Source: ARRA BARM Manual

PROCESS SELECTION

What is the appropriate process??

- Review of technical & economical factors
- Overlap between full depth and partial depth treatment is substantial

Objective to meet

- Surface rehabilitation
- Structural improvement

Pavement Condition

- Type and extent of pavement deformation

Pavement Condition vs. Time

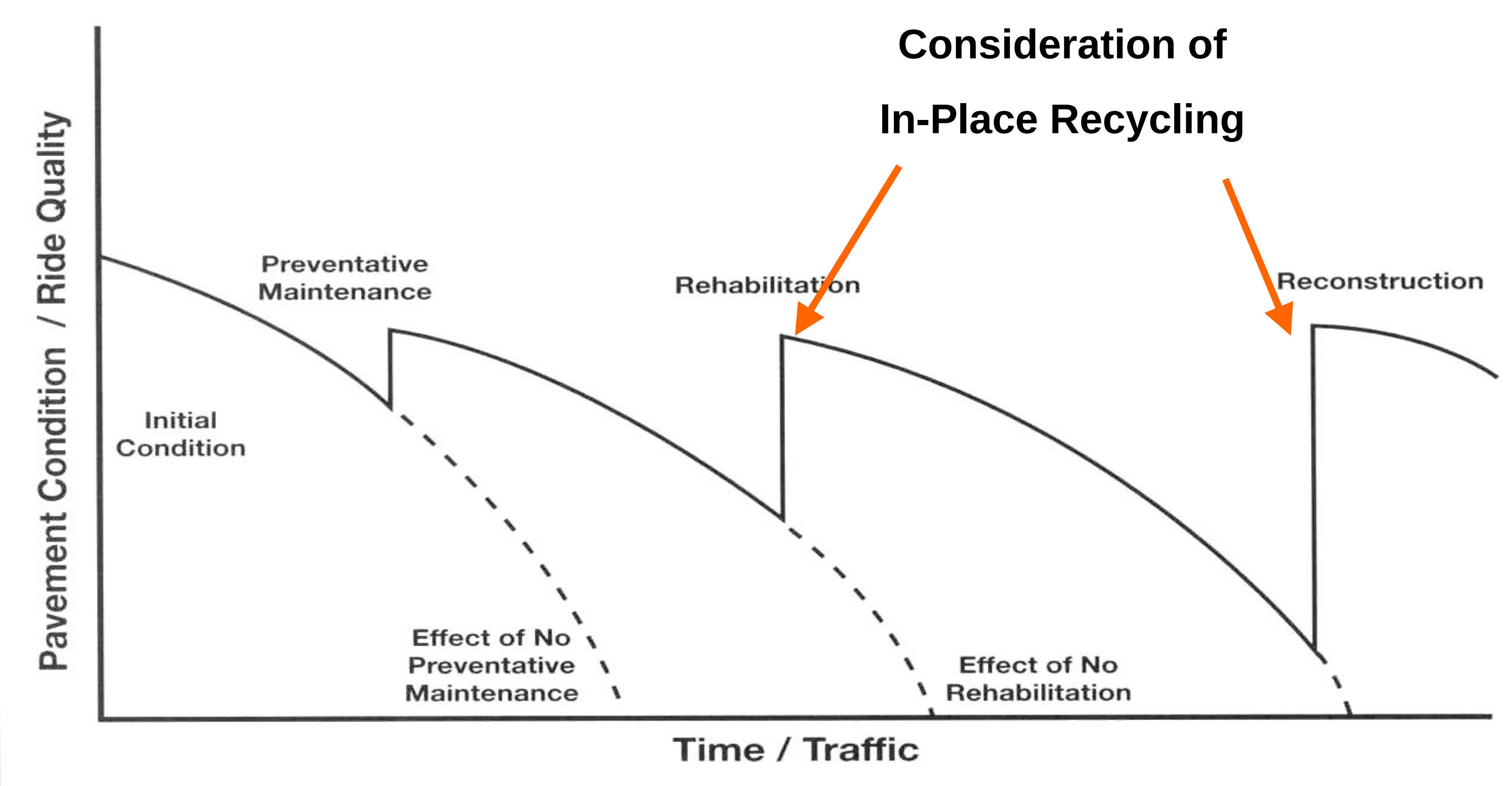


Figure 2-1: Pavement Deterioration vs. Time

Time + Traffic + Environment = *Deterioration*

DESIGN CONSIDERATIONS FULL DEPTH RECLAMTION

- Suitable for all bituminous pavements exhibiting extensive distresses, including structural deficiencies
- Suitable for various depth pavements, maximum processing depth up to 350 mm
- Thicker pavements may require pre-milling
- Process depth can be varied to achieve desired blend of underlying

Full Depth Reclamation

ADVANTAGES
FULL DEPTH RECLAMTION

- 100 % reuse of existing materials
- Elimination of reflection cracking
- Can be used for all types of surface treatments, cold and hot mix pavements
- Cross fall, superelevation and profile can be easily adjusted
- Addition of stabilizing agents will increase strength without changing


FULL DEPTH RECLAMATION CANDIDATE ?

Design Considerations - FDR with Expanded Asphalt or Partial Depth Reclamation with Expanded/Emulsion

- Surface Rehab. or Structural Improvement?
- Pavement depth & distresses (rut depth, crack pattern) may dictate Full versus Partial
- Is cross-fall correction needed?
- What grade raise is acceptable
- Is pre-milling required

Full Depth or Partial Depth Bituminous Reclamation

Full Depth Reclamation

OR

Partial Depth Reclamation

Elimination of the surface cracks with application of Expanded Asphalt to the pre-pulverized mixture of a portion of the underlying granulars with the entire road surface to stabilize and improve road strength

Mitigation of surface cracks with application of bituminous binder to a portion of the existing asphalt structure - leaving the granulars and the remaining road base intact

Full Depth Expanded Candidates

May require base repair

and drainage improvements

Distorted, severe rutting

Severe cracking

Full Depth Paver Laid Expanded

Mill, process, mix with expanded AC and place with paver to specified depth / width & compact

Rural Project – 4.35 m (14 +’) width

Expanded Stabilized Base

➔ *Materials that can be recycled with the Expanded Asphalt process include :*

1. 100% RAP
2. 100% Virgin
3. Any blend of RAP and underlying granulars
4. Any blend of Virgin Granulars and RAP
5. Any blend of Surface Treatment and underlying granulars
6. Stock piles of RAP and Crushed Concrete

ADVANTAGES

FULL DEPTH RECLAMTION with EXPANDED ASPHALT

- Reuse of the full Asphalt layer and portion of underlying granulars and shoulder material
- Eliminates reflective cracking
- Pre-pulverizing allows cross-fall and profile correction, can accommodate Road widening
- Easy to add corrective aggregates or additional stabilizers during the process

Partial Depth Reclamation with Expanded Asphalt or Emulsified Asphalt Stabilization

One step Process

Process within the existing Pavement Layer to appropriate design thickness (100 – 125 mm), cross fall and width, compact and place wearing course

Now covered by Provincial and Local Method Specifications

Design Considerations

Partial Depth Reclamation with Emulsion/Expanded Asphalt Stabilization

- Existing pavement depth? Is it sufficient ?
- Is cross-fall correction needed
- What grade raise is acceptable
- Is pre-milling required
- Are Cracks Full Depth, Load Associated?
- What surface wearing course is

Partial Depth Stabilization Candidates

Adequate Drainage

Good Cross-section

Sufficient Asphalt Depth

Partial Depth Rural Project

Pre-Milling

Improves Longitudinal Smoothness

Corrects or restores cross-fall

Electronically controlled

Partial Depth Rural Project

Rte 333 Partial Depth Stabilization

100 mm processing depth

Partial Depth Core

50mm surface HOT MIX

100 mm of Partial Depth Bituminous Stabilization - Paver Laid

underlying existing hot mix

Partial Depth Project - Urban

Pre-mill to reveal curb & allow surface overlay and restore design cross-fall

Partial Depth Project – Urban HRM

ADVANTAGES

Partial Depth Reclamation with Expanded/Emulsion Asphalt Stabilization

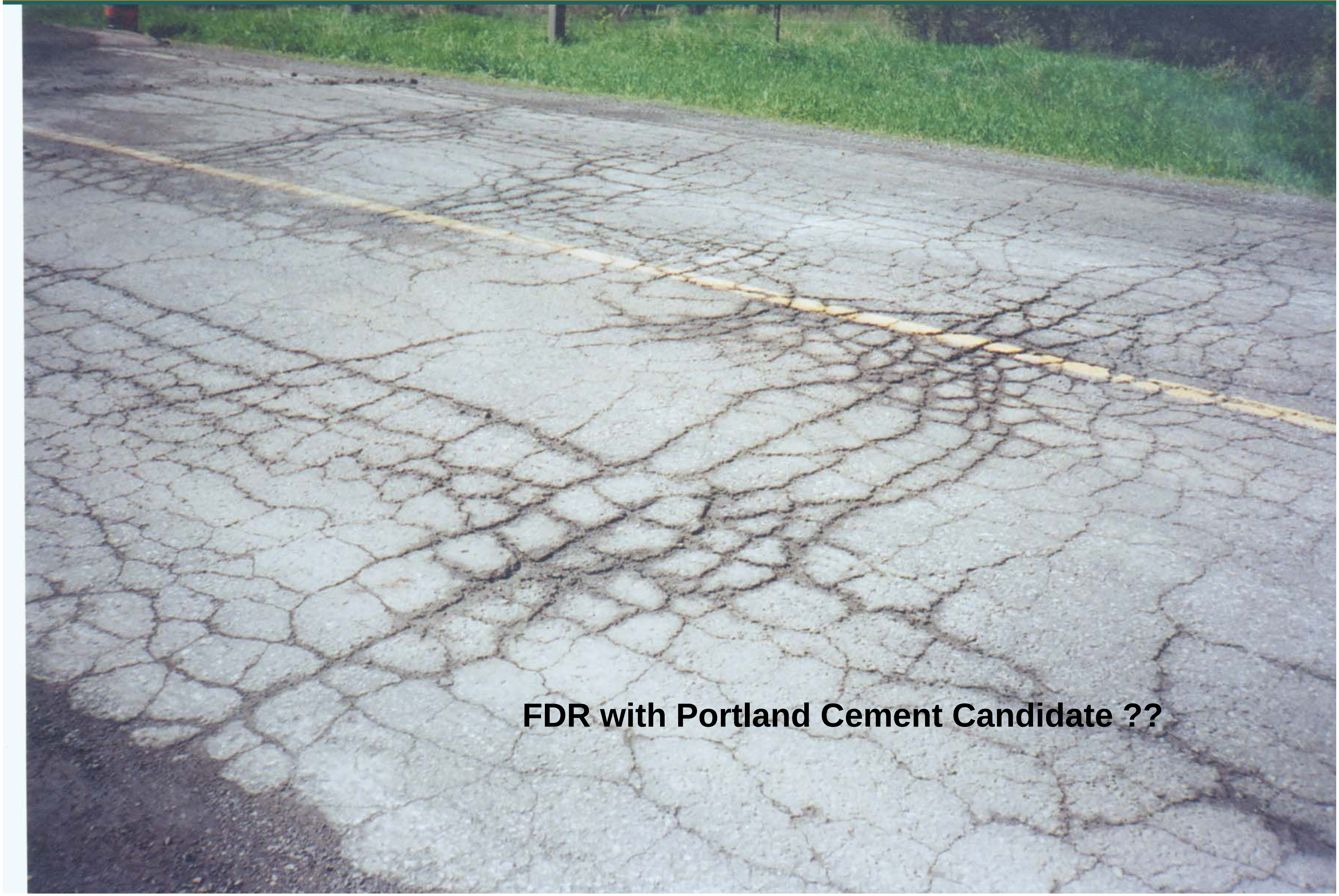
- One step process, no pre-pulverizing
- Less disruptive to traffic and adjacent properties
- Much lower amount of new Binder required, therefore less cost
- Mitigates reflective cracking
- Allows choice of binder – Expanded Asphalt or Emulsified Asphalt

Design Considerations

Full Depth Reclamation with Portland Cement

- Depth of Existing Asphalt
- Depth of Pre-Pulverizing
- Type and depth underlying granulars/sub base
- In-Situ moisture
- Amount of Cement Required
- Method to apply and evenly distribute cement

FDR Stabilization with Cement



FDR Reclamation with Cement

Application of Portland Cement

Stabilization with Cement

Mixing/Blending of Portland Cement

ADVANTAGES

Full Depth Reclamation with Portland Cement

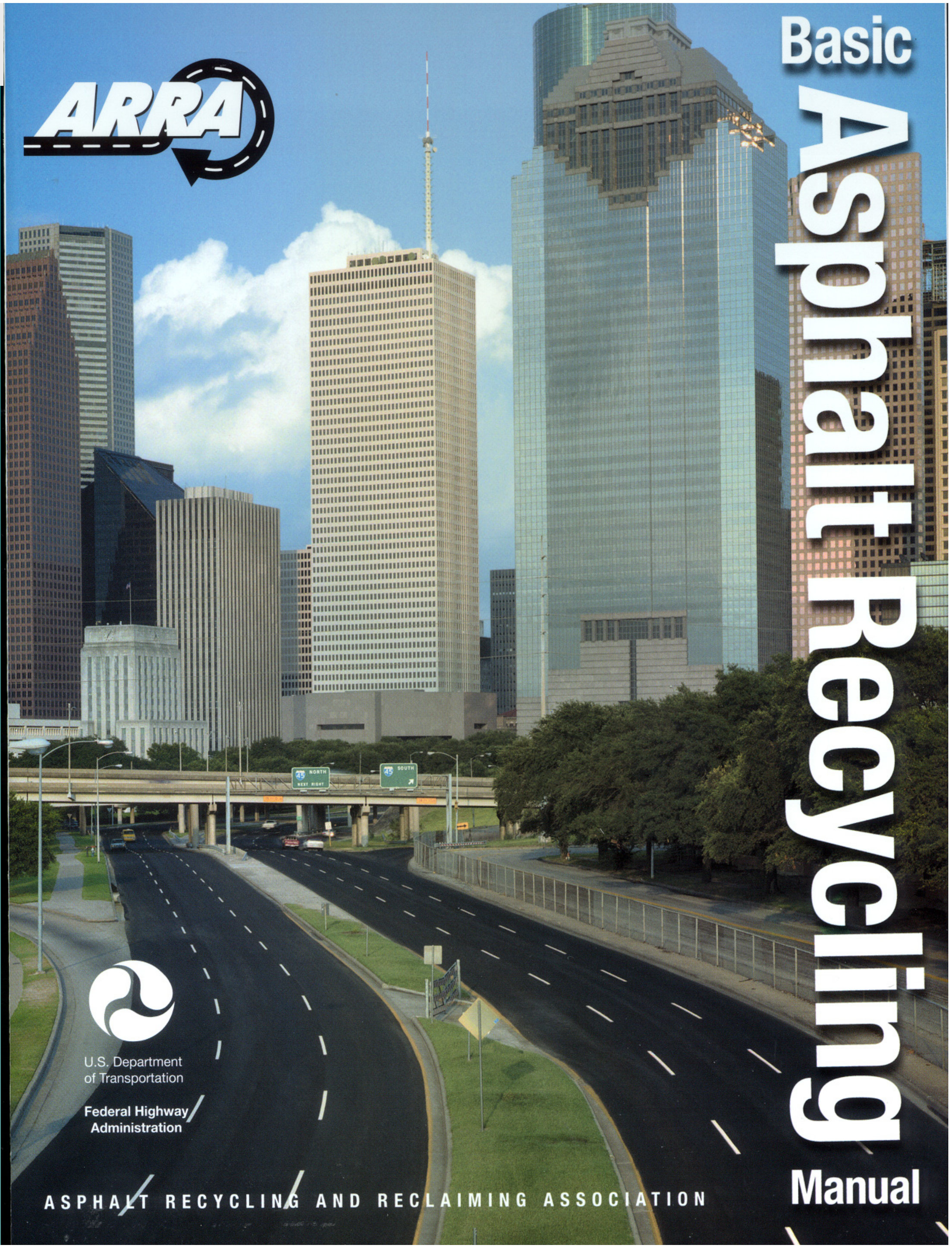
- Provides an increase in strength of the processed material
- Reduces permeability
- Provides rigid support for surface wearing course
- Long working season

Design Considerations

Basic Asphalt Recycling Manual or BARM

Produced by the Asphalt Recycling and Reclaiming Association (ARRA)

good resource



Stabilization with various Binders

Starting aggregate
- Milled Asphalt
-Crushed base
-Additives

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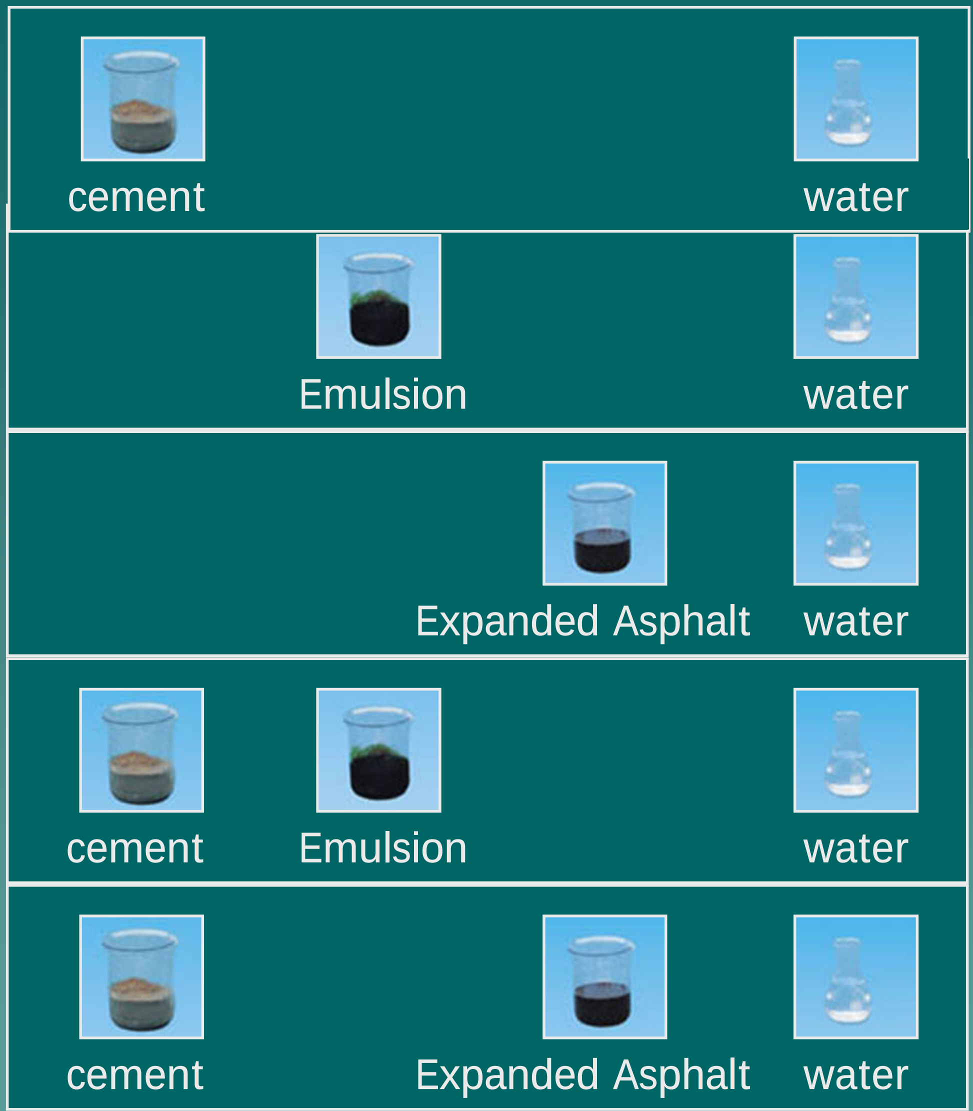

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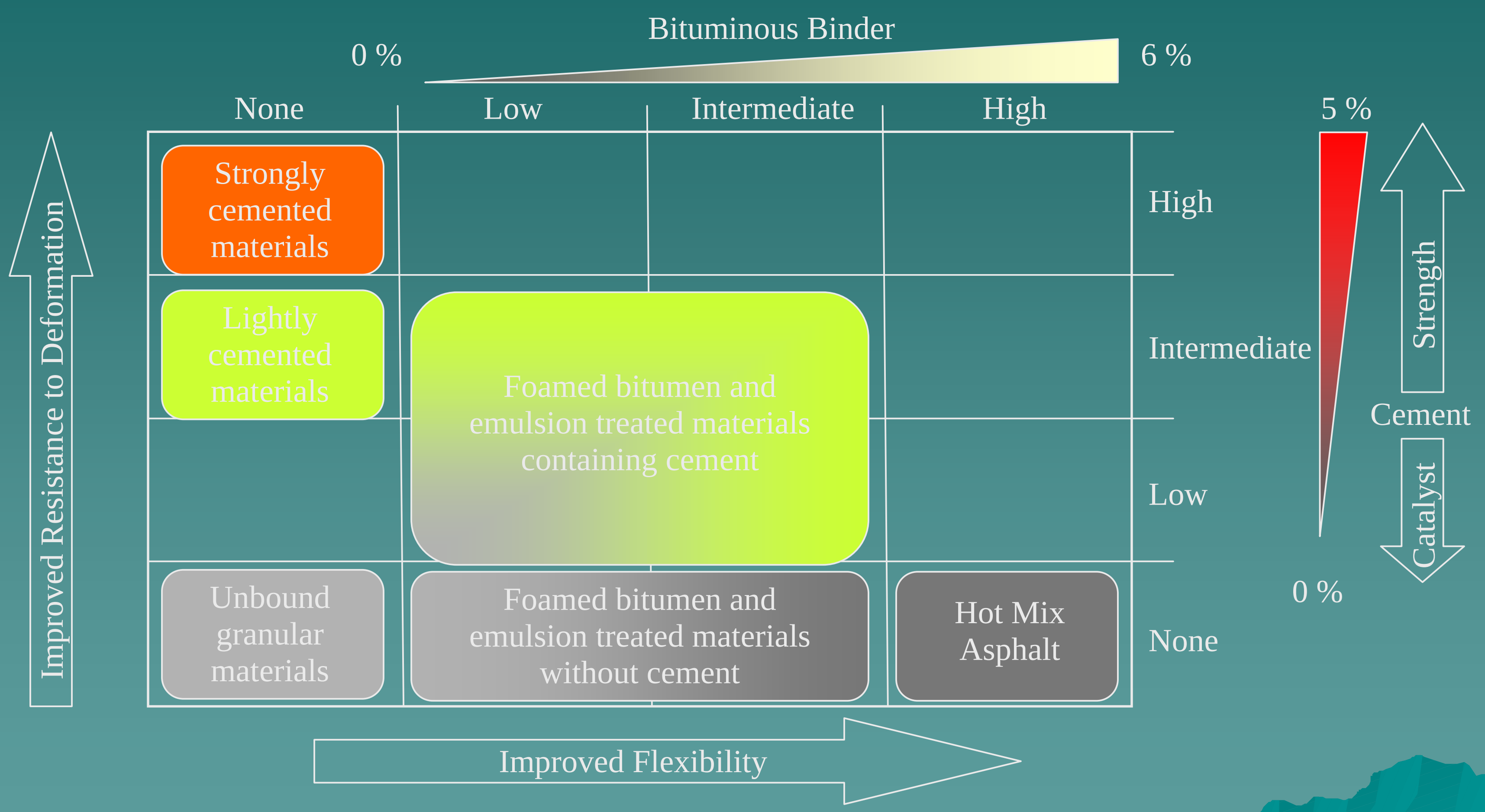
Stabilized base layer

Bituminous and/or cementitious Binders

Effect of Portland Cement



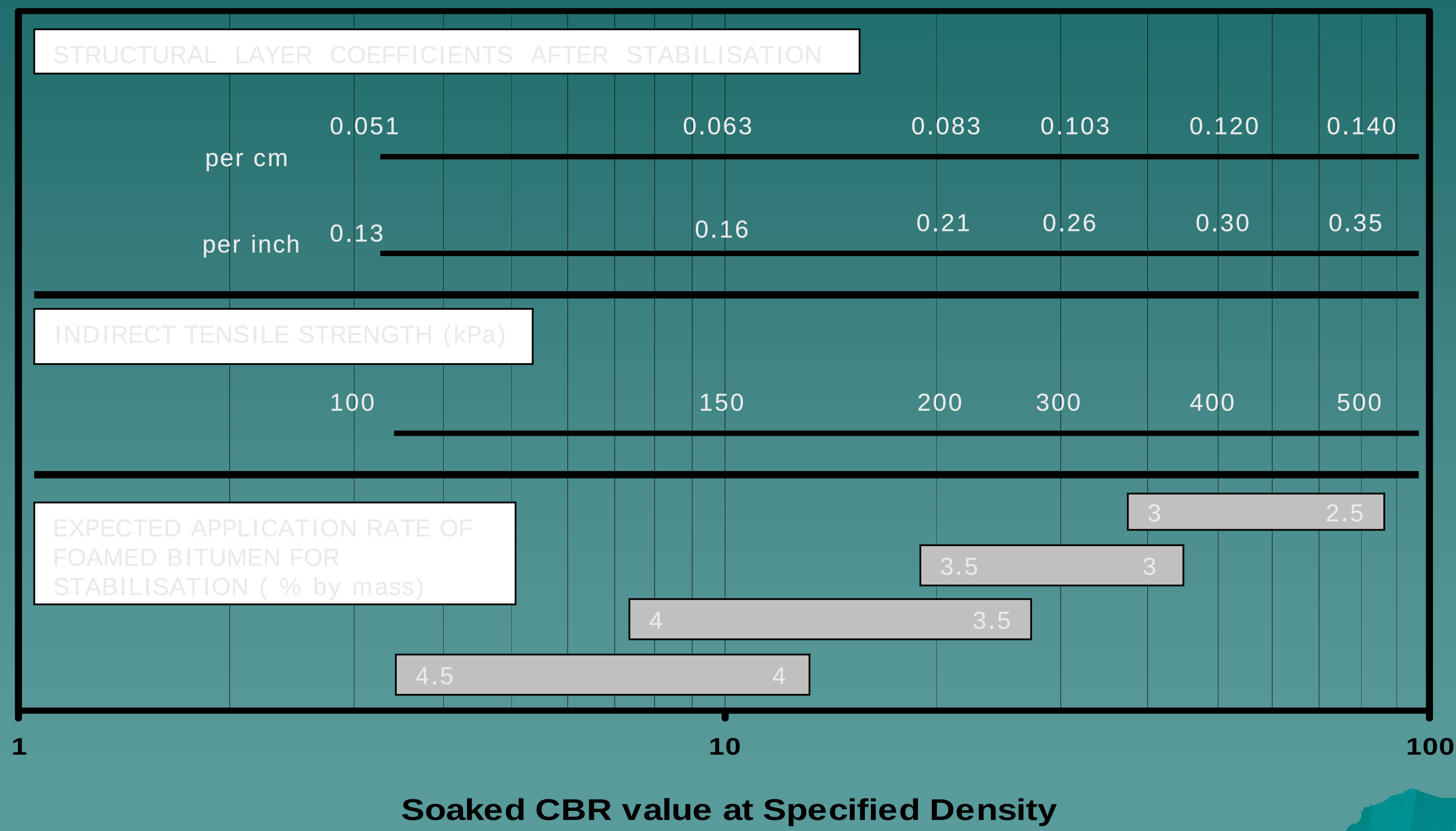
Source: Asphalt Academy TG2, Sept. 2002, South Africa

AASHTO Structural Values

Table A3.1 Typical structural layer coefficients (from AASHTO)

Material type	Characteristic	Structural layer coefficient (per inch) / (per cm)
Asphalt surfacing	Elastic modulus 2500 to >10000 MPa	0.20 to 0.44 / 0.08 to 0.17
Asphalt base	Continuous graded, 6 % voids	0.20 to 0.38 / 0.08 to 0.15
Stabilized Asphalt base	est. 10 – 14% voids	0.30 – 0.38 / 0.12 – 0.15
Bitumen treated base		0.10 to 0.30 / 0.04 to 0.12
Graded crushed stone	CBR > 80 %	0.14 / 0.055
Natural gravel, type 1	CBR 65 to 80 %	0.12 / 0.047
Natural gravel, type 2	CBR 40 to 65 %	0.10 / 0.040
Soil, type 1	CBR 15 to 40 %	0.08 / 0.032
Soil, type 2	CBR 7 to 15 %	0.06 / 0.024
Cohesionless sand	PI = 0	0.04 to 0.05 / 0.016 to 0.020
Cement-treated crushed stone	UCS 1.0 to 3.0 MPa	0.17 / 0.067
Cement-treated gravel	UCS < 1.0 MPa	0.12 / 0.047

Suggested Layer Coefficients



Source: Wirtgen Cold Recycling Manual, 2nd Edition, Nov. 2004

In-Place Recycling GBE Values

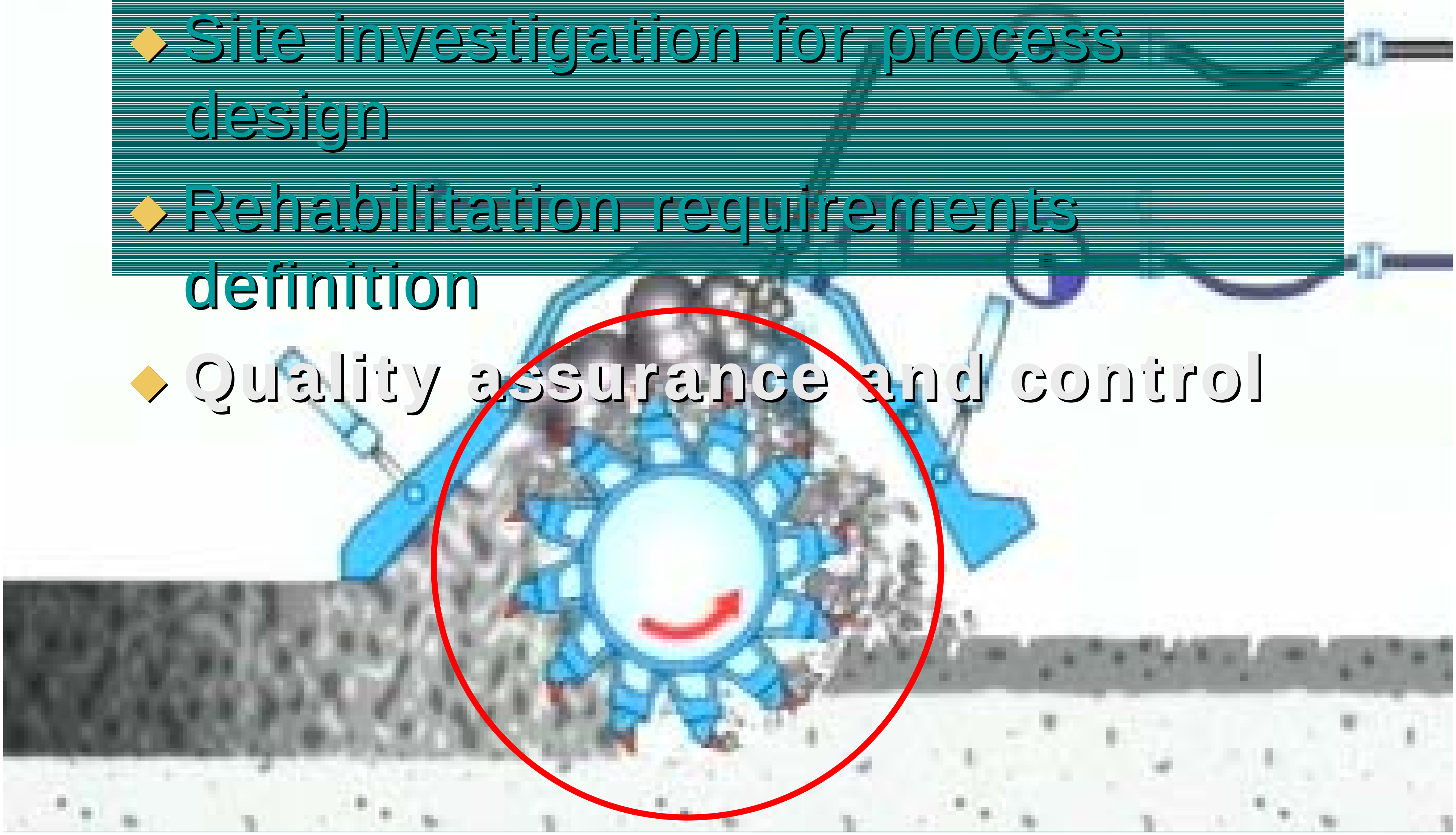
- *GBE - Granular Base Equivalency*
- *GBE is used by some agencies to evaluate and design pavement structures based on load requirements and the level of traffic (SN used for AASHTO method)*
- *GBE values*

	GBE	
Virgin Granular "A"	*1.00*	*0% AC*
Full Depth Expanded	*1.6 - 1.80*	*2.5 – 3 % AC*
Partial Depth Bituminous	*1.6 – 1.80*	*1.2 – 2.0 %AC*
Hot Mix	*2.00*	*4.8 - 5.2% AC*

In-Place Recycling allows a substantial reduction of liquid AC compared to hot mix, with significant strength increase

Critical elements for process

- Site investigation for process design
- Rehabilitation requirements definition
- Quality assurance and control



Required for any In-Place Recycling Project

- Pre-engineering and design
- Complete mix design for the recycled base material
- Field quality control, i.e. compaction, general appearance of the mix, smoothness
- Lab quality control, i.e. sample handling, physical mix properties
- Post construction review and acceptance

NSTIR Recycling Specifications

1. Full Depth Reclamation with Expanded Asphalt Stabilization (Method Specification)
2. Partial Depth Reclamation with Expanded Asphalt Stabilization (Method Specification)
3. Partial Depth Reclamation with Expanded Asphalt Stabilization (Method Specification)
4. Full Depth Reclamation with Portland Cement

HRM similar except FDR with Cement

Full Depth Reclamation with Expanded Asphalt Stabilization Gradation

NSTIR and HRM

Sieve Designation	Percentage Passing by Mass
40.0 mm	98 – 100 %
25.0 mm	95 – 100 %
5.00 mm	35 – 65 %
630 um	15 – 40 %
80 um	7 – 15 %

Full Depth and Partial Depth Bituminous Reclamation – Compaction and Thickness

- Compaction to minimum 83.0% of the maximum theoretical density of the mix and no individual result below 79.0%.

	Requirements
Compaction Method	Nuclear Gauge
Field Moisture	Yes, as per ASTM D 2216
Mat Thickness	At least 90% minus 20 mm, No location > minus 30 mm

Environmental Benefits to Recycling Moving Towards a Sustainable Future

- Reduced energy costs due to the in-place process
- Reuses existing pavement and granular materials
- Minimizes material transfer and the related trucking
- Reduces the need for non-renewable resources, aggregates and liquid asphalt cement
- Significant reduction in the related green house gases due to cold process and reduced trucking
- An Environmental Life Cycle Model is available, PaLATE Model that can determine the reduction in Green House Gases and other models being developed
- Meets the principles of the Federal – Nova Scotia Gas Tax Agreement, In-Place Recycling fitting the definition of a "Environmentally Sustainable Municipal Infrastructure Projects

Defining Sustainable Transportation

"Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewal resources, limits consumption of renewable resources to sustainable yield levels, reuses and recycles its components, and minimizes the use of land and the production of noise."

Source: Centre for Sustainable Transportation, University of Winnipeg

Thank you.

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Questions?

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NSUPA

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