Base Stabilization Guidance and Additive Selection for Pavement Design

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Who is the LRRB?

LRRB

LOCAL
ROAD RESEARCH
BOARD

Serves local agencies to:

- Research local agency specific issues
- Develop new initiatives
- Apply new knowledge
- Implement new technologies

...MAKING A DIFFERENCE

What was the Issue?

Issue: High level education on the selection of base stabilization additives

Intended Audience: City and County Engineers

What was the solution?

Guidebook that addresses:

- Base Stabilization
- Base Modification
- In Place Pavement Recycling Methods
- Stabilization Additives
- Stabilization Additive Selection
- Steps to Successfully Stabilize a Road
- Stabilization Troubleshooting
- Laboratory Mix Design
- Proprietary Products
- Research on Why Stabilization Works

In-place Recycling: Most Common Bituminous Recycling Options

Cold In-Place Recycling

Full Depth Reclamation

Base Stabilization Types

Chemical Stabilization:

Incorporation of stabilizers that either react chemically with the material being stabilized (e.g., lime reacts with clays) or react on their own to form cementing compounds (e.g., cement)

- Cement: Portland or hydrated
- Lime: hydrated or quick lime
- Fly-ash: by-product of coal combustion and can be in the form of self-cementing Class C or Class F (when used in combination with other additives)
- Cement Kiln Dust (CKD): by-product of cement production
- Lime Kiln Dust (LKD): by-product of lime production

Base Stabilization Types

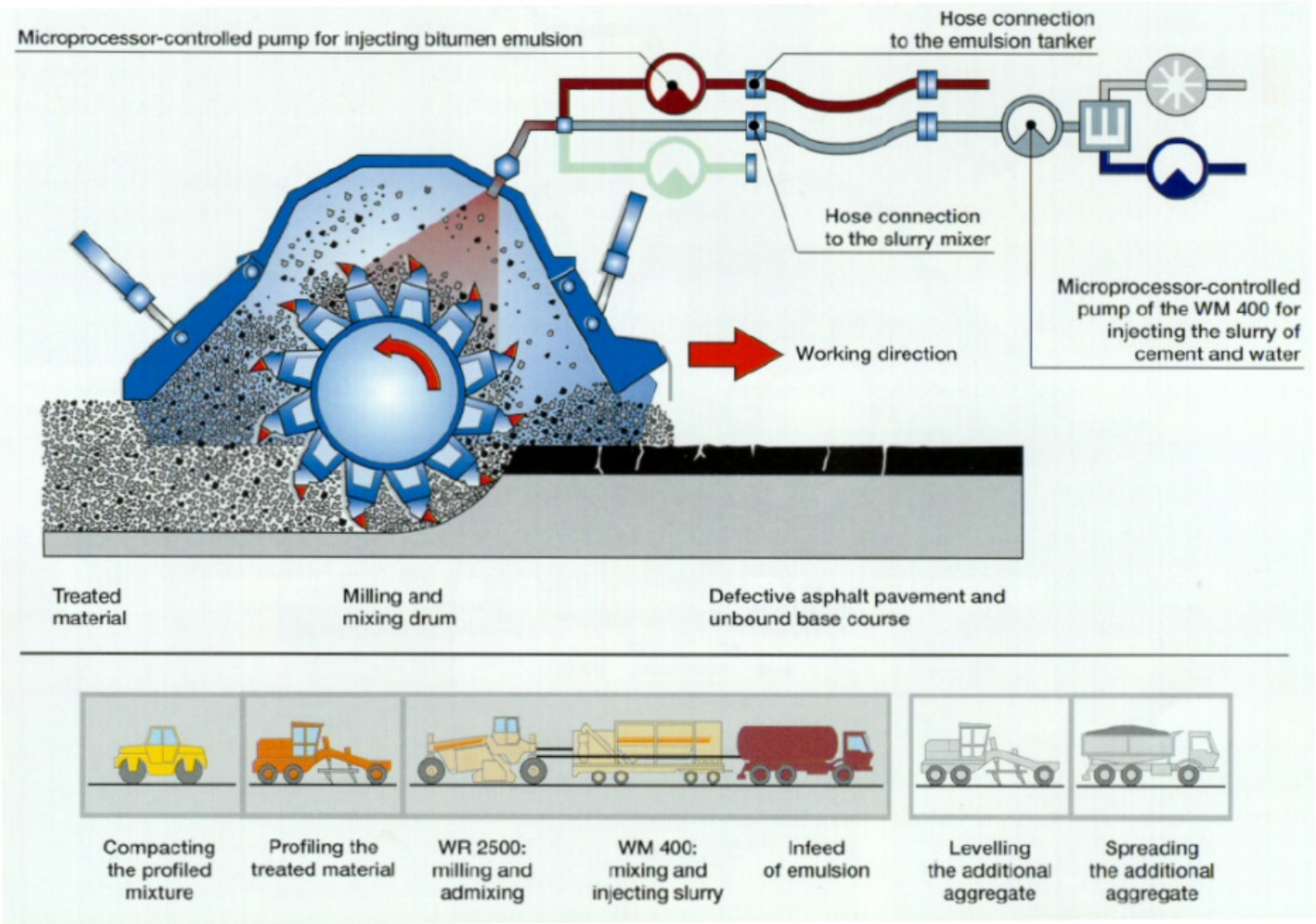
Bituminous Stabilization:

Incorporation of a bituminous material that alters the surface chemistry of the aggregate particles

- **Asphalt emulsion** which is an emulsion of asphalt binder, water, and emulsifier.
- **Foamed asphalt** is a mixture of compressed air and a small amount of cold water that's injected into hot asphalt binder (140C to 170C).

Foamed asphalt adheres to fine particles (mainly passing No. 200 sieve) creating an asphalt bound filler that acts as mortar binding the coarse aggregates together.

SFDR Process



SFDR Can Address…

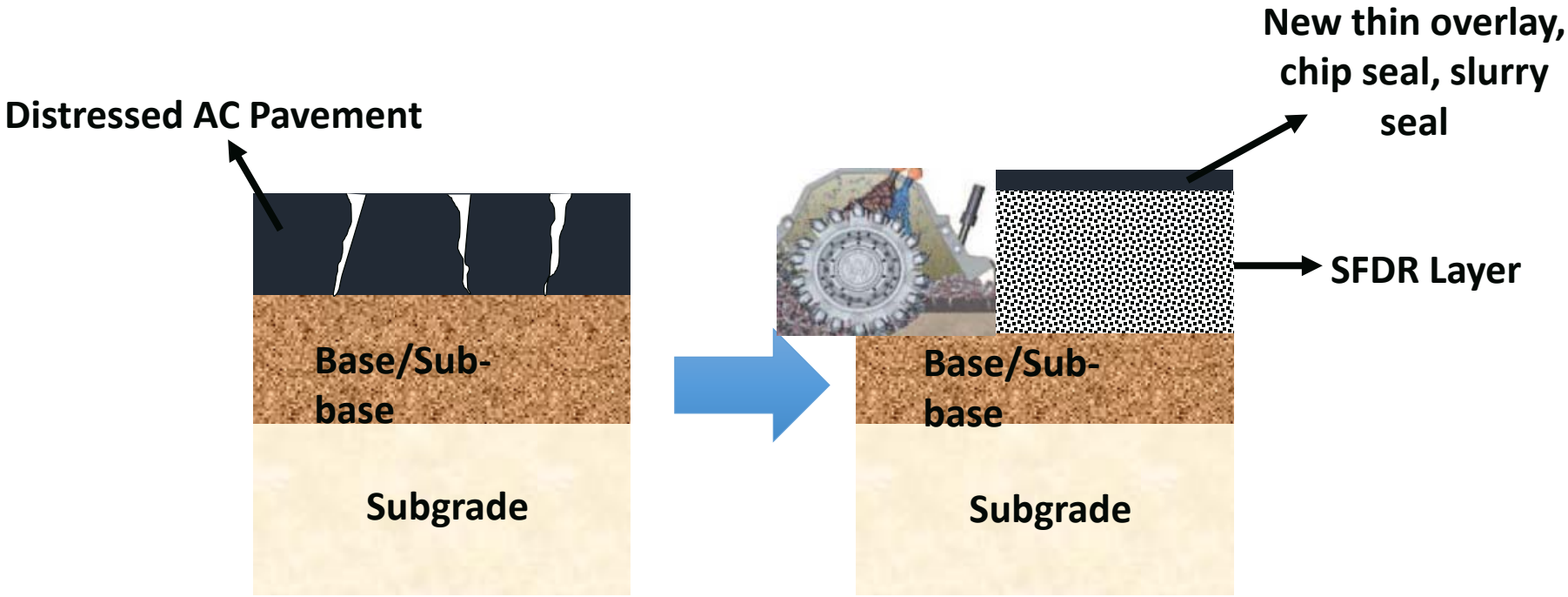
- All forms of cracking including fatigue, edge, slippage, block, longitudinal, and reflective
- Reduced ride quality due to swells, bumps, sags, patches, and depressions
- Permanent deformations including, rutting, corrugations, and shoving
- Loss of bond between pavement layers
- Moisture damage (stripping)
- Loss of surface integrity due to raveling, potholes, and bleeding
- Inadequate structural capacity
- Subgrade instability by increasing structural capacity of the base and surfacing layers

Base Stabilization Can Improve…

- Shear strength
- Modulus (stiffness)
- Resistance to moisture
- Stability
- Durability
- Resistance to fatigue
- Resistance to rutting
- Grade change restrictions

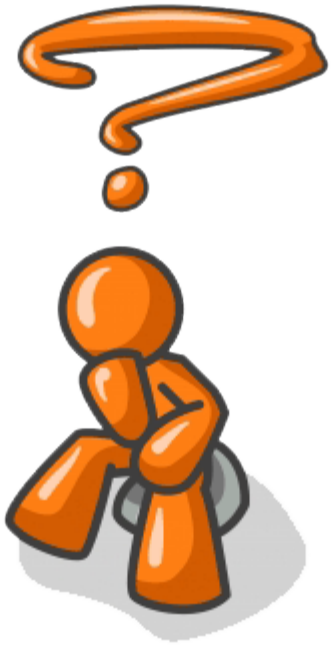
Stabilized Full Depth Reclamation

- A Full Depth Reclamation through pulverization of a bound surfacing layer, blending the pulverized/ reclaimed material with underlying aggregates and a stabilization additive to produce a homogeneous base material



Base Stabilization

- Many products exist to stabilize base materials for roadway construction, but it is not always clear which product is the right one to use! ????



Stabilization/Modification Options

- Cutbacks/Roadmix
- Proprietary Products – (206 +)
- Engineered Emulsion
- Lime/chlorides
- Foamed Asphalt
- Flyash/Cement
- Combinations of above

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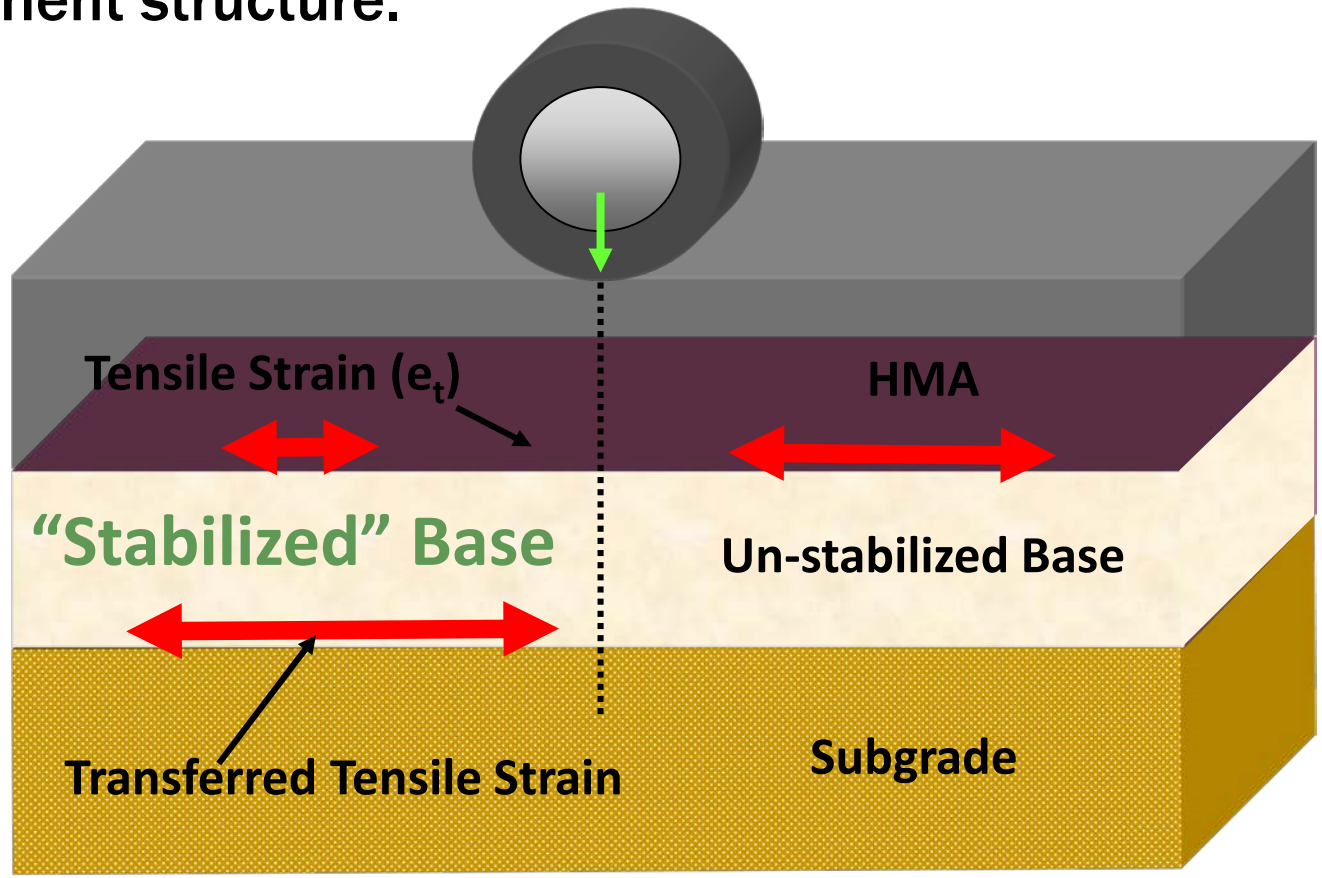
More on Base Stabilization…

- Base Stabilization refers to permanent improvements made to a base aggregate layer resulting in a bound structural pavement layer with measurable elastic and strength characteristics.

- A **laboratory mix design** is required to optimize the type and quantity of additive to be incorporated

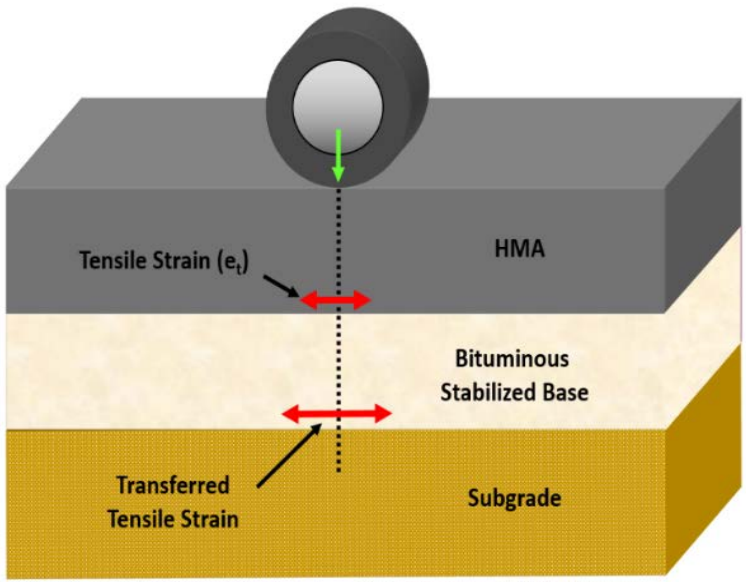
Why Stabilization Works?

- Transfers maximum horizontal tensile strains from the bottom of the hot mix asphalt (HMA) layer deeper into the pavement structure.

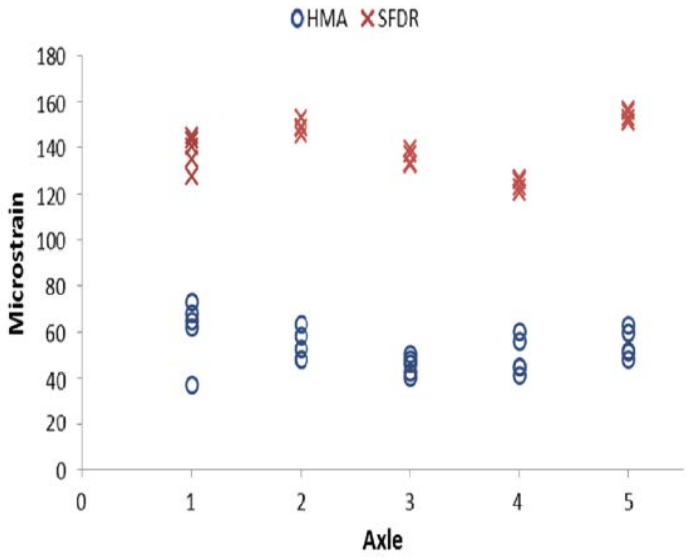


Key to improved performance

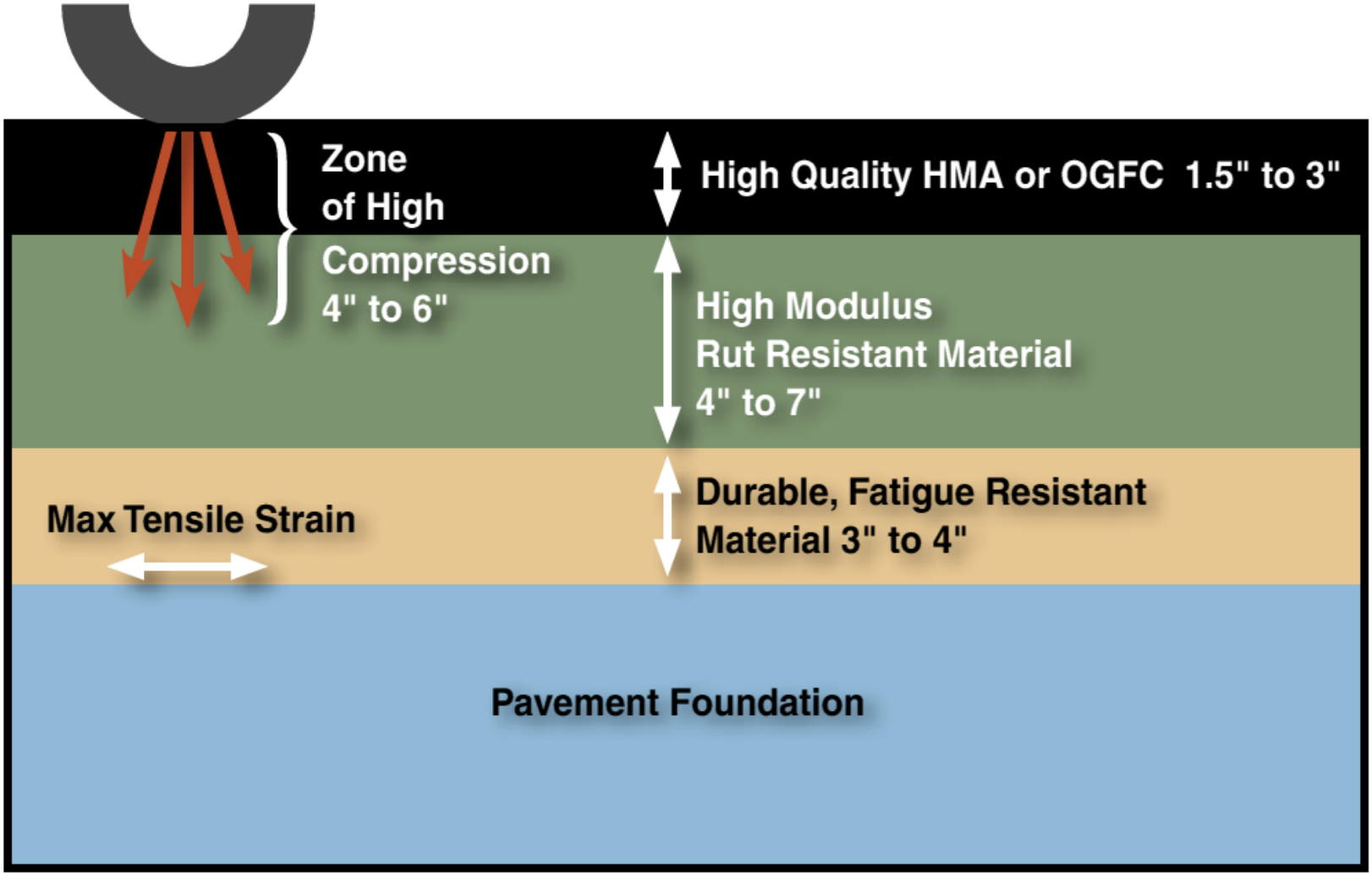
- Max Tensile Strain



- 50% less on HMA



Perpetual Pavement Three Layer System

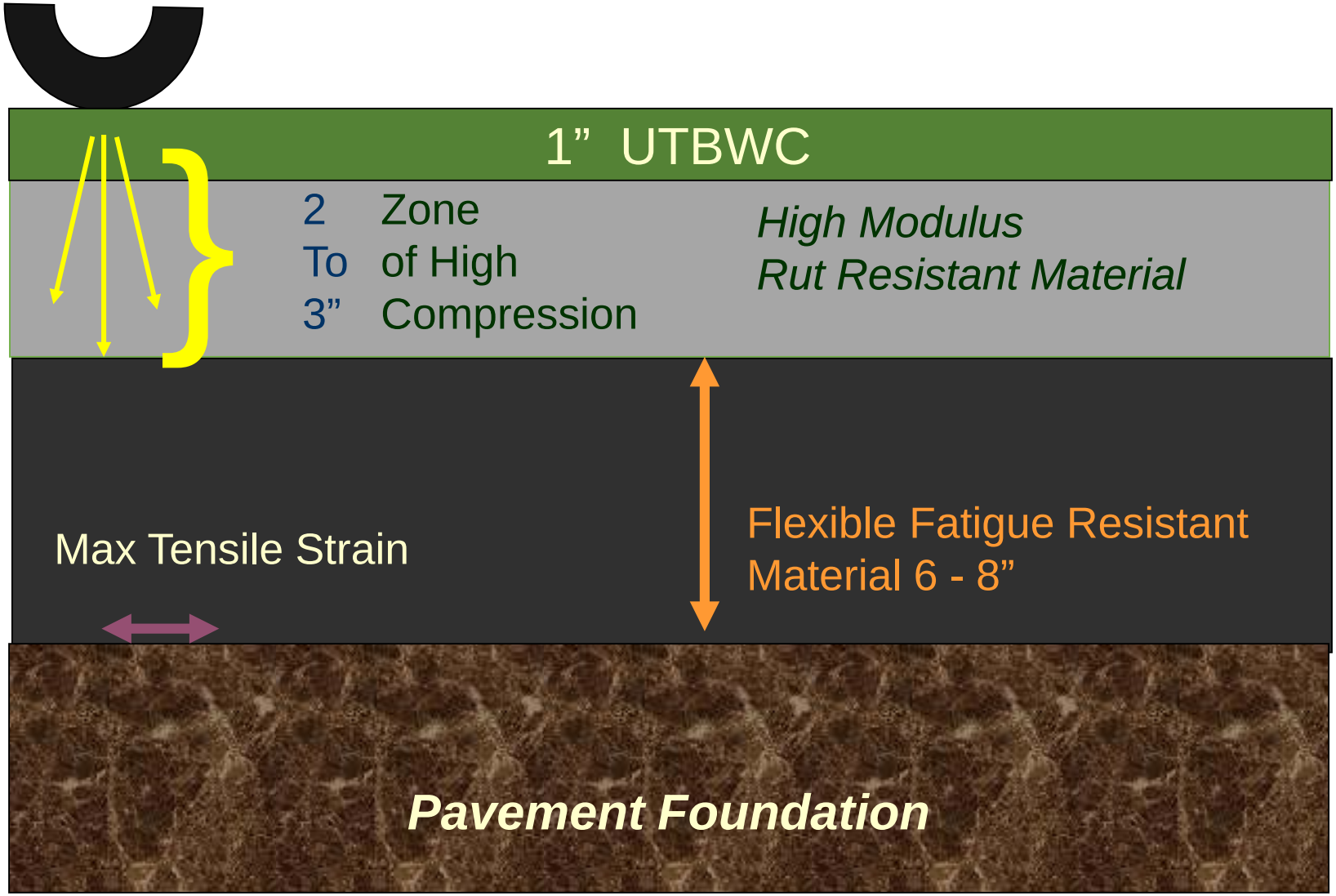


Newcomb et al, 2000

MnRoad I-94 Albertville

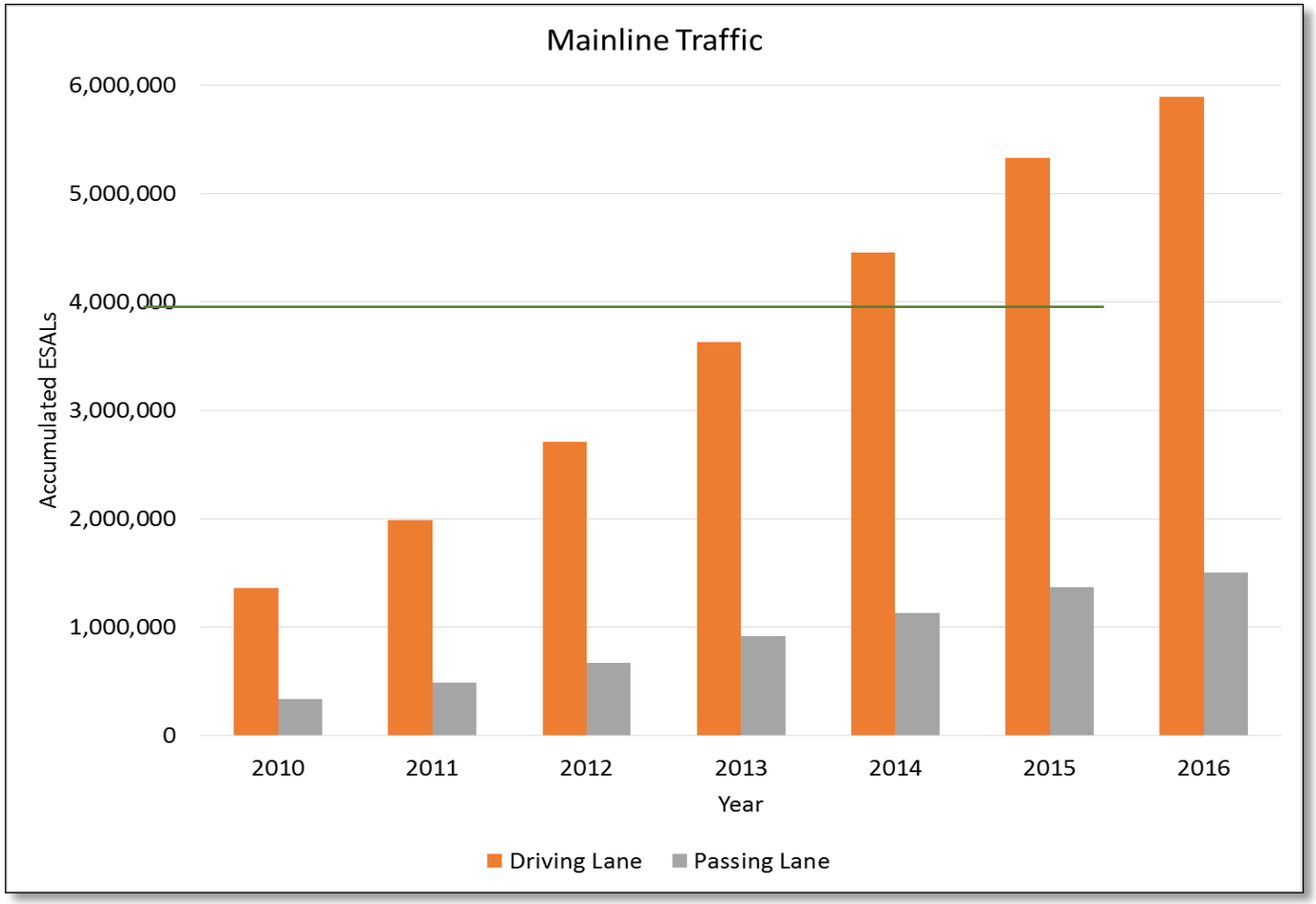
- Cell 2
  - 50% RAP
- Cell 3
  - 75% RAP
- Cell 4
  - 100% RAP

MnRoad Cells 2-4



MnRoad Cells 2-4
Design Life: 3.5 M ESAL (SEM Materials)

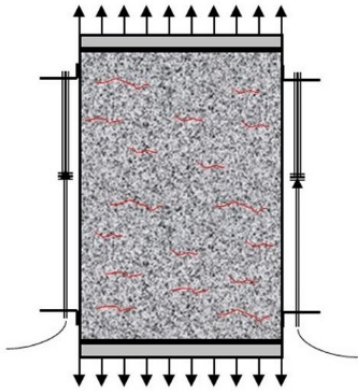
Estimated traffic (I-94): Feb.09 – fall 16: ~ 6.0 M ESAL



MnRoad Cells 2,3,4

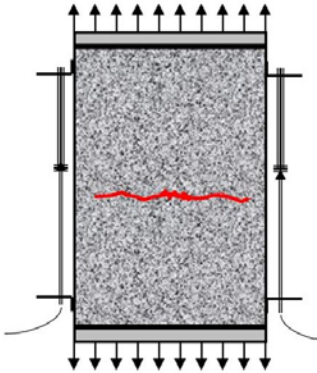
Fatigue Cracking Origins: Material Factors

- Initiation
  - Microscopic defects and incompatibilities amplify applied stress and microcracks form



Fatigue Cracking Origins: Material Factors

- Initiation
  - Microscopic defects and incompatibilities amplify applied stress and microcracks form
- Coalescence
  - Microcracks grow and coalesce into macrocracks
- Propagation
  - Macrocracks move through the asphalt concrete ultimately showing up as visible flaws on pavement surface



UNIVERSITY OF ARKANSAS

AAPT Association of Asphalt Paving Technologists

ARIZONA STATE UNIVERSITY

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  Incorporation of stabilizers that either react chemically with the material being stabilized (e.g., lime reacts with clays) or react on their own to form cementing compounds (e.g., cement)

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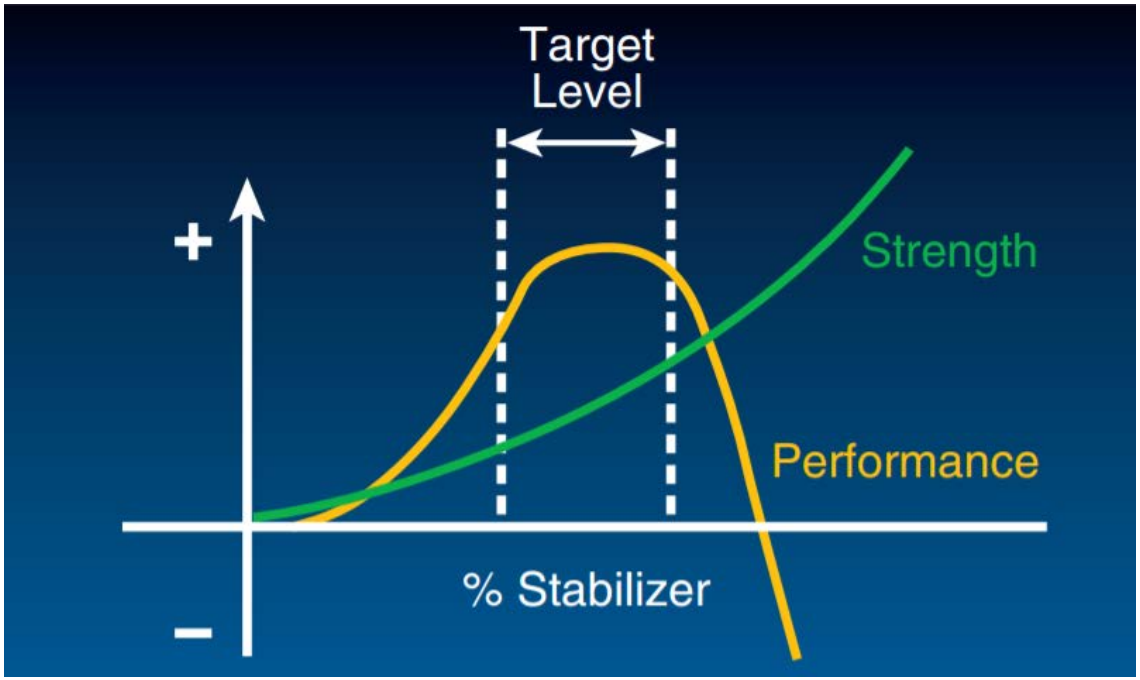
More on Base Stabilization

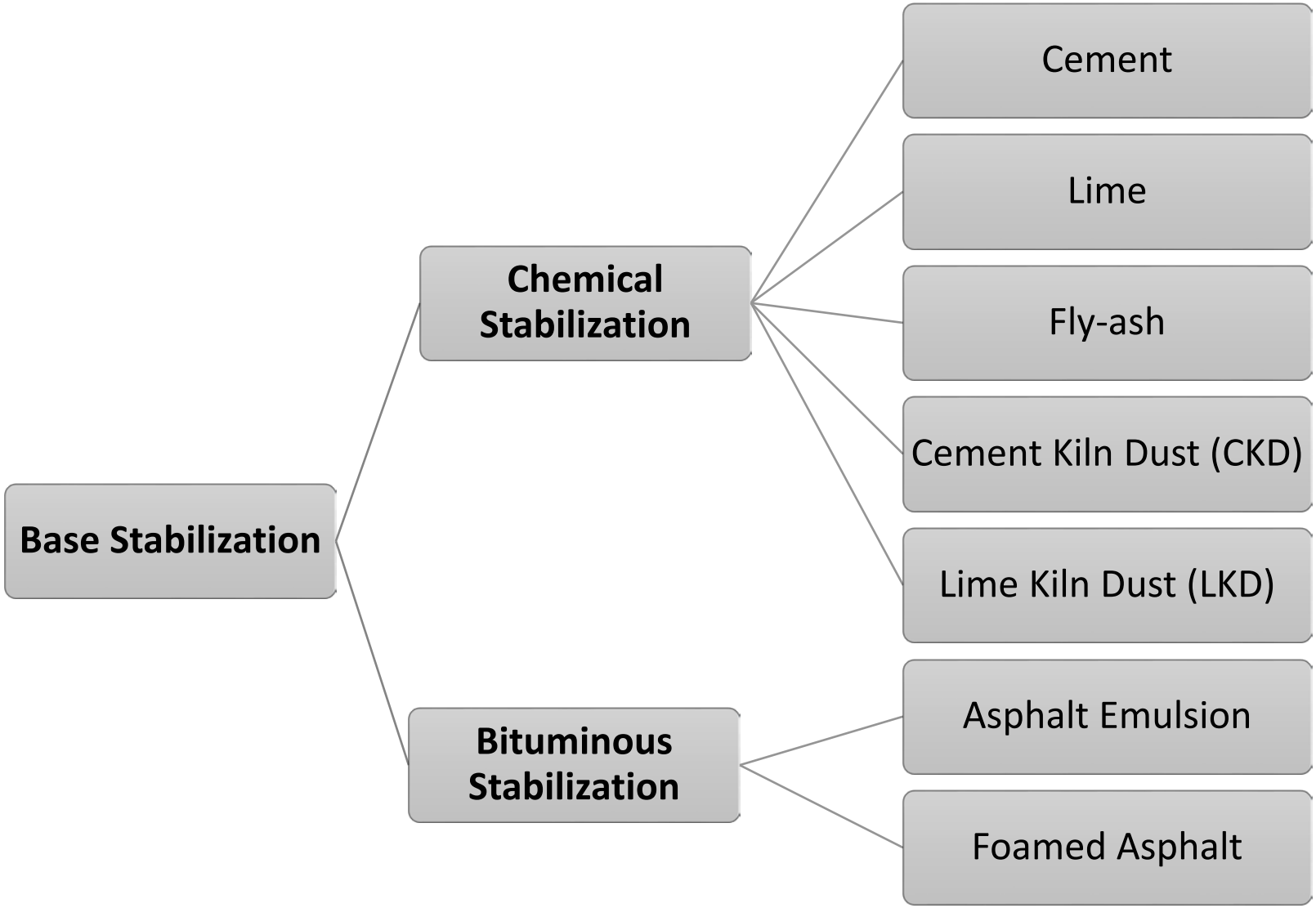
- Strength gain should be in a range that provides increased strength and stability without creating a rigid brittle blend that can induce cracking of the overlying pavement surface.



Base Modification

- **Base Modification** refers to the incorporation of additives to base materials that provide **short term improvements** intended to facilitate construction as a **compaction aid**.
- The base layer is thought to remain essentially unbound.
- Modifiers including proprietary products, do not have design procedures and laboratory and field verification testing.

Base Stabilization Additives



Additive Selection

Reclaimed Material Type	Well-Graded Gravel	Poorly Graded Gravel	Silty Gravel	Clayey Gravel	Well-Graded Sand	Poorly Graded Sand	Silty Sand	Clayey Sand
USCS[1] Classification	GW	GP	GM	GC	SW	SP	SM	SC
AASHTO[2] Classification	A-1-a	A-1-a	A-1-b	A-1-b A-2-6	A-1-b	A-3 A-1-b	A-2-4 A-2-5	A-2-6 A-2-7
Asphalt Emulsion SE[3]>30 or PI[4]<6 P200[5]<20%								
Foamed Asphalt PI<10 5%<P200<20%								
Cement, CKD, and Fly-ash PI<20								
Lime, LKD PI>20 P200<25%								

Not recommended Recommended Highly recommended

Additive Selection

Well-Graded Gravel/Poorly Graded Gravel	• Emuslion
Silty Gravel/Clayey Gravel	• Foamed Asphalt • Cement/CKD/Fly-ash
Well-Graded Sand/Poorly Graded Sand/Silty Sand	• Cement/CKD/Fly-ash
Clayey Sand	• Lime/LKD • Cement/CKD/Fly-ash

Full Depth Reclamation (SFDR) Keys to Success – Strength & Flex

Stabilization Considerations

Cutbacks or Road Mix

Proprietary Products

Engineered Emulsion

Foam Asphalt or Lime

Fly Ash or Cement

Prone to Rutting — **Prone to Cracking**

Flexible ⟷ **Stiff**

Granular ⟷ **Organic Clay**

Bituminous Stabilization Highlights

- In foamed asphalt, binder goes through a short-term aging which could adversely affect the mixture fatigue performance.
- With foamed asphalt some fine particles are needed, generally about 5 to 20 percent passing 200 sieve.
- Asphalt emulsion does not require heat during the stabilization process and therefore is not expected to age the asphalt.
- Asphalt emulsion is a safer product than foamed asphalt since no heat is needed.

Chemical Stabilization Highlights

- Incorporation of an excessive amount of additive increases rigidity of the base layer with the potential to induce cracking.
- Cement, Cement Kiln Dust (CKD), and fly-ash typically are limited to aggregate materials where the plasticity index is less than 20.
- Lime and/or Lime Kiln Dust (LKD) are more often recommended for aggregate materials with a plasticity index of about 20 or greater.
- Some variability in by-product stabilization additives (fly-ash, Cement Kiln Dust (CKD), and Lime Kiln Dust (LKD)) should be expected.

CCPR Test Sections at MnRoad

Questions?

LRRB