Performance Evaluation of Asphalt Pavements with Full-depth Reclaimed Base

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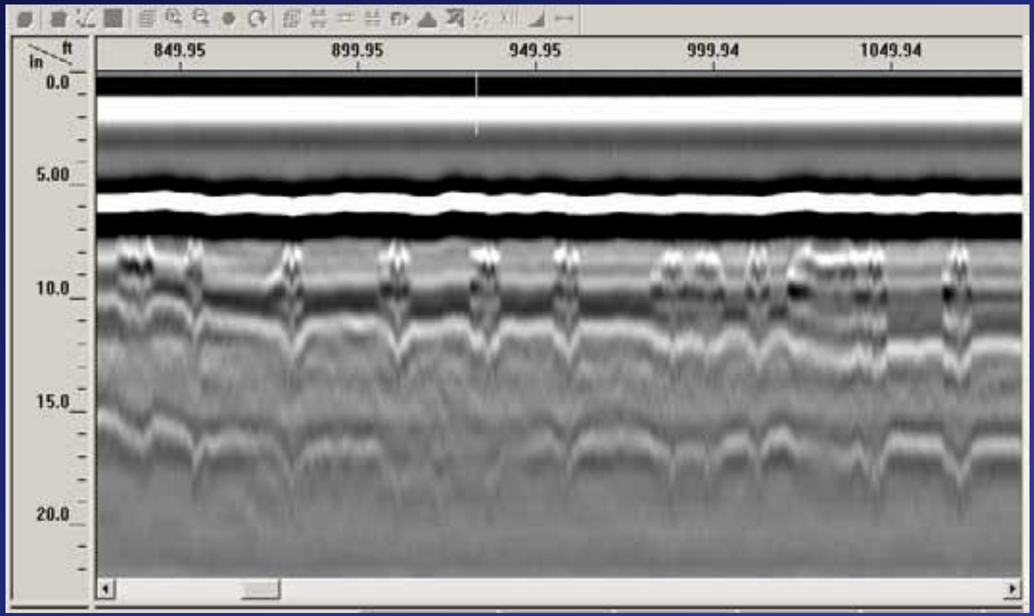
Background

- **Full depth reclamation (FDR)**
  - A widely used method for pavement rehabilitation
  - Pulverize the entire pavement surface layer and blends it with a portion of granular base/ sub-base material (typically 50-50).



- Eliminate all distress areas.
- Eliminate potential for reflective cracking.

- **Stabilized FDR (SFDR)**
  - Counties have started to use
  - Add stabilizer to FDR
    - Engineered emulsion, base I and fly ash.
  - Increase stiffness of base --- reduce HMA overlay thickness.
    - Significant cost saving

Research Project

Objective

Evaluate performance of stabilized full-depth reclamation materials used for pavement base layer.

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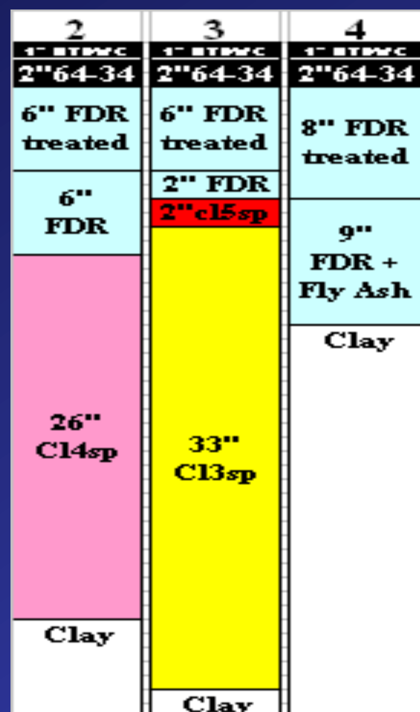
Selected Projects

- MnROAD three test sections
  - Cooperative research project between Road Science LLC. and Mn/DOT
  - I-94 (Feb. 09)



Several county project

County	Road	Project Limits	Stabilizer	Stabilizer Content	Construct ed	Thickness (inches)	Stabilized Depth	Stabilized Aggregate	Subgrade Soil
LeSueur	CSAH 2	CSAH 11 to S. Jct. CSAH 5	Class C fly ash	6%	2008	6"	12"	0.0"	Plastic
LeSueur	CSAH 13	CSAH 13 to 0.5 mile S. of CSAH 12	Emulsion and Class C fly ash	3.5% Emulsion, 2% fly ash	2008	6"	7"	1-3"	Plastic
Pope	CSAH 28	CR 79 to TH 55	T15 Base One	.004 gal./yd2/in	2007	3.5"	4"	4"	Class 4 (sand-gravel)
Pope	CSAH 29	TH 104 to TH 55	none.	n/a	2004	3.5"	n/a	8"	(sand-gravel)
Goodhue	CSAH 30	TH 56 to CSAH 1	Fortress	4.50%	2008	stabilized 2.5" and 1.5" HMA on	6" w. Fortress, 6" unstabilized	8"	n/a
Olmsted	CSAH 13	W. County Line to CSAH 3	Fortress	3.85%	2005	4"	6"	5.75"	n/a

- **Empirical Equation to estimate GE:**

$$R = (0.41+0.873*Mr)^{1.28}$$

$$\text{Log}(BB_{80}) = 2.65 – 0.016GE - .56\text{Log}(R)$$

- **Mn/DOT uses granular equivalence (GE)**
  - Granular material (Class5): GE=1

- **Some preliminary results**
  - Olmsted CSAH 13
    - 4"HMA, 6" SFDR (7.75"HMA+ 2.5"Agg +3.85%Em)

      Effective GE = 24; GE (SFDR) = 1.9
  - Pope CSAH 29 and CSAH 28
    - CSAH 29: 3.5" HMA; 8" FDR (50-50)
    - CSAH 28: 3.5" HMA; 4" SFDR (Base One); 4"FDR

      CSAH 29: Eff. GE=17; GE (FDR) = 1.6

      CSAH 28: Eff. GE=18; GE(SFDR) = 1.9

- **LeSueur CSAH 2 and CSAH 13**
  - CSAH 2: 6" HMA over 12" SFDR (6% Fly ash) over subgrade.
  - CSAH 13: 6" HMA over 7" SFDR (3.5% emulsion & 2% fly ash) over 3" non-stabilized agg. base.

    GE of CSAH2 SFDR is about 1.8

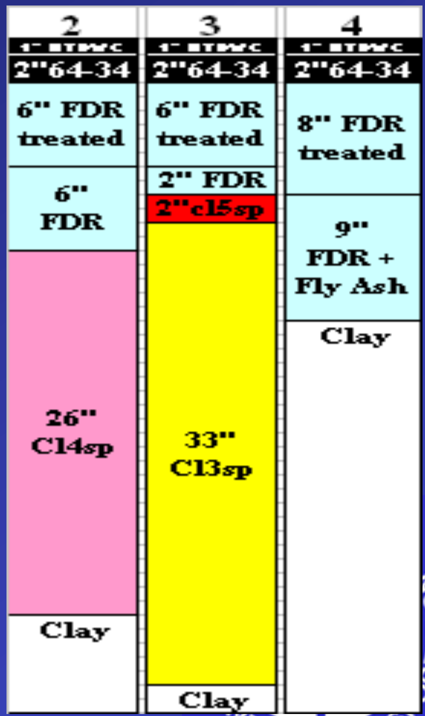
    GE of CSAH 13 SFDR is about 2.1 ??

- **MnROAD (Cell 2,3 and 4)**

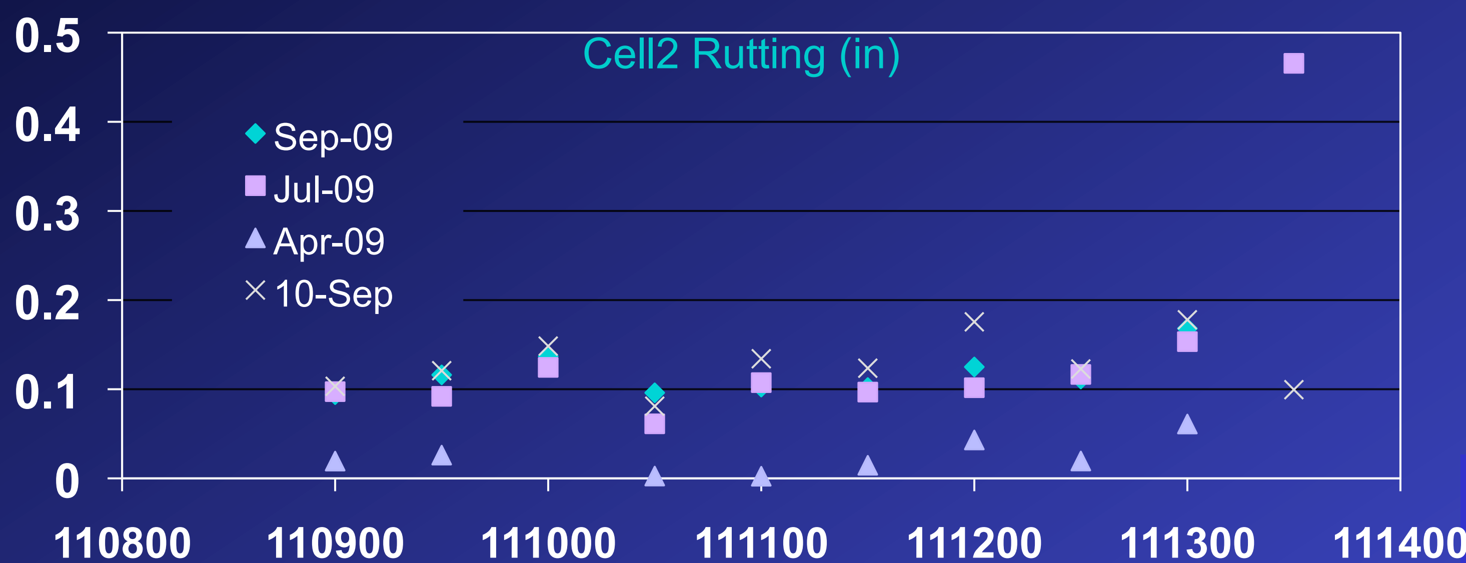
  Cell2: FDR – 50-50 (4.25%Em); GE = 1.5

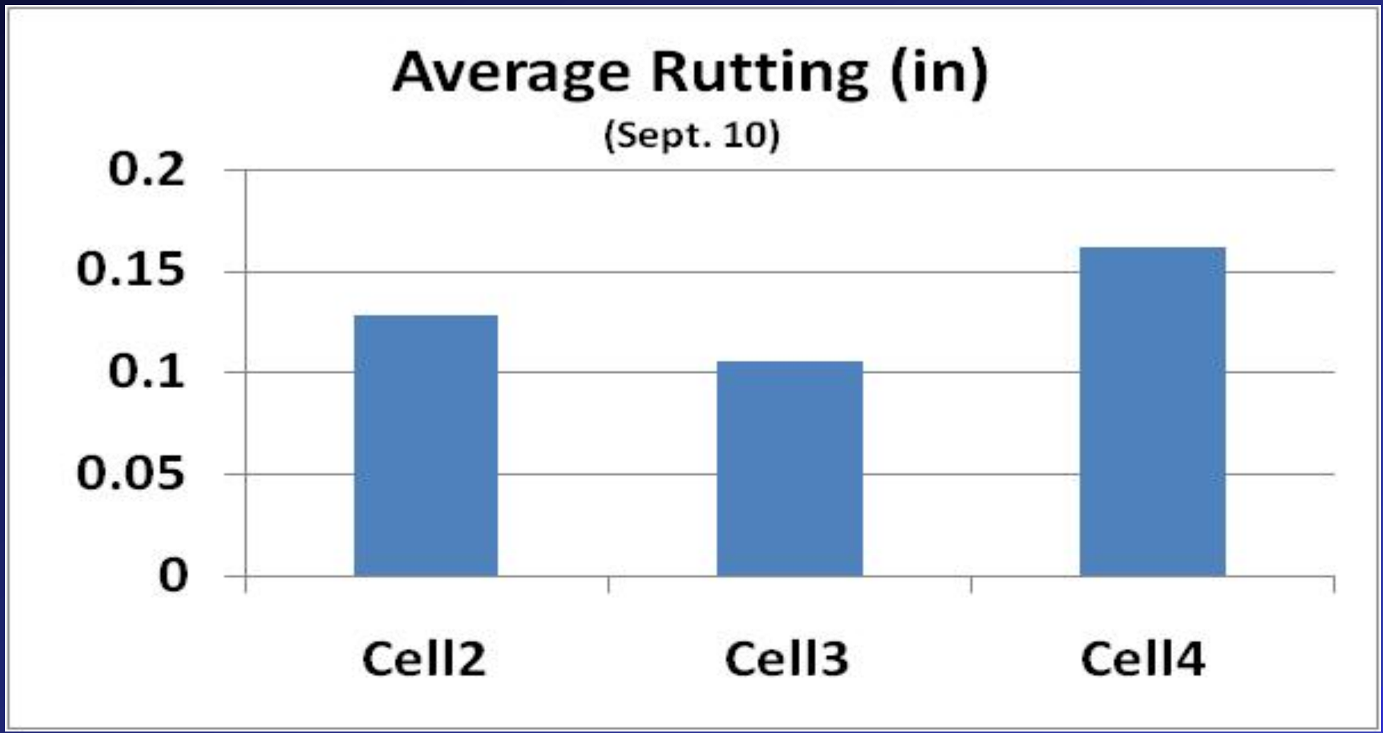
  Cell3: FDR – 75-25 (3.5%EM); GE = 1.8

  Cell4: FDR – 100RAP (3.25%EM); GE=1.4



- Interstate traffic (I-94): 1.2 M ESAL
  - Feb.09 – Jan. 11
- No cracks
- Normal consolidation





Average Rutting (in)
(Sept. 10)
0.2
0.15
0.1
0.05
0
Cell2
Cell3
Cell4

MnROAD Test Section (Cell 2, 3, 4)

- **TERRA Cooperative Research Project**
  - Road Science LLC and Mn/DOT

*** Study how the emulsion-stabilized FDR in the different sections affects pavement performance in an accelerated loading scenario (interstate)**

- **Demonstrate viable rehabilitation options for flexible pavements**
- **Demonstrate how stabilization is optimized based on quantity of RAP and depth**

Mix Design

- Increase the probability of a successful project
- Additive type determination and check compatibility
- Determine additive quantities and other requirements such as water
- Is add-rock or a secondary material required?
- Provide QC targets
- Sampling is very important

Mix Design

- Mixing with multiple contents – Engineered Emulsion
- High shear mixer for thorough mixing
- Superpave Gyratory Compaction – 30 gyrations
- Curing to simulate short-term or long-term strength
- Testing

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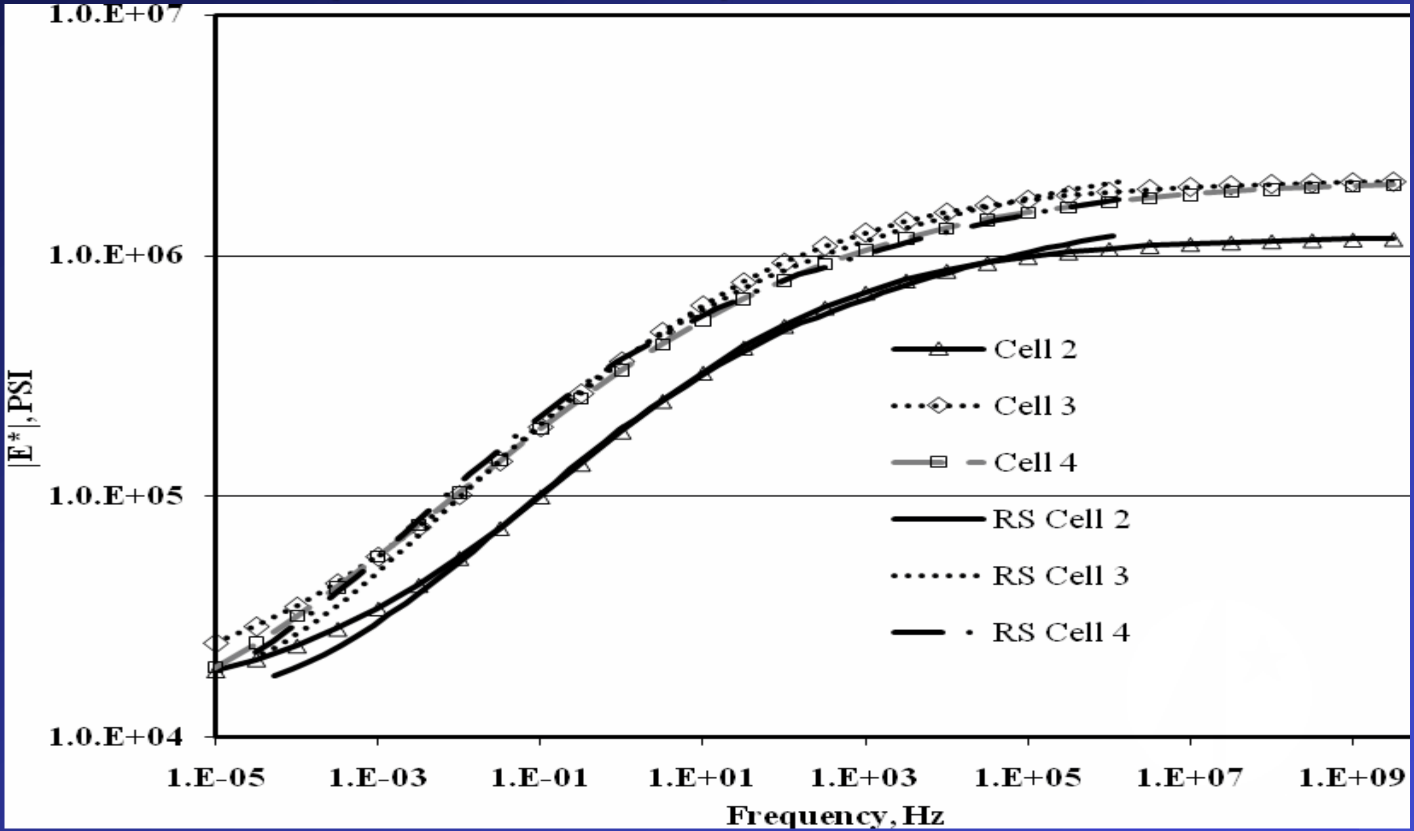
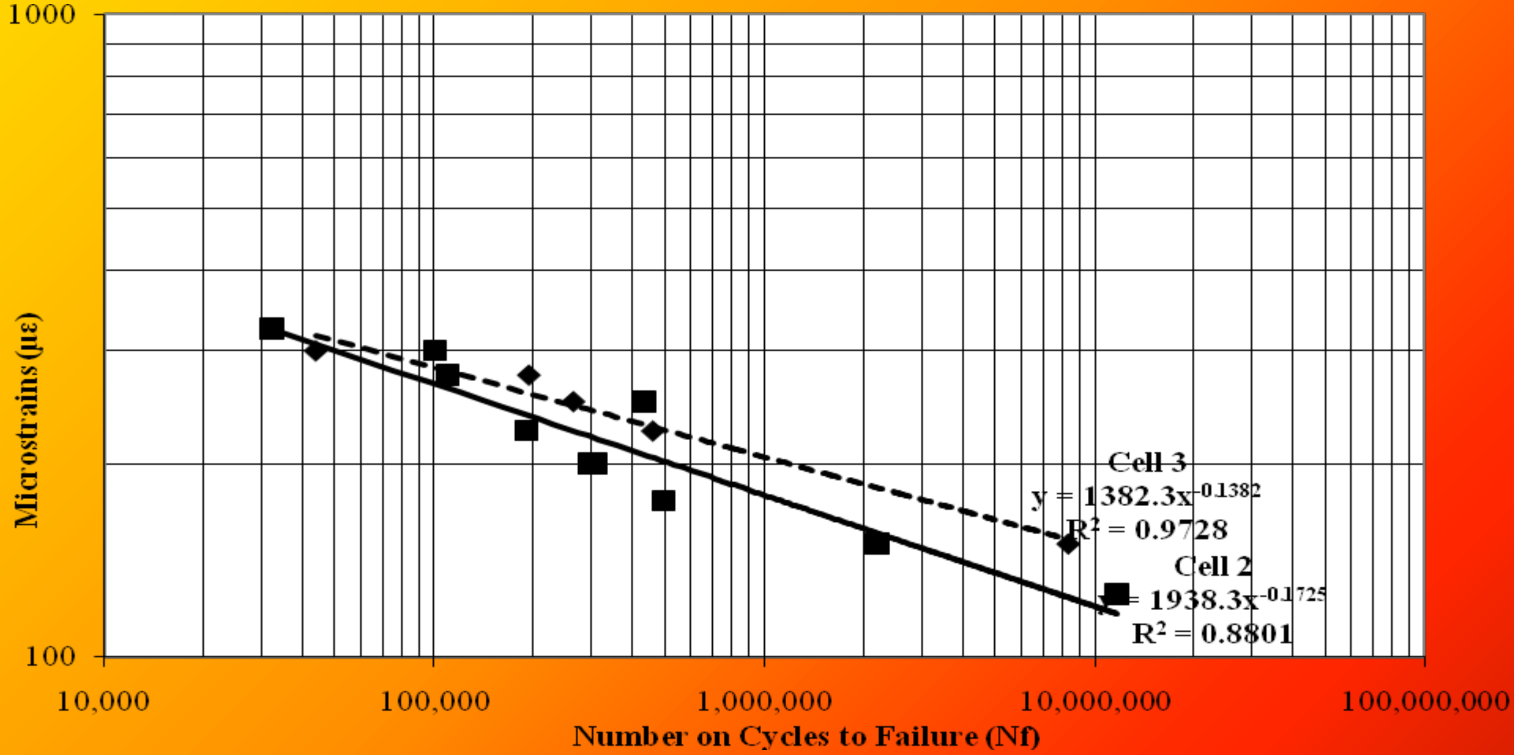
Mix Design

	Cell 2	Cell 3	Cell 4	Shoulder	Specs
RAP/base blend	50 / 50	75 / 25	100% RAP	50 / 50	--
Design emulsion, %	4.0	3.0	0.75	4.5	--
Air voids, %	10.2	9.3	13.2	10.0	--
Short-term strength	241	276	430	225	175 g/25 mm, min.
ITS at 25°C	52	59	51	59	40 psi, min.
Conditioned ITS at 25°C	25	30	33	25	25 psi, min.
Critical cracking temp.	-32°C	-42°C	-31°C	-46°C	-27°C at 2 inches

- **Dynamic Modulus (AASHTO TP-62)**
  - E* test -- Mn/DOT and Road Science
  - Input for all layers to predict deflection when a load is applied – estimation of pavement response



- Fatigue – Road Science



Construction

Cell 2	Cell 3	Cell 4	Shoulder
1 inch TBWC	1 inch TBWC	1 inch bonded 64-34 HMA	Micro surfacing
2 inches 64-34 HMA	2 inches 64-34 HMA	2 inches 64-34 HMA	4 inches FDR-EE (50/50 blend)
6 inches FDR-EE (50/50 blend)	6 inches FDR-EE (75/25 blend)	8 inches FDR-EE (100% bituminous)	36” base (Cells 2 & 3) 5” base (Cell 4)
6 inches untreated FDR (50/50 blend)	2 inches untreated FDR (75/25 blend)	9 inches Class C fly-ash treated clay	Clay
26” Class 4 base	2” Class 5 base over 33” Class 3 base	Clay	
Clay	Clay		

Construction

- Reclaimer used for pre-pulverization, emulsion addition, and fly ash stabilization of Cell 4 subgrade

Construction

- Padfoot compactor for breakdown compaction, followed by motor grader
- Followed by finish rollers
- Normally opened to rolling traffic after finish rolling

Construction

- Crushed RAP placement in Cell 4. The HMA surface had been removed for fly ash stabilization.
- After RAP placed back down, it was reclaimed with emulsion

Construction

- Placement of HMA on emulsion-stabilized base
- Normally a few days to a week of curing before overlay. Measure in-place moisture.

Construction

- Micro surfacing being placed on shoulder

Current Performance

- No cracking as of last fall.
- Normal deformation of 0.15 inch
- Currently ~1/2 of design ESALs

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Summary and Conclusions

- **SFDR seems a good pavement rehabilitation option that can be used in cities, county roads, or state highways.**
  - Initial testing shows SFDR is stronger.

- **SFDR sections at MnROAD are performing very well so far.**

Summary and Conclusions

- **Mix design procedures have been developed and have good track record**
- **Construction needs**
  - Project selection
  - Sampling
  - Water content
  - Emulsion content
  - Compaction
  - Time to overlay