Midwestern States In-Place Recycling Conference
CIR/FDR Mix Design Considerations

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American Engineering Testing, Inc.

WHY DO A MIX DESIGN?

- A mix design ensures that the material will perform in the desired manner
  - Increases the probability of success
- Allows for an accurate, efficient, pavement structural design
  - Known, measureable performance criteria allows the engineer to design the pavement structure
    - Design for strength, flexibility, stability, stiffness, etc.
    - Choose additives, proportions, gradation, to achieve the desired properties

WHY DO A MIX DESIGN?

- Puts engineer in a defensible position for the decisions that were made on a project design
- How do you know this rehab option is a good or the correct choice?
- Could you have done it cheaper?
- Did you use the correct additive?
- Did you use the right amount of additive?

WHY DO A MIX DESIGN?

- Provides information necessary to make field adjustments
  - CIR
    - Range of emulsion contents
      - Temperature Sensitivity – mix design is done at 73°F
    - Range of gradations
      - Mix design gradation is manufactured in lab
      - Field gradation can depend upon temperature, aggregate size, cutting head
  - FDR
    - Range of additive contents
    - Range of gradations
    - Range of moisture contents
      - Adjustments of additives (cementitious materials) for higher moisture

Cold In-place Recycling (CIR)

Mix Design

Superpave Gyratory Compactor

Lab

Cold In-place Recycling (CIR)

Fundamentals of CIR

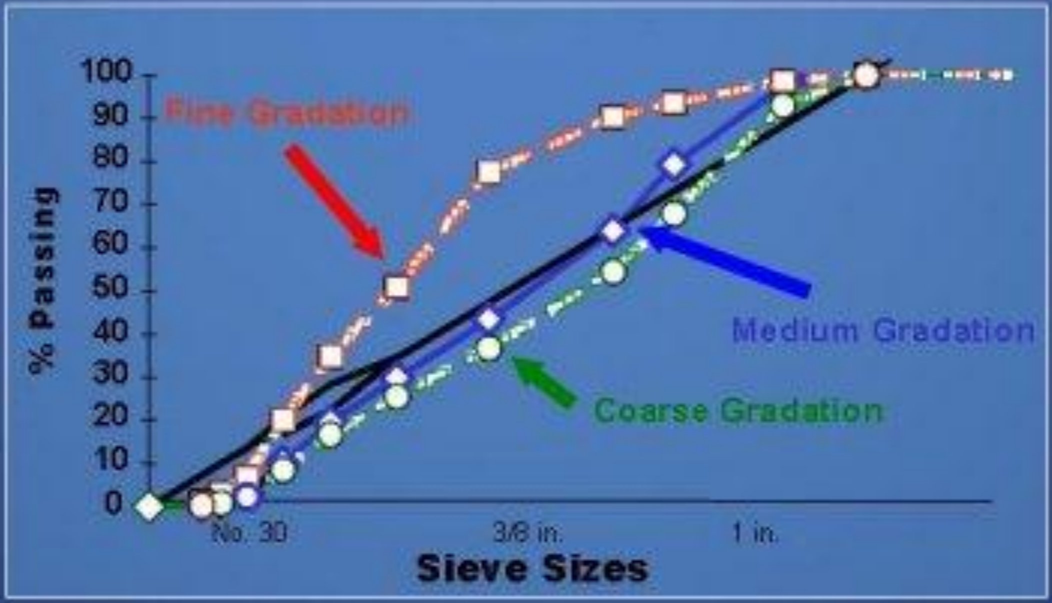
Comparison of Conventional and Engineered CIR in Minnesota

- Conventional
  - No mix design
    - 2% Emulsion
  - QC requirements
    - Two gradations per day
    - 100% passing 1-1/2"
    - 90-100% passing 1"
    - Control strip
- Engineered
  - Defined sampling protocol
  - Engineered design
    - Emulsion content can range from 1.0% to 4.0%
    - Additional additives for stability (cement, fly ash, add rock)
  - Performance-related specs

Cold In-place Recycling (CIR)
Mix Design

RAP/Base Analysis

- Foamed Asphalt, Engineered Emulsion and Fly Ash
  - Field cores crushed to 3 gradation bands
  - A design made for at least 2 gradations



Cold In-place Recycling (CIR)

- Mix design
  - Reclaimed Asphalt Pavement (RAP) crushed to defined gradations
  - Emulsion formulated
  - Superpave Gyratory Compactor (SGC) mixes at field moisture content
- Performance-related tests




Cold In-place Recycling (CIR)

- Test for stability/retained stability
  - Sometimes requires add rock or stiffer binder
- Tensile strength
- Low Temperature Cracking
  - Confirm Binder PG Grade
  - $-20^{\circ}C$ to $-40^{\circ}C$ temperature range in MN, ND, IA
  - Typical PG grade is XX-34 or XX-28

Cold In-place Recycling (CIR)

AMERICAN ENGINEERING TESTING, INC.
550 Cleveland Avenue North
ST. PAUL, MN 55114

Date: 4/5/09
Customer: [illegible] County
Sample: Bituminous Cores
AET Project #: 25-00823
Project: [illegible] County CSAH 25

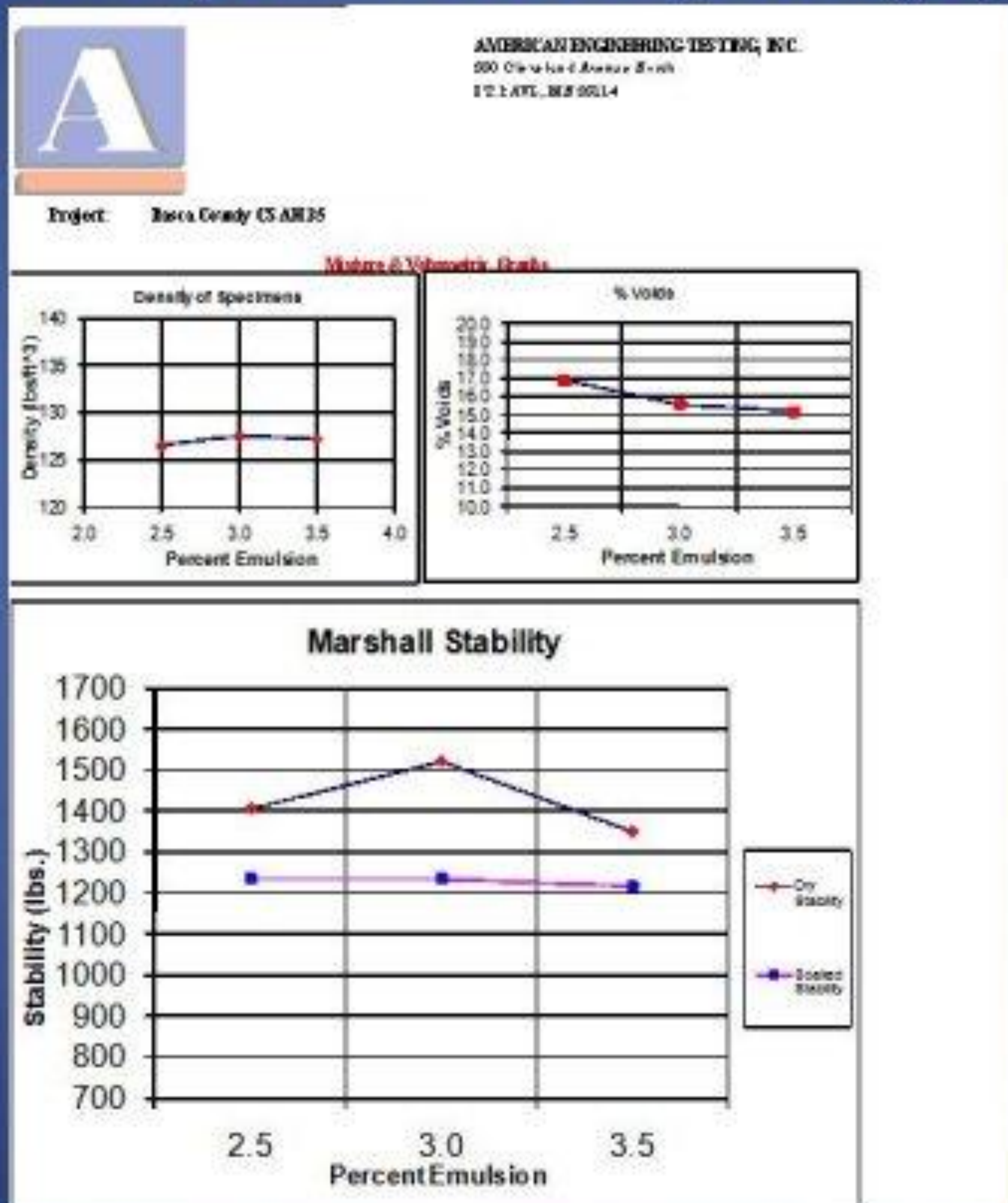
Gyratory Compacted
SEMReflex Mix Design
Engineer: David Rettner
Phone: (651) 755-6795

RECOMMENDATION (See Conclusion Below)
Target Emulsion Content: 2.3% +/- 0.4%
Gallons per square yard (4" CIR Section): 1.79 +/- 0.2
Target Moisture Content: 1.5% +/- 0.5%

Mixture Data & Volumetrics
30 Gyrations

Emulsion	Reflex	Reflex	Reflex
Percent Emulsion	2.3	3.8	3.3
% Added Water	1.5	1.5	1.5
Bulk Specific Gravity (Gmb)	2.027	2.043	2.050
Density lb/ft³	126.5	127.5	127.2
Maximum Specific Gravity (Gmm)	2.439	2.421	2.403
Dry Stability @ 40 C	1404	1321	1349
% Vacuum Saturation	48	54	61
Retained Stability @ 40 C (Soaked)	1256	1234	1217
% Retained Stability	89	93	90
% Voids	16.9	15.4	15.2
Coating Test	n/a	n/a	n/a

Cold In-place Recycling (CIR)

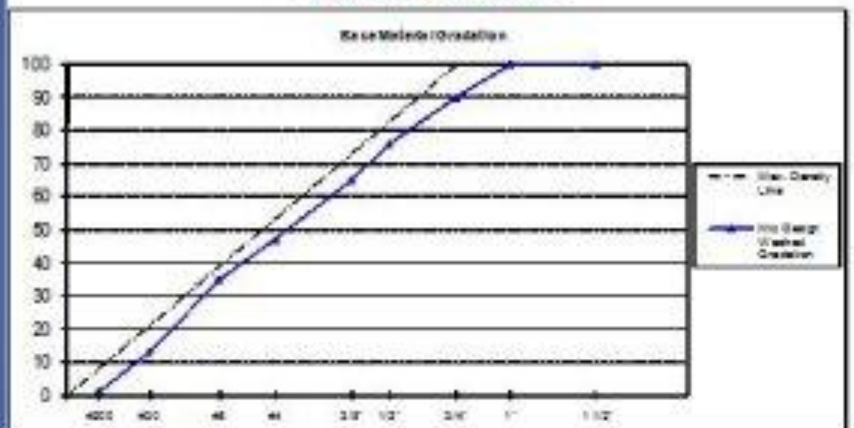


Cold In-place Recycling (CIR)

AMERICAN ENGINEERING TESTING, INC.
550 Cleveland Avenue North
ST. PAUL, MN 55114

Project: [illegible] County CSAH 35

Agg Data and 0.45 Power Charts



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% of Blend	100	0	
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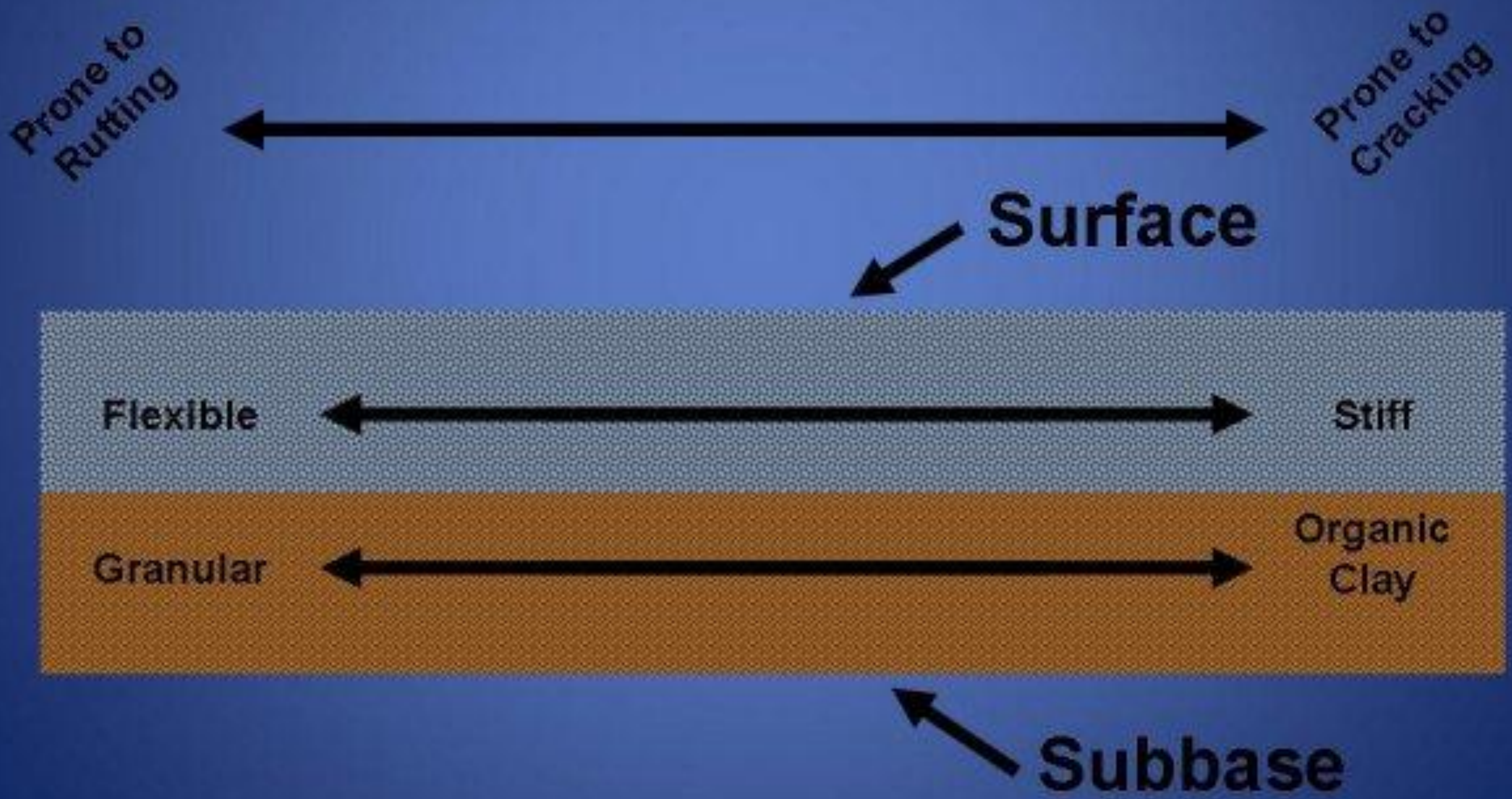
Full Depth Reclamation (FDR)

- Choose Stabilization Technique or Techniques to Evaluate
  - Emulsion
  - Cement/Emulsion
  - Fly Ash/Emulsion
  - Lime
  - Lime/Cement
  - Fly Ash

Full Depth Reclamation (FDR)

Keys to Success

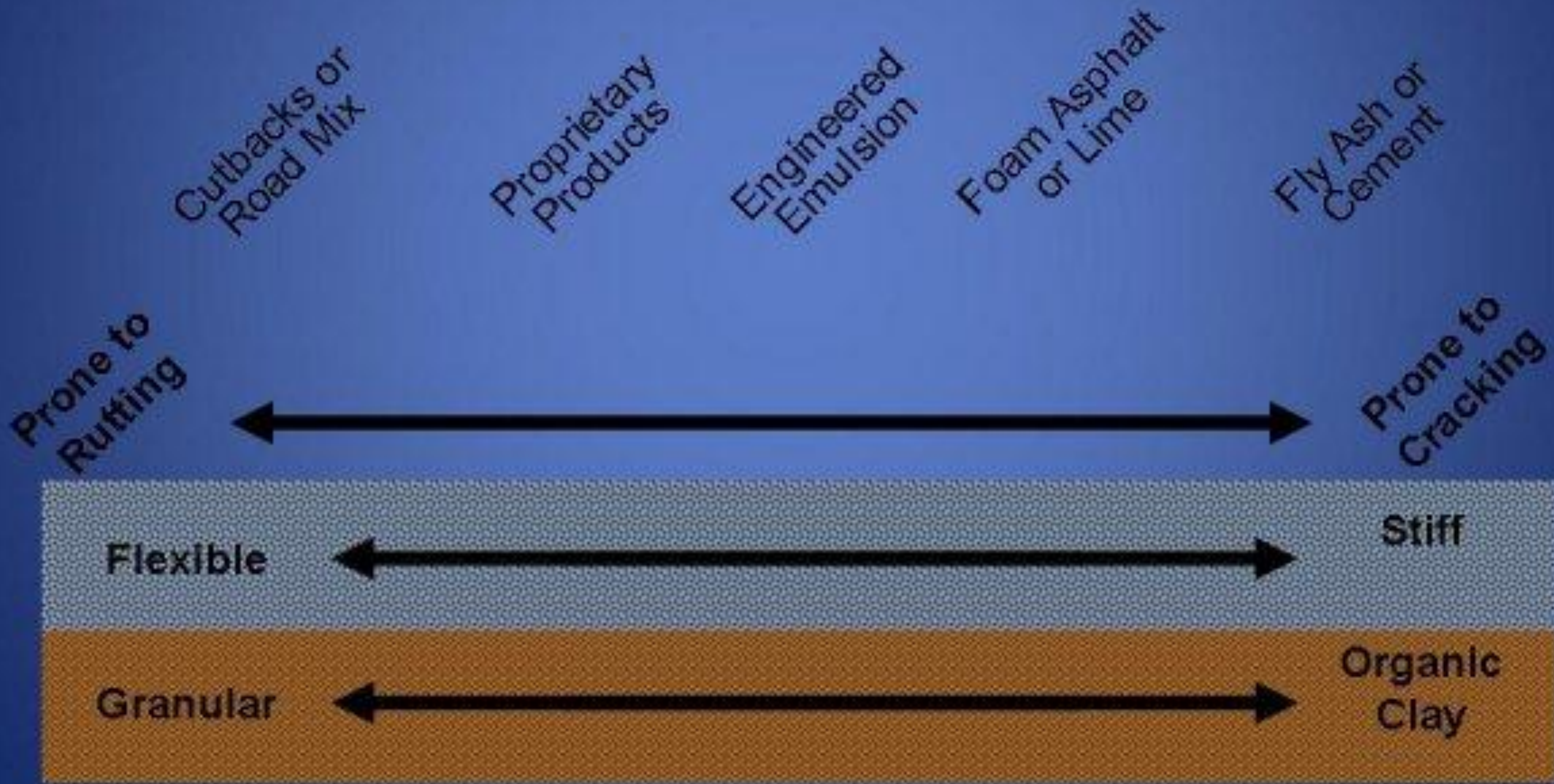
Stabilization Considerations



Full Depth Reclamation (FDR)

Keys to Success

Stabilization Considerations



Full Depth Reclamation (FDR)

- After Stabilization Technique or Techniques are Selected Determine Evaluation Parameters
  - Strength
  - Stability
  - Flexibility
  - Moisture content ranges

Full Depth Reclamation (FDR)

FlyAsh Stabilization											
AET Job Number : 28-00028				4" DIA, area 12.56							
		6% FlyAsh						**6% FlyAsh**			
OPT M.C. 10%						**M.C. 9%**					
3 DAY	Load	PSI	**14 DAY**	Load	PSI	**3 DAY**	Load	PSI	**14 DAY**	Load	PSI
A	510	40.6	**A**	430	34.2	**A**	632	50.3	**A**	520	41.4
B	420	33.4	**B**	470	37.4	**B**	519	41.3	**B**	350	27.9
C	519	41.3	**C**	470	37.4	**C**	510	40.6	**C**	540	43.0
	AVG	**38.5**		**AVG**	**36.4**		**AVG**	**44.1**		**AVG**	**37.4**
		8% FlyAsh						**8% FlyAsh**			
OPT M.C. 9.6%						**M.C. 8.6%**					
3 DAY	Load	PSI	**14 DAY**	Load	PSI	**3 DAY**	Load	PSI	**14 DAY**	Load	PSI
A	505	40.2	**A**	890	70.9	**A**	767	61.1	**A**	881	70.1
B	540	43.0	**B**	587	46.7	**B**	755	60.1	**B**	912	72.6
C	500	39.8	**C**	563	44.8	**C**	789	62.8	**C**	845	67.3
	AVG	**41.0**		**AVG**	**54.1**		**AVG**	**61.3**		**AVG**	**70.0**
		10% FlyAsh						**10% FlyAsh**			
OPT M.C. 9.6%						**M.C. 8.6%**					
3 DAY	Load	PSI	**14 DAY**	Load	PSI	**3 DAY**	Load	PSI	**14 DAY**	Load	PSI
A	811	64.6	**A**	991	78.9	**A**	935	74.4	**A**	856	68.2
B	722	57.5	**B**	778	61.9	**B**	688	54.8	**B**	1069	85.1
C	677	53.9	**C**	890	70.9	**C**	632	50.3	**C**	1036	82.5
	AVG	**58.7**		**AVG**	**70.6**		**AVG**	**59.8**		**AVG**	**78.6**
		14% FlyAsh						**14% FlyAsh**			
OPT M.C. 8.0%						**M.C. 7.2%**					
3 DAY	Load	PSI	**14 DAY**	Load	PSI	**3 DAY**	Load	PSI	**14 DAY**	Load	PSI
A	2168	172.6	**A**	3321	264.4	**A**	2111	168.1	**A**	2865	228.1
B	2122	168.9	**B**	2179	173.5	**B**	1859	148.0	**B**	3492	278.0
C	1721	137.0	**C**	2636	209.9	**C**	2271	180.8	**C**	3298	262.6
	AVG	**159.5**		**AVG**	**215.9**		**AVG**	**165.6**		**AVG**	**256.2**

Full Depth Reclamation (FDR)

AMERICAN ENGINEERING TESTING, INC.
550 Cleveland Avenue North
ST. PAUL, MN 55114

Date: 4/2008
Customer: SEM Materials, St. Paul MN
Sample: Bituminous and Aggregate Base
AET Project #: 20-07858
Project: Lelanau County Rd 13

Gyratory Compacted
SEM Materials Fortress Mix Design
Engineer: David Rettner
Phone: (651) 755-8795

RECOMMENDATION (See Conclusion Below)
Target Emulsion Content: 3.5% +/- 0.25%
Gallons per Square Yard of Base/Agg.: 2.5 +/- 0.2 (For a 6" thick stabilized section)
Target Moisture Content: 3.0% +/- 0.5%

Mixture Data & Volumetrics

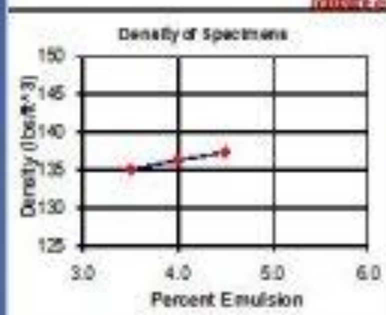
30 Gyrations

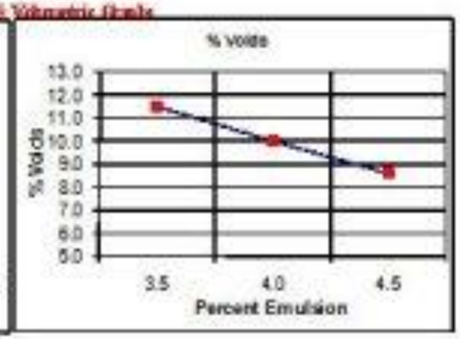
Emulsion	Fortress	Fortress	Fortress
Percent Emulsion	3.5	4.0	4.5
% Premix Water	3.8	3.0	3.0
Bulk Specific Gravity (Gmb)	2.143	2.183	2.208
Density, lb/ft³	133.0	134.2	137.3
Maximum Specific Gravity (Gmm)	2.464	2.426	2.408
IDT (psi) @ 25 C	51.2	46.2	46.5
% Vacuum Saturation	60	57	57
Conditioned IDT (psi) @ 25 C (Soaked)	40.7	43.2	43.2
% Retained Stability	79	94	97
% Voids	11.5	10.0	8.4
Coating Test	n/a	n/a	n/a

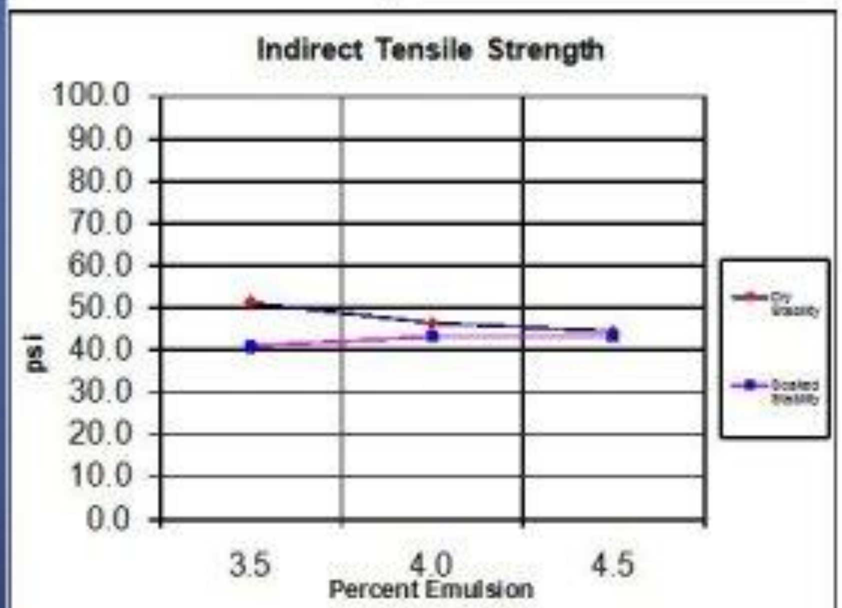
Full Depth Reclamation (FDR)

AMERICAN ENGINEERING TESTING, INC.
ST. PAUL, MN 55114

Project: LeSueur County R113







Questions?