Pavement Preservation Research in North Carolina

Y. Richard Kim, P.E., Ph.D., Professor of Civil Engineering
Jaejun Lee and Andrew Jerome, Graduate Research Assistant
North Carolina State University

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Chip Seal Power in NC

- Miles Completed in 2004: *2,880 miles*
- Percent of Roadway Pavement Expenditures: *6.3%*
- Percent of Miles Paved: *46%*

Research Needs in Chip Seals

- Lack of unified design procedure or construction process among different divisions in NC
- Empirical methods
- Difficult to adopt new materials
- Lack of performance data
- Application to higher volume roads

Chip Seal Projects at NCSU

- Optimizing Gradations for Surface Treatments (NCDOT Project HWY-2004-04) - *Aggregate*
- Quantifying the Benefits of Improved Rolling of Chip Seals (NCDOT Project HWY-2006-06) - *Rolling*
- Performance Based Analysis of Polymer Modified Emulsions in Bituminous Surface Treatments (NCDOT Project HWY-2007-06) – *Emulsion*
- Development of a New Chip Seal Mix Design Method (NCDOT Project HWY-2008-04) – *Mix Design*

Research Goals at NCSU

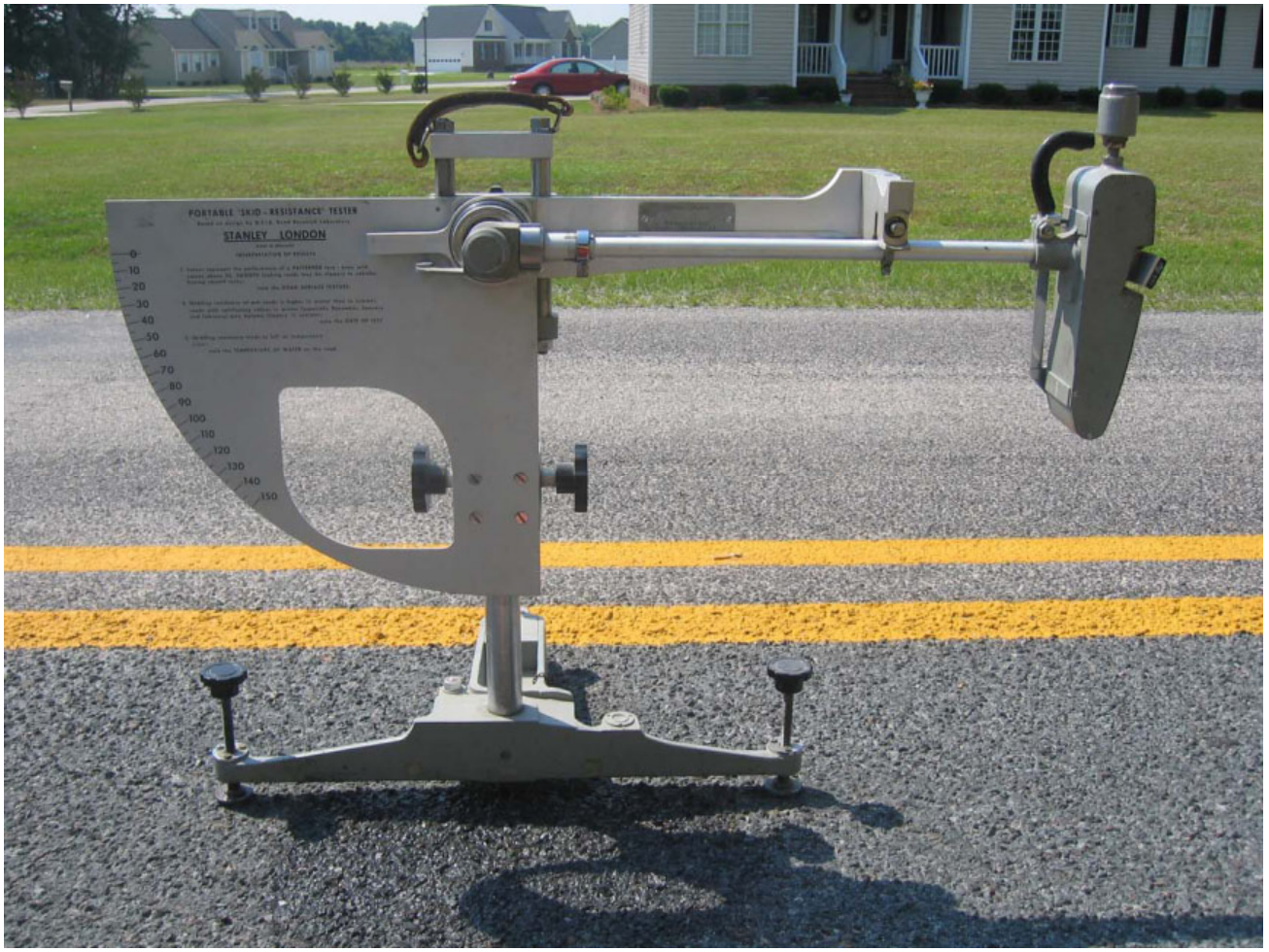
- Develop and introduce more advanced and performance based test and analysis methods to chip seal specifications, design, and construction
- Improve the performance of chip seals by refining current and developing new materials and construction techniques
- Extend the application of chip seals to higher traffic volume roads

Performance Test Methods

Existing Test Methods

Test	Location	Performance Properties
British Pendulum Test	Lab, Field	Skid resistance
Locked Wheel Skid Test	Field	Skid resistance
Sand Circle Test	Lab, Field	Surface texture depth
Vialit Test	Lab, Field	Adhesion between aggregate and emulsion
Flip-Over Test	Lab, Field	Amount of excess aggregates
Sweep Test	Lab	Aggregate retention performance

British Pendulum Test



Locked Wheel Skid Test

Sand Circle Test

Vialit Test

Vialit Test Method

- Curing samples in the oven at 35°C for 24 hours.
- Flip over samples to remove excess aggregate.
- Place samples upside down on a device.
- Drop the ball three times within 10 sec.
- Measure the weight of samples.

Flip-Over and Sweep Test

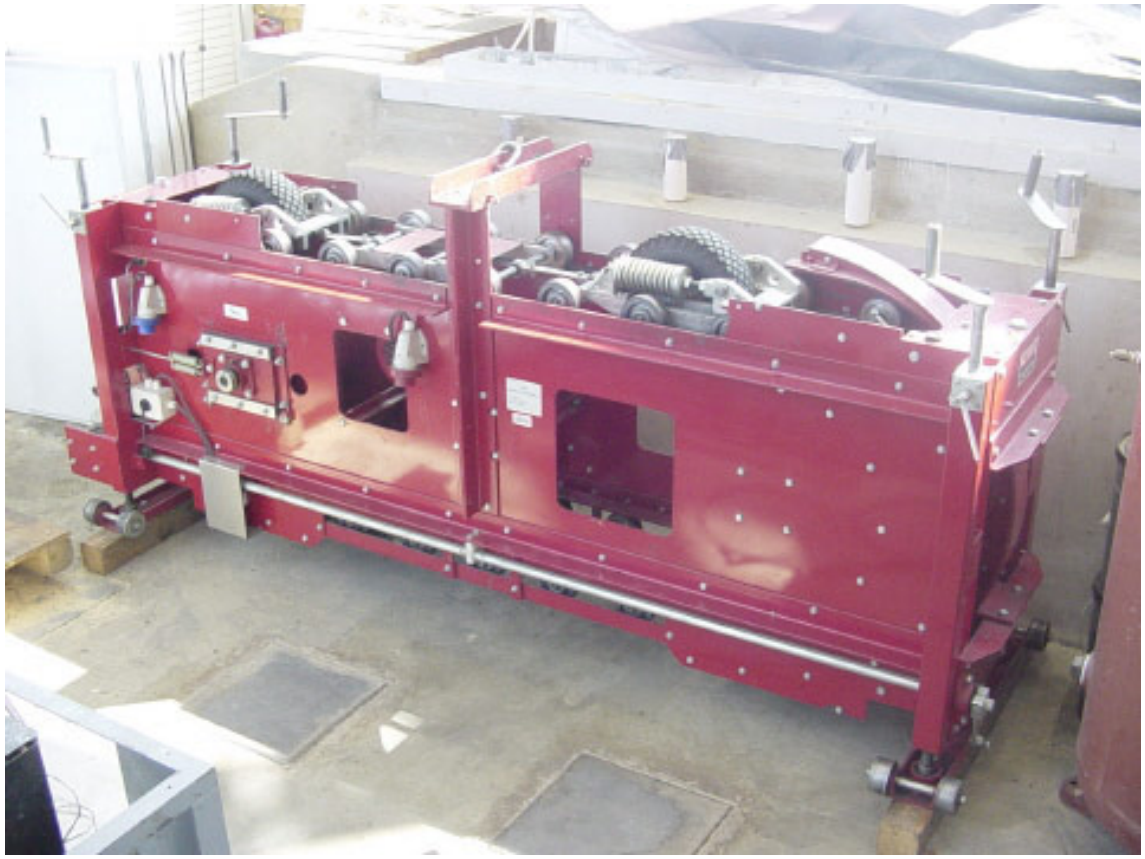
Flip Over Test

- Cure samples in the oven at 35°C for 24 hours.
- Turn samples vertically and brush to remove the excess aggregate on the sample.
- Measure the sample weight.

NCSU Test Methods

Test	Location	Performance Properties
MMLS3 Test	Lab	Aggregate retention, Bleeding
Modified Sand Circle Test	Lab, Field	Surface texture, Aggregate exposure depth
Laser Profiling Test	Lab, Field	Surface texture, Aggregate exposure depth
Surface Digital Imaging Test	Lab, Field	Bleeding evaluation
Crosssectional Digital Imaging Test	Lab	Surface texture, Aggregate embedment depth

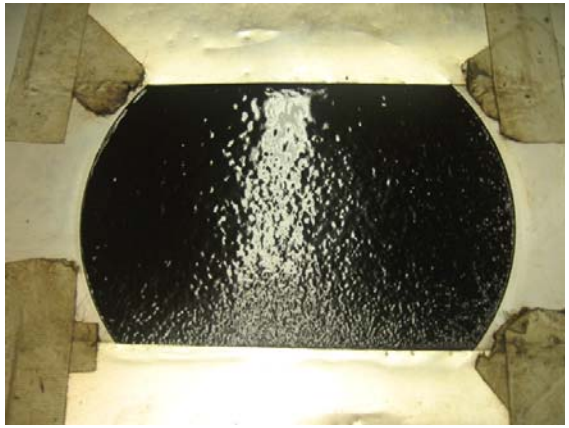
MMLS3



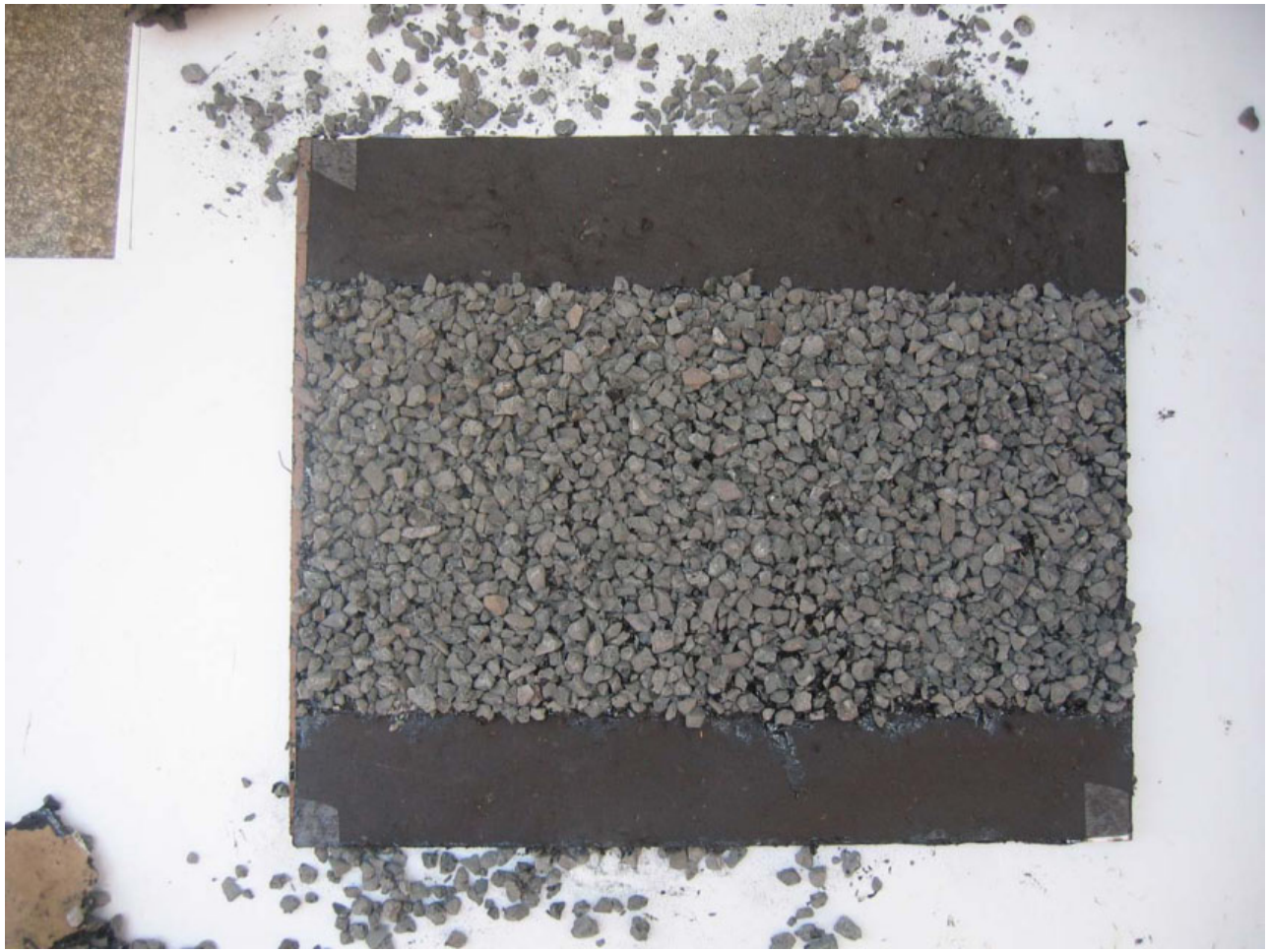

NC STATE


GRAINGER
GRAINGER

MMLS3 Specimen Preparation



MMLS3 Specimen Ready for Testing

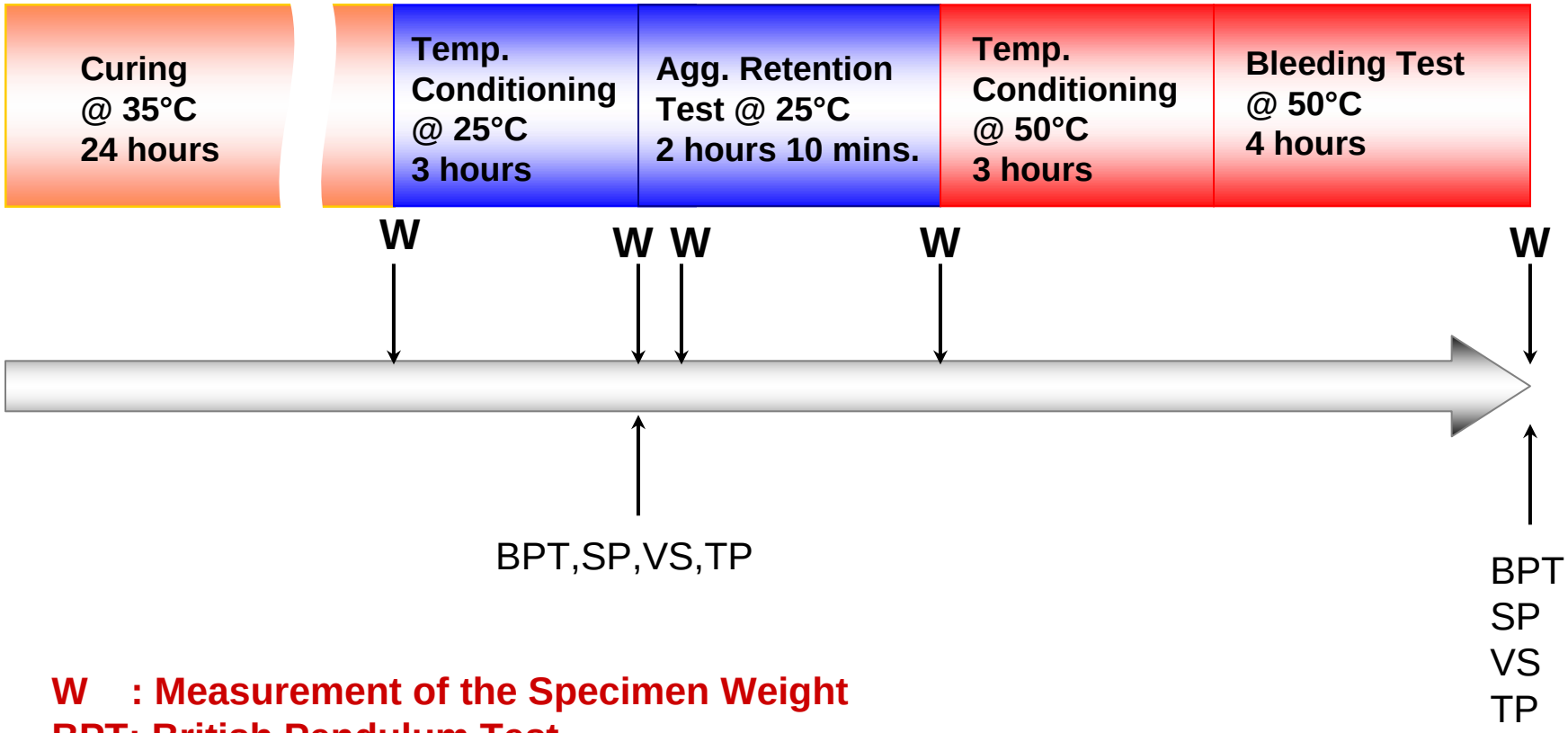


MMLS3 Test Preparation






MMLS3 Test Procedure



W : Measurement of the Specimen Weight
BPT: British Pendulum Test
SP : Sand Patch Test
VS : Visual Survey
TP : Transverse Profiling

Before Loading

990 passes at 25°C

2,970 passes at 25°C

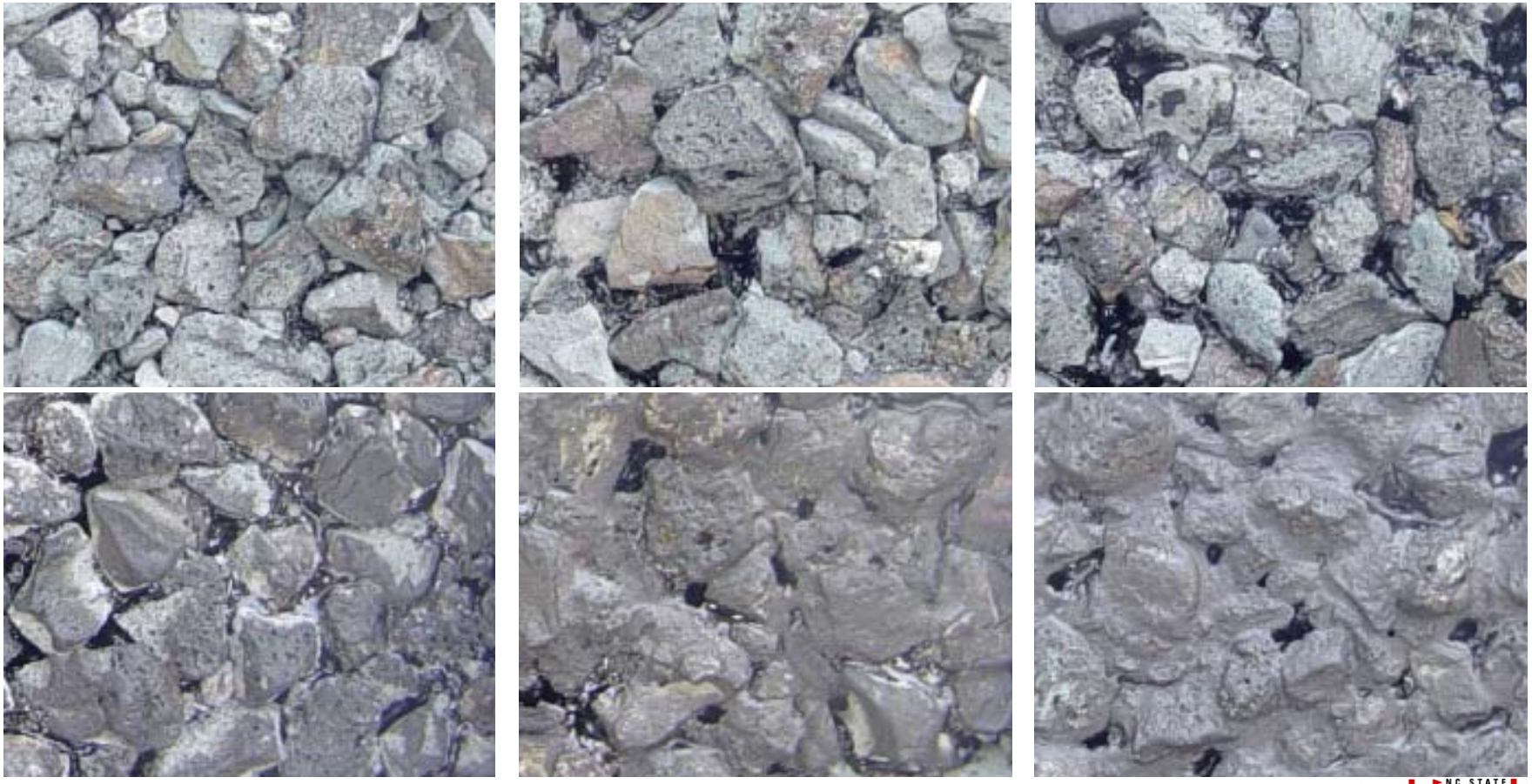
5,940 passes at 25°C

11,600 passes at 25°C

23,760 passes at 50°C

Bleeding Test

0.26 gal/yd² **0.35 gal/yd²** **0.4 gal/yd²**



Modified Sand Circle Test

Sample Preparation

- Pour epoxy onto sample, do not disturb until epoxy has set, allow approximately 24 hours.
- Place the sample in a tray with sufficient kerosene to completely submerge remaining surface seal attached to the epoxy, allow soaking for minimum 12 hours.
- Wash remaining binder off plate with citra-solve.

Modified Sand Circle Test

Measurement of Embedment Depth

- Measure the weight of filled sand into a circle ring (W_1).
- Put a circle ring on the specimen.
- Pouring the sand into the circle ring.
- Screen off the excess sand with a straightedge.
- Determine the weight of the remained sand in the circle ring (W_2).
- Calculate the average embedment depth

$$\text{Average embedment depth} = \frac{1272M}{Dd^2}$$

where

D = Loose unit mass of the sand (g/cm^3)

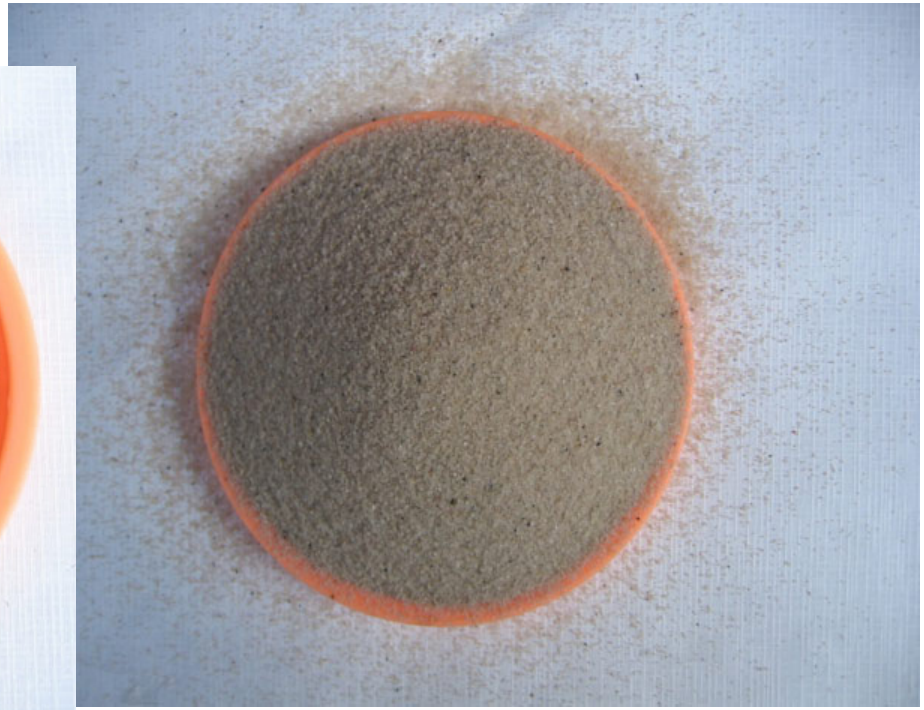
d = Diameter of the circle ring (mm)

M = Mass of the applied of sand (W_2-W_1) (grams)

Modified Sand Circle Test

Pour Sand into the Ring

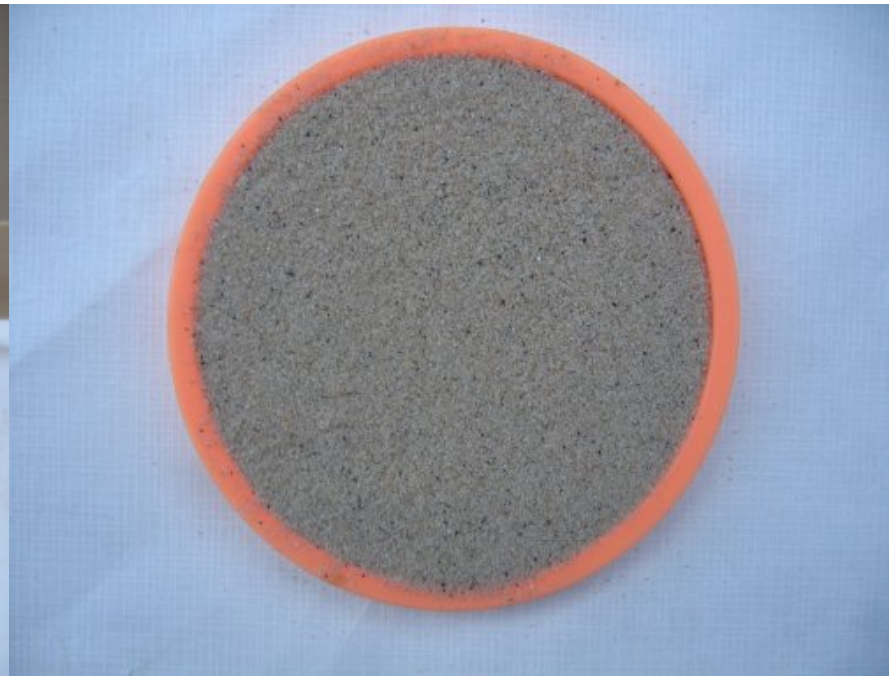
Put the circle ring.



Pour the sand into circle ring.

Modified Sand Circle Test

Fill Sand into the Ring



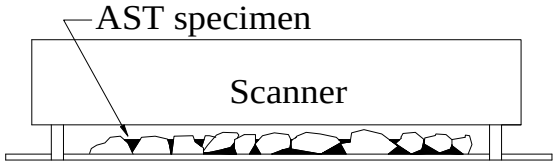
Screen off the excess sand.

Fill the sand into the circle ring.

Digital Imaging of Surface

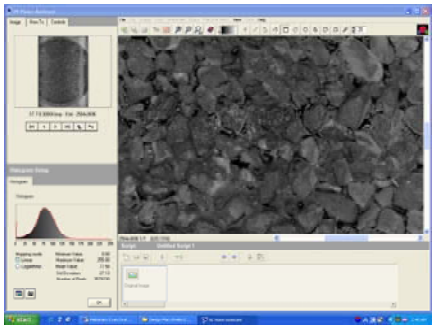
(a)

Image acquisition



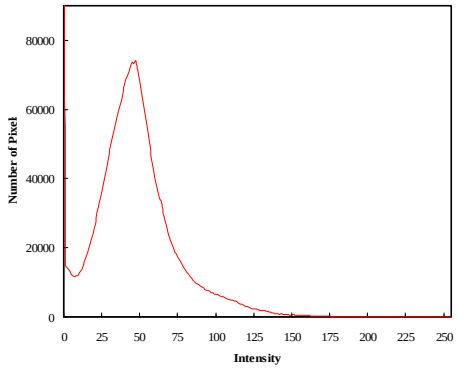
(c)

Image processing



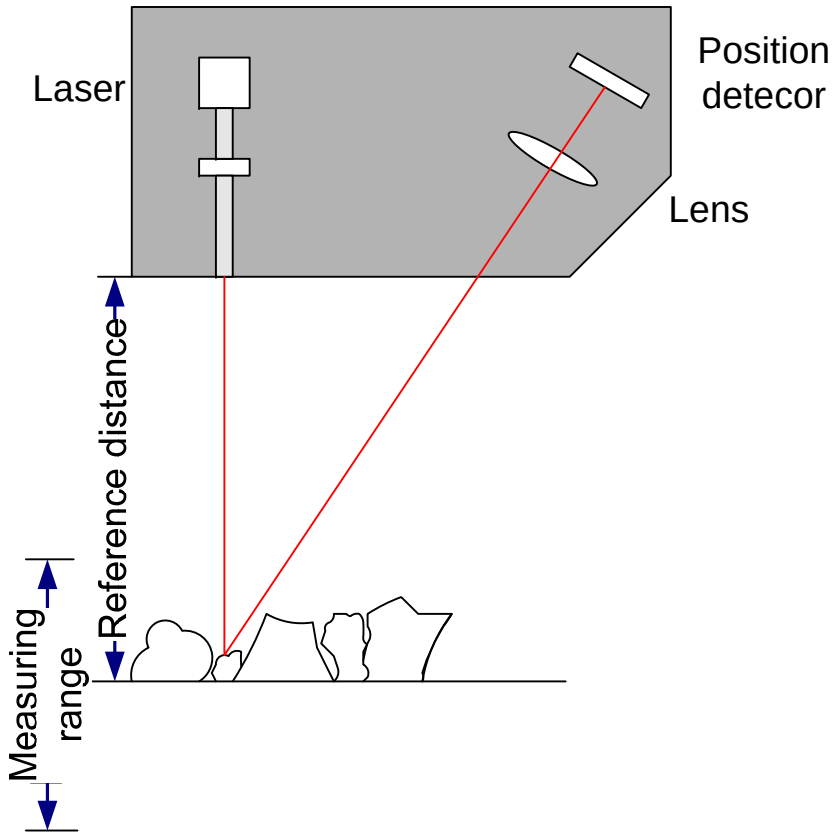
(c)

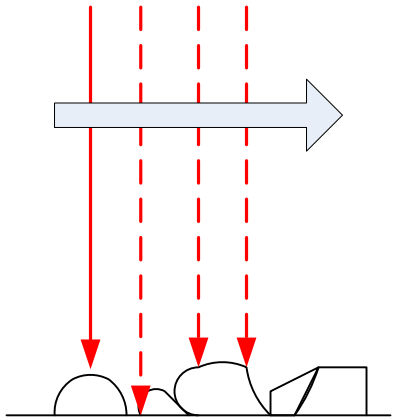
File conversion



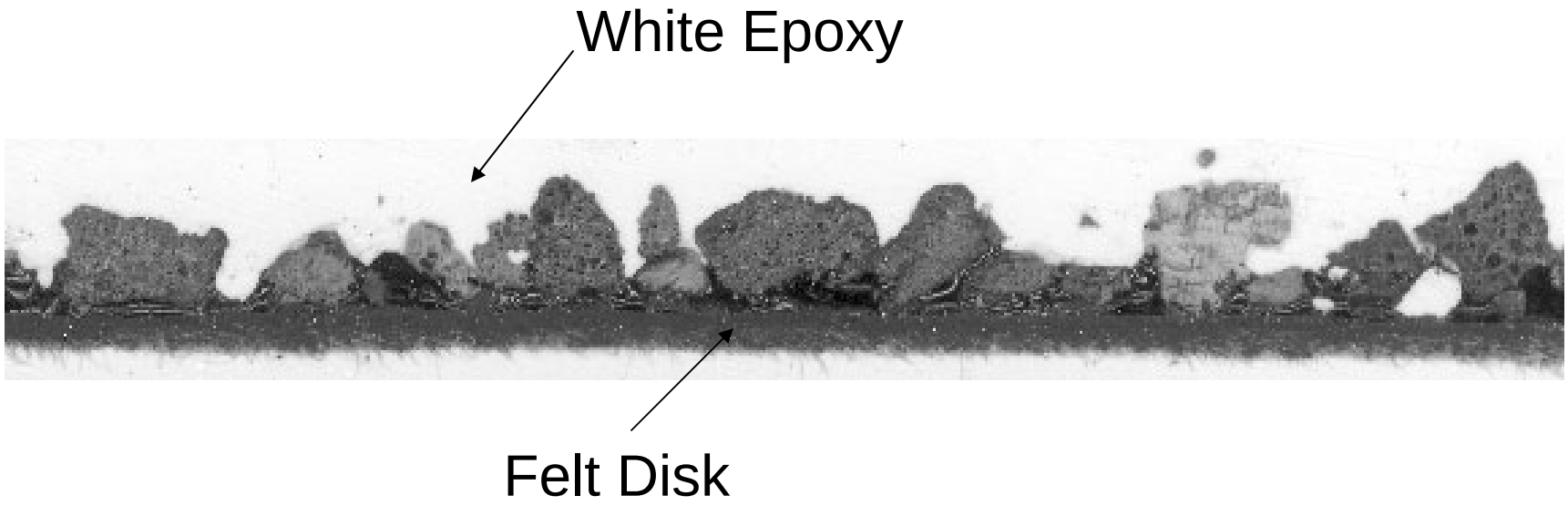
(d)

Laser Profiling Test



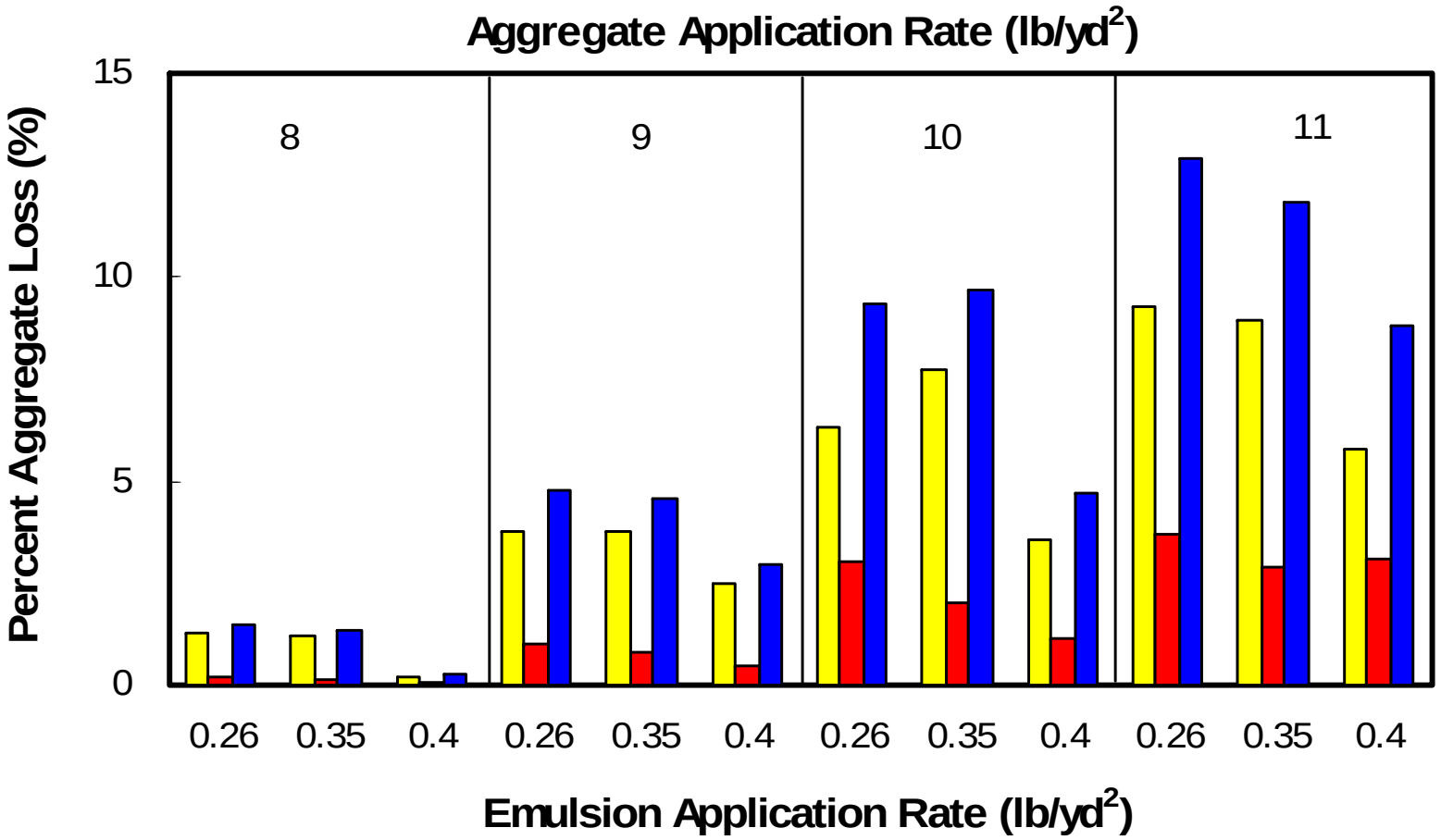


Digital Imaging of Cross-section



Optimizing Aggregate Gradation

MMLS3 Test Results

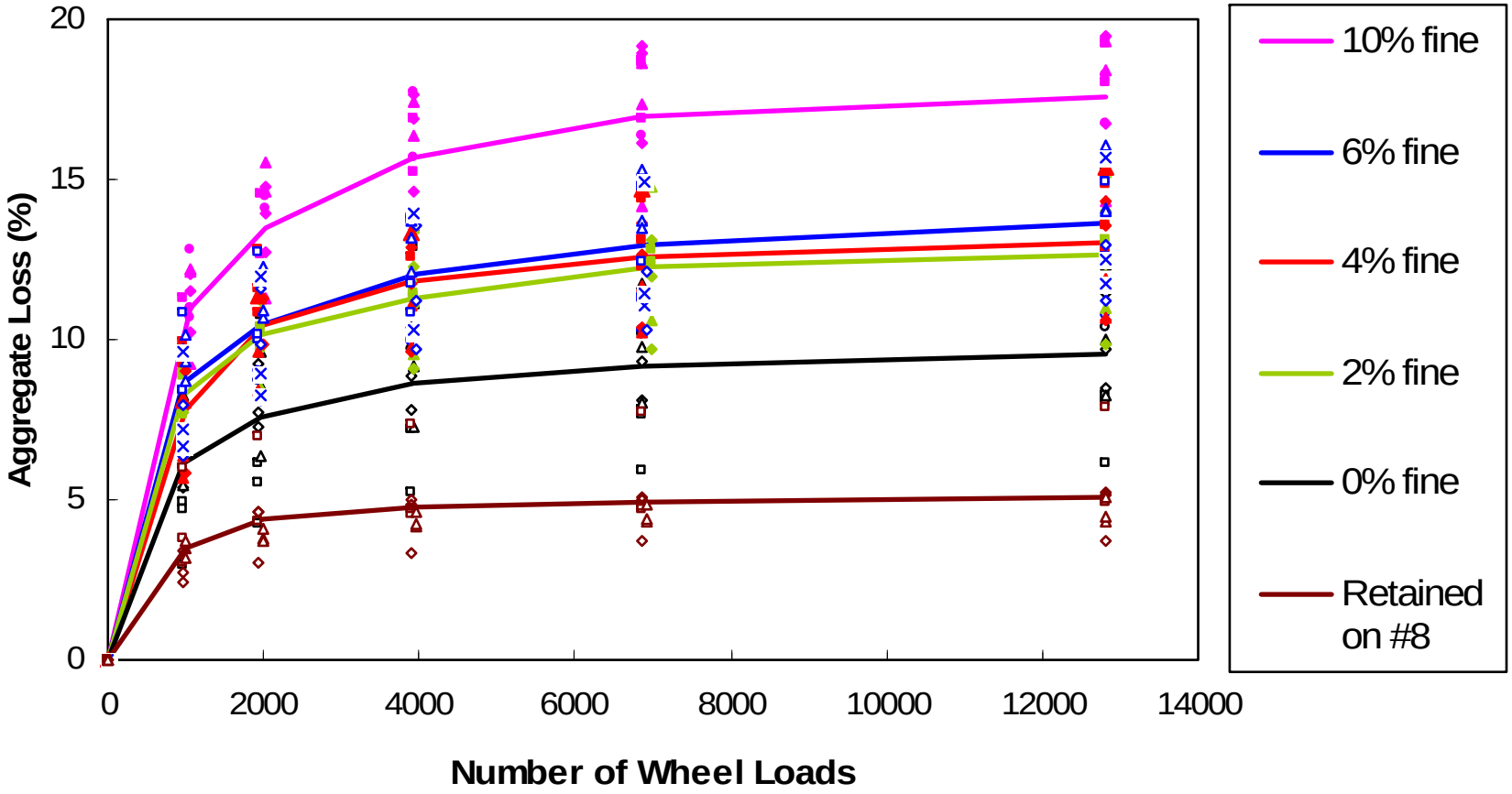


Experimental Program

	Granite 78M	*Light-Weight 5/16”*
Fine Content Effect	0%	
	2%	
	4%	
	6%	
	10%	
Uniform Gradation Effect	Retained on #8	Retained on #8

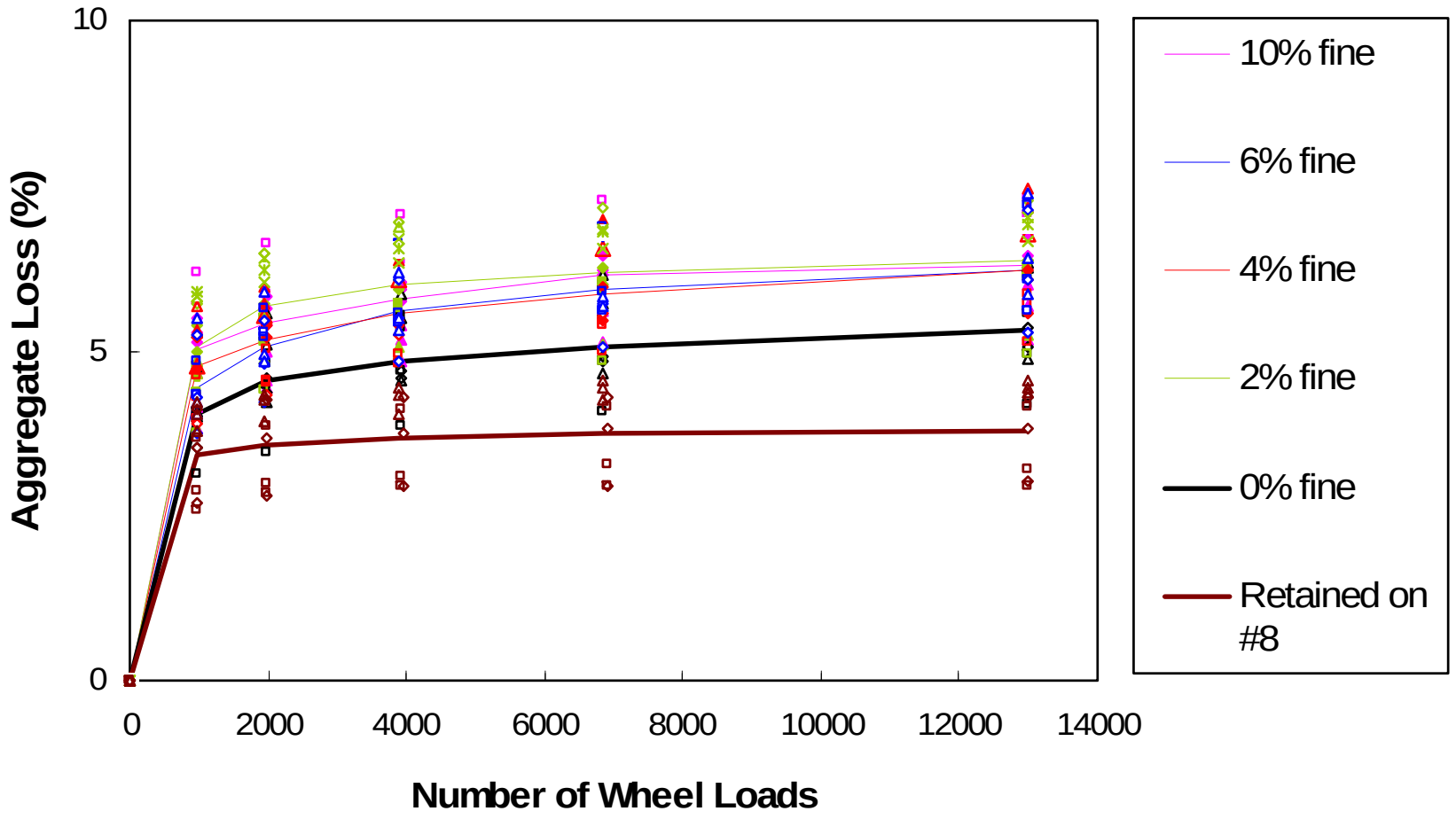
Aggregate Retention Test

Granite



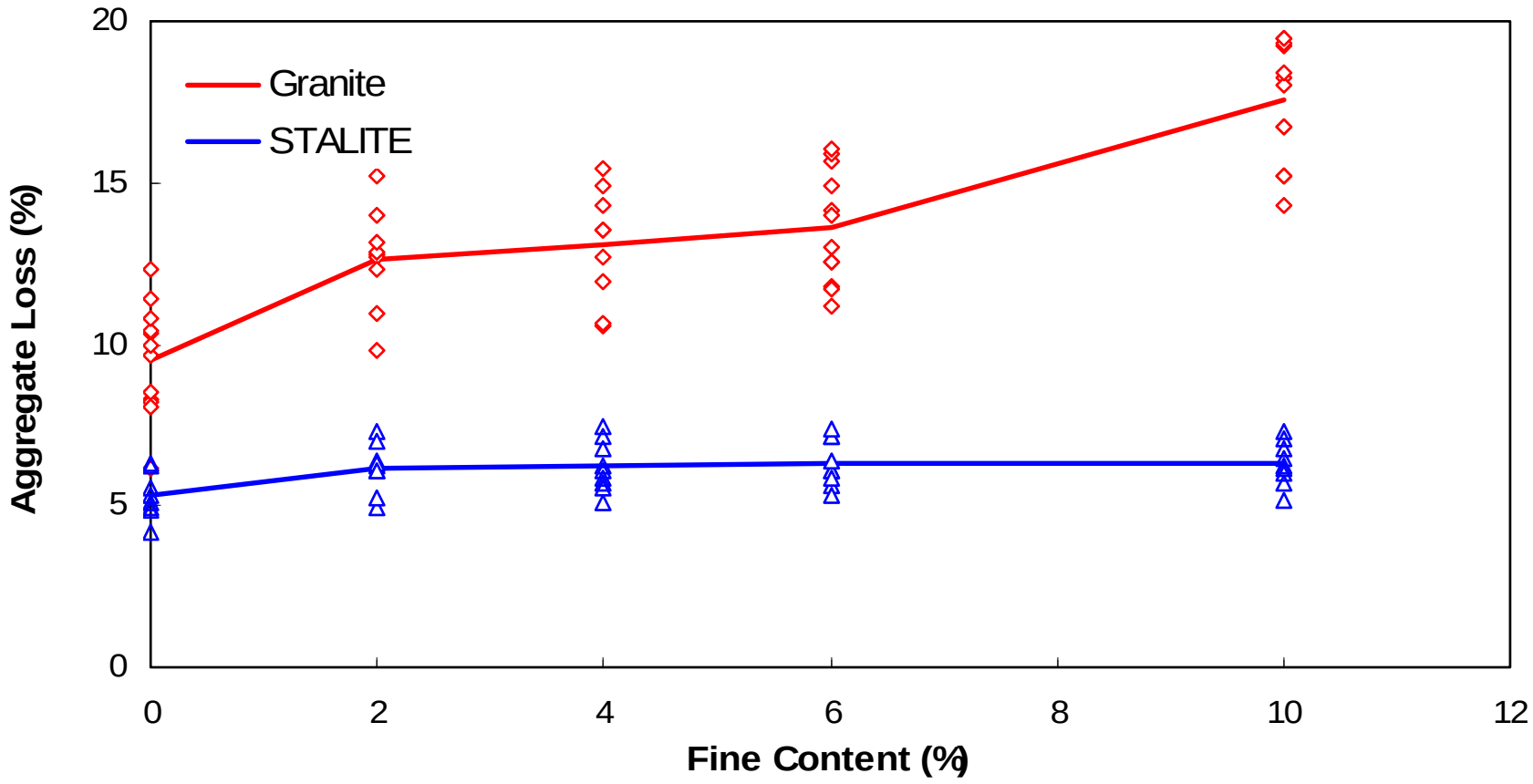
Aggregate Retention Test

Light-Weight

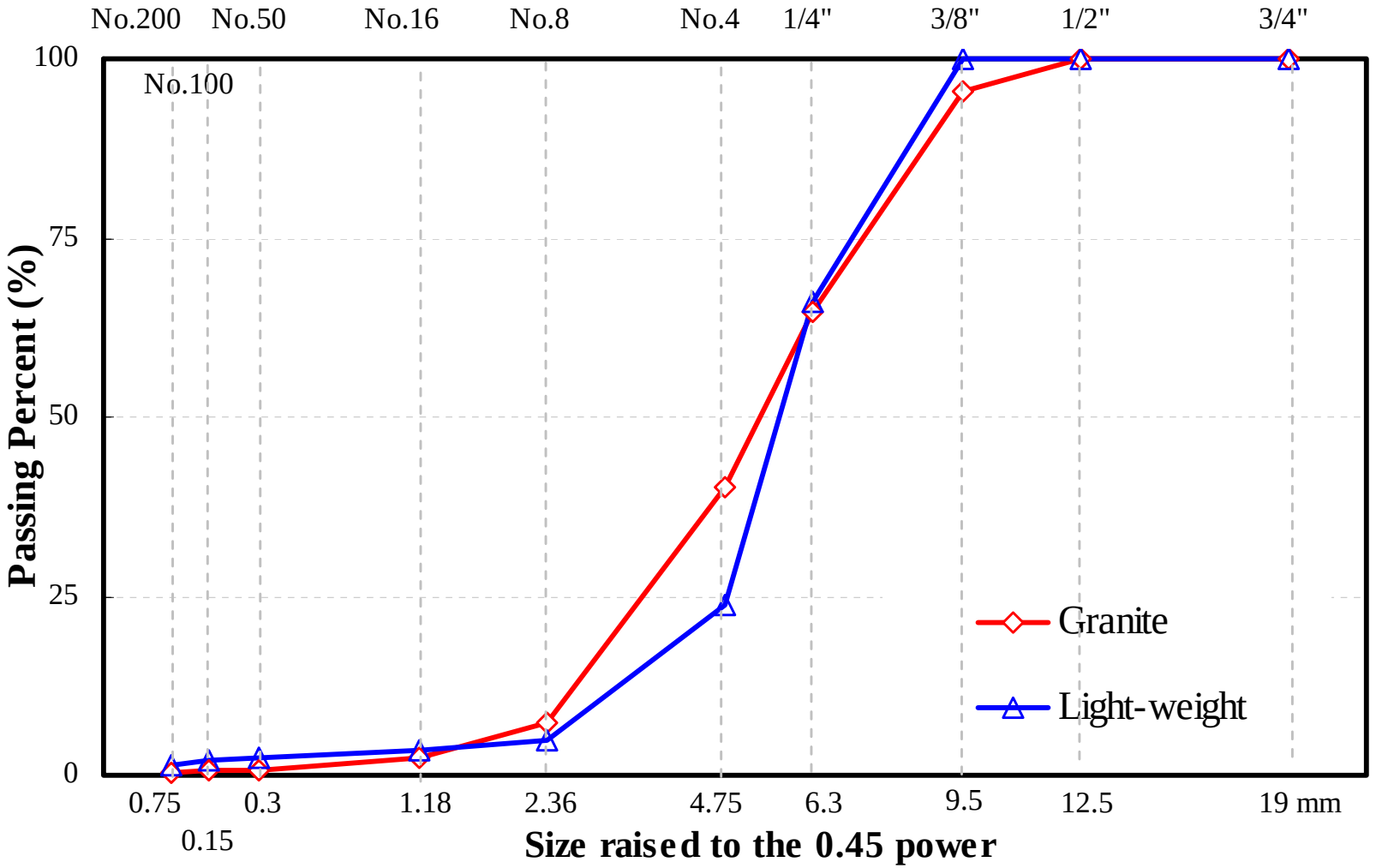


Aggregate Retention at 13k cycles

Granite vs. Light-Weight



Aggregate Gradations



Before Loading	After Agg. Retention Test	After Bleeding Test
		
Granite 78M		
		
Light-weight 5/16”		

Original Gradation with 2% Fines

Granite

Light-Weight

Granite 78M

2% Fines

Retained on #8

Retained on #8

Granite

Light-Weight

Recommendation #1

- Maintain the maximum allowable fine content at the current specification level, i.e., 1.5%. The literature review and the national survey on the maximum allowable fine content support this recommendation. The enforcement of this specification becomes increasingly important the more the aggregate deviates from the uniform gradation.

Recommendation #2

- Use only the materials retained on the No. 8 sieve for the AST construction. Although this recommendation may not be feasible to implement due to economic and practical constraints with regard to quarries, some Divisions may have certain local situations (such as poor performance of ASTs, a cooperative relationship with quarries, etc.) that may make the implementation of this recommendation possible.

Optimizing Chip Seal Rolling

Research Needs

- The performance life of chip seals in North Carolina is about half of that in Australia or New Zealand.
- Target “low hanging fruit,” that is, relatively low cost changes in rolling procedures that could significantly improve the chip seal performance in North Carolina.

Steel Wheel Roller

Pneumatic Tire Roller

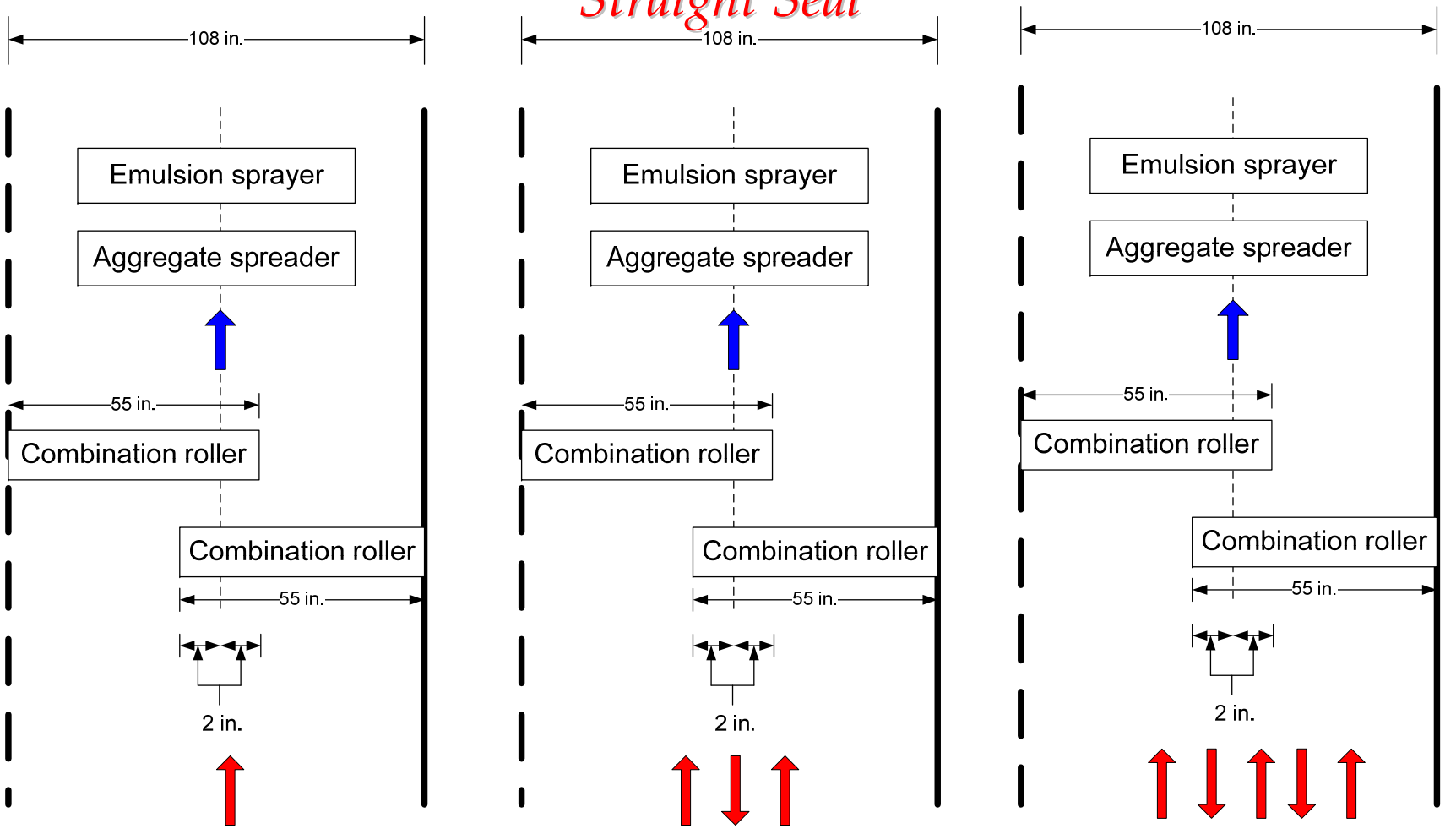
Combination Roller

Average Aggregate Loss Ratio

Test Method	Chip Seal Type	Roller Type			
		Steel	Pneumatic	S & P	Combination
Vialit (10 min.)	Straight	1.20	1.00	1.93	1.22
	Split	1.00	3.26	2.58	2.28
	Triple	1.31	2.01	2.19	1.00
Vialit (30 min)	Straight	1.97	1.37	1.00	1.51
	Split	1.00	4.78	2.46	2.64
	Triple	3.12	6.23	6.30	1.00
FOT	Straight	1.00	1.08	1.11	1.05
	Split	1.60	1.70	1.06	1.00
	Triple	1.23	1.44	1.30	1.00
MMLS3	Straight	1.15	1.45	1.00	1.25
	Split	1.00	1.54	1.43	1.14
	Triple	1.54	1.02	1.22	1.00
Sum		17.12	26.88	23.58	16.09

Rolling Pattern

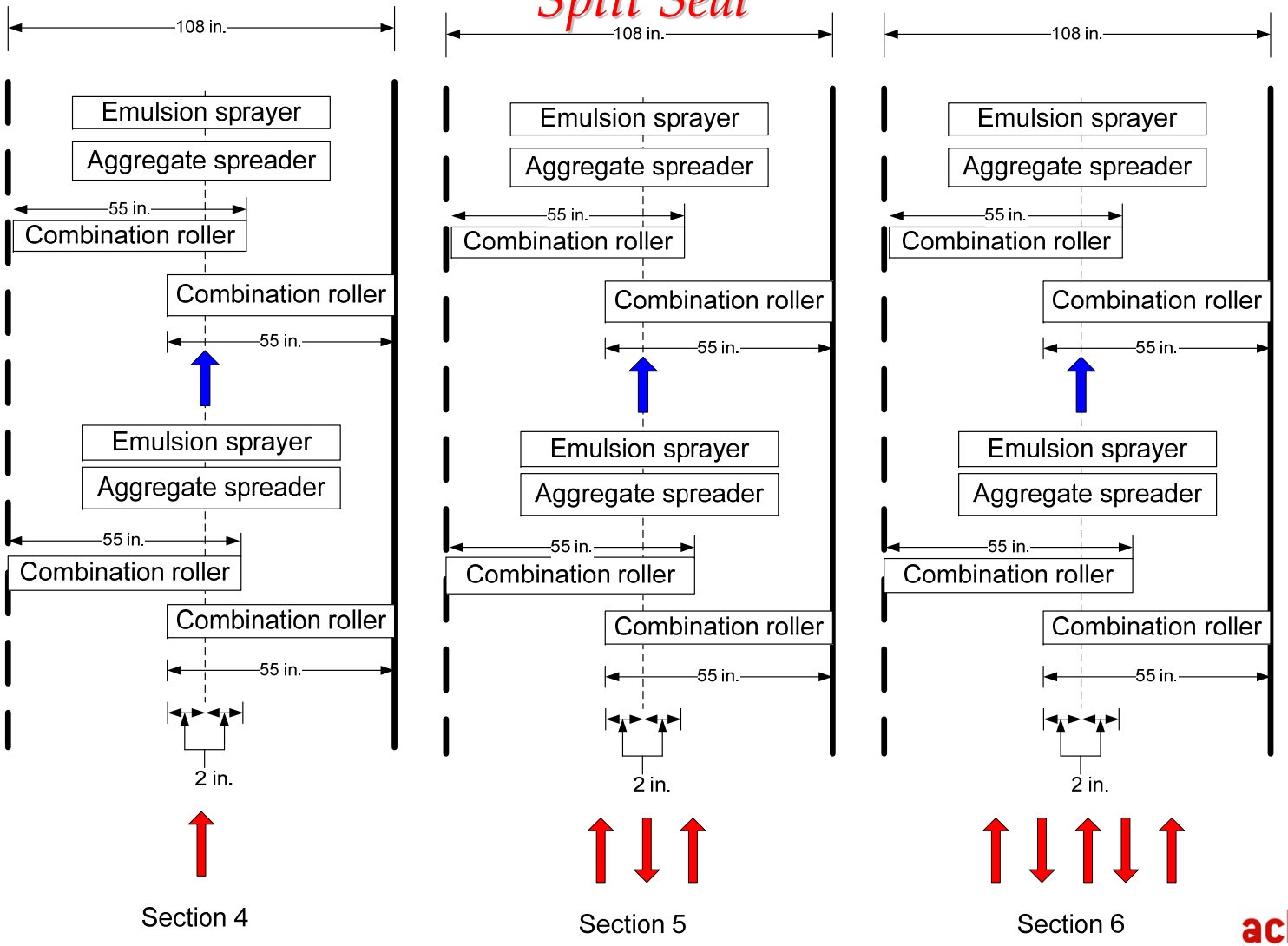
Straight Seal



Section 1 Section 2 Section 3

Rolling Pattern

Split Seal



Phase II Construction Schedule

Date	Section	Seal Type	Aggregate	Number of Coverages
Sep. 25 2006	1	Straight	Granite 78M	One
	2			Three
	3			Five
	4	Split	Granite 78M + Stalite 5/16"	One
	5			Three
	6			Five

Application Rates

Seal type		Aggregate		Emulsion
		Type	Application Rate (lb/yd^2)	Application Rate (gal/yd^2)
Straight		Granite 78M	17	0.35
Split	Bottom Layer	Granite 78M	17	0.25
	Top Layer	Stalite 5/16"	9	0.25

Note: The application rates were determined from a trial construction.

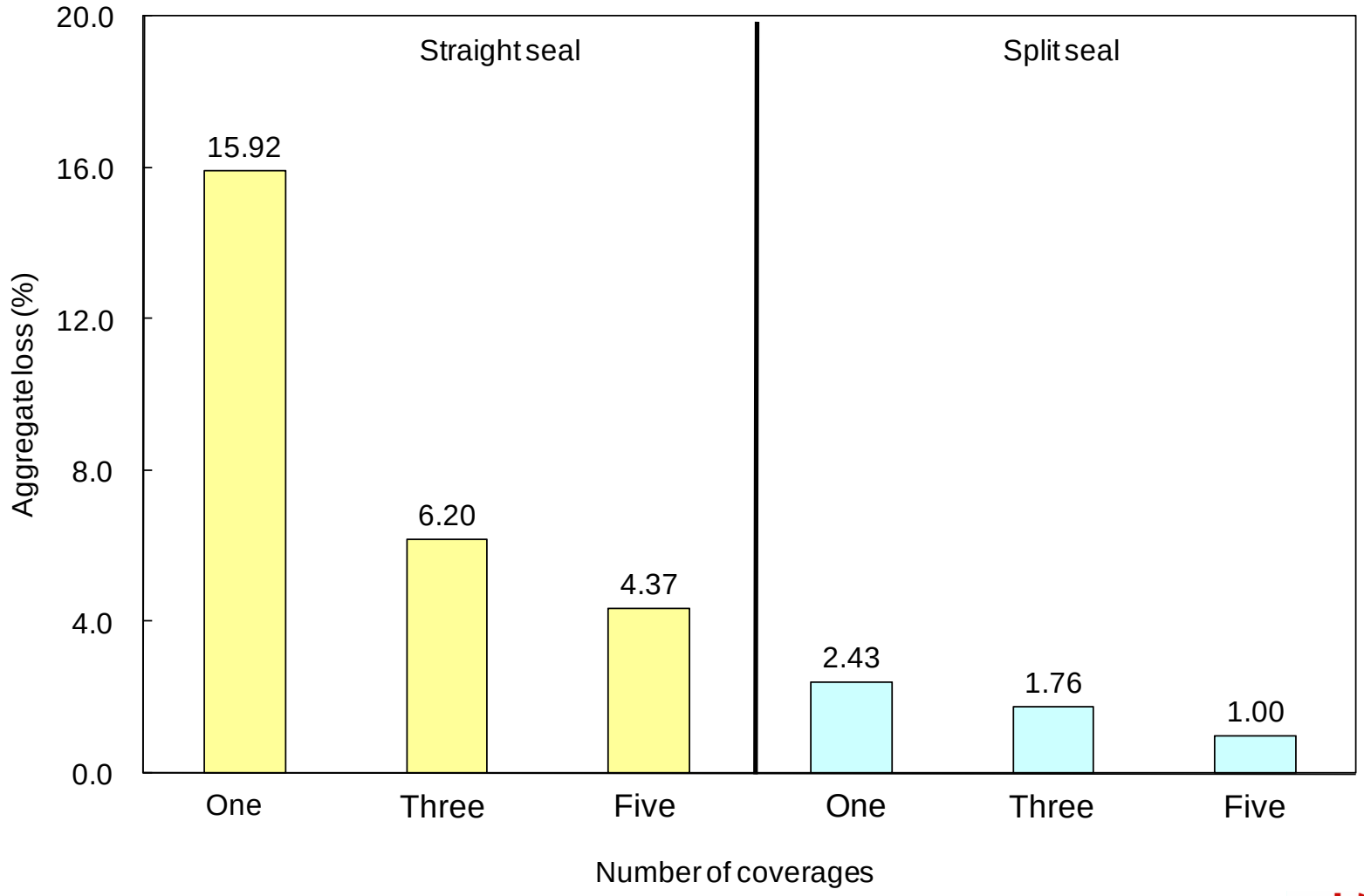
Placing Sample Templates

Spraying Emulsion

Spreading Aggregate

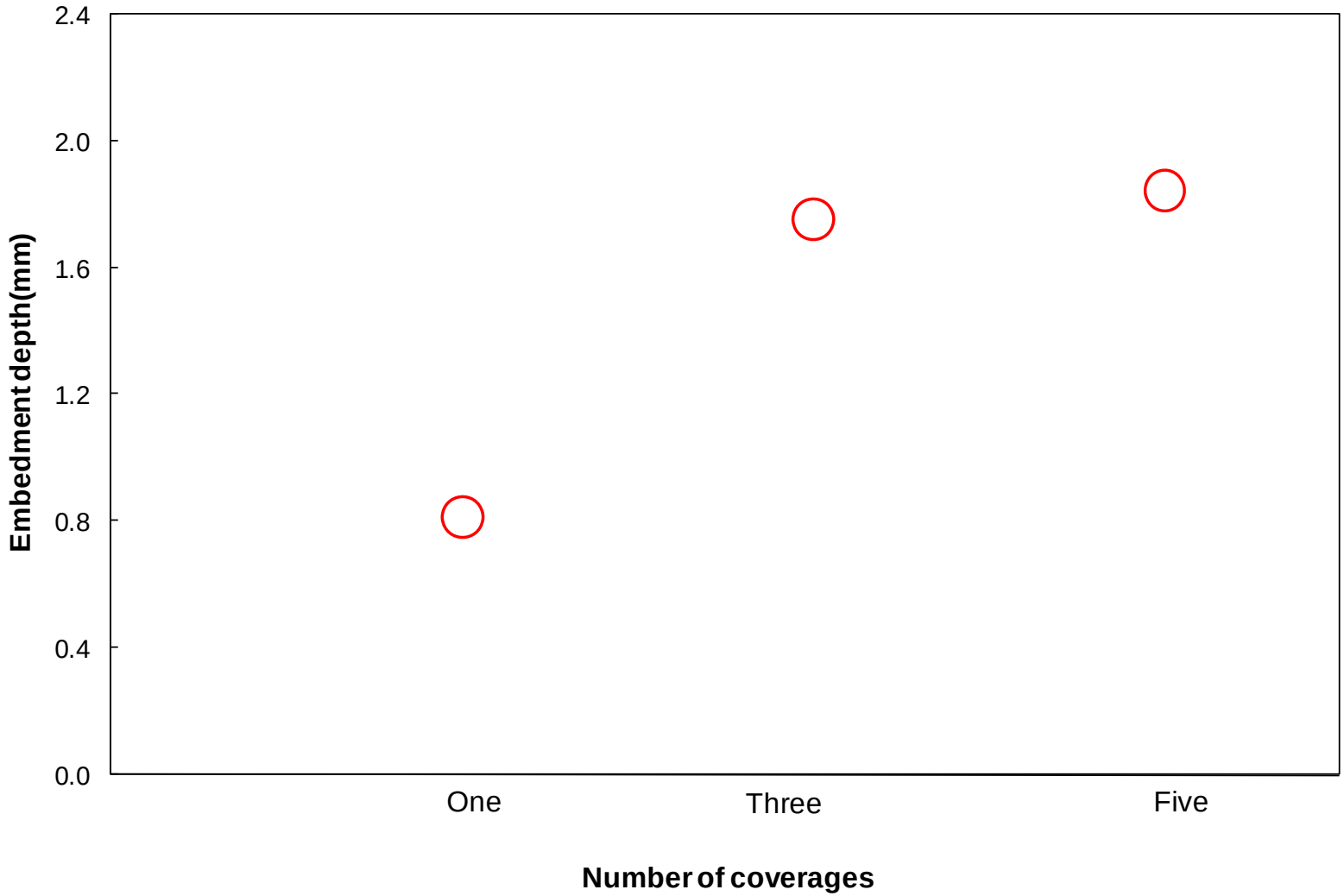
Rolling

Vialit Test Results



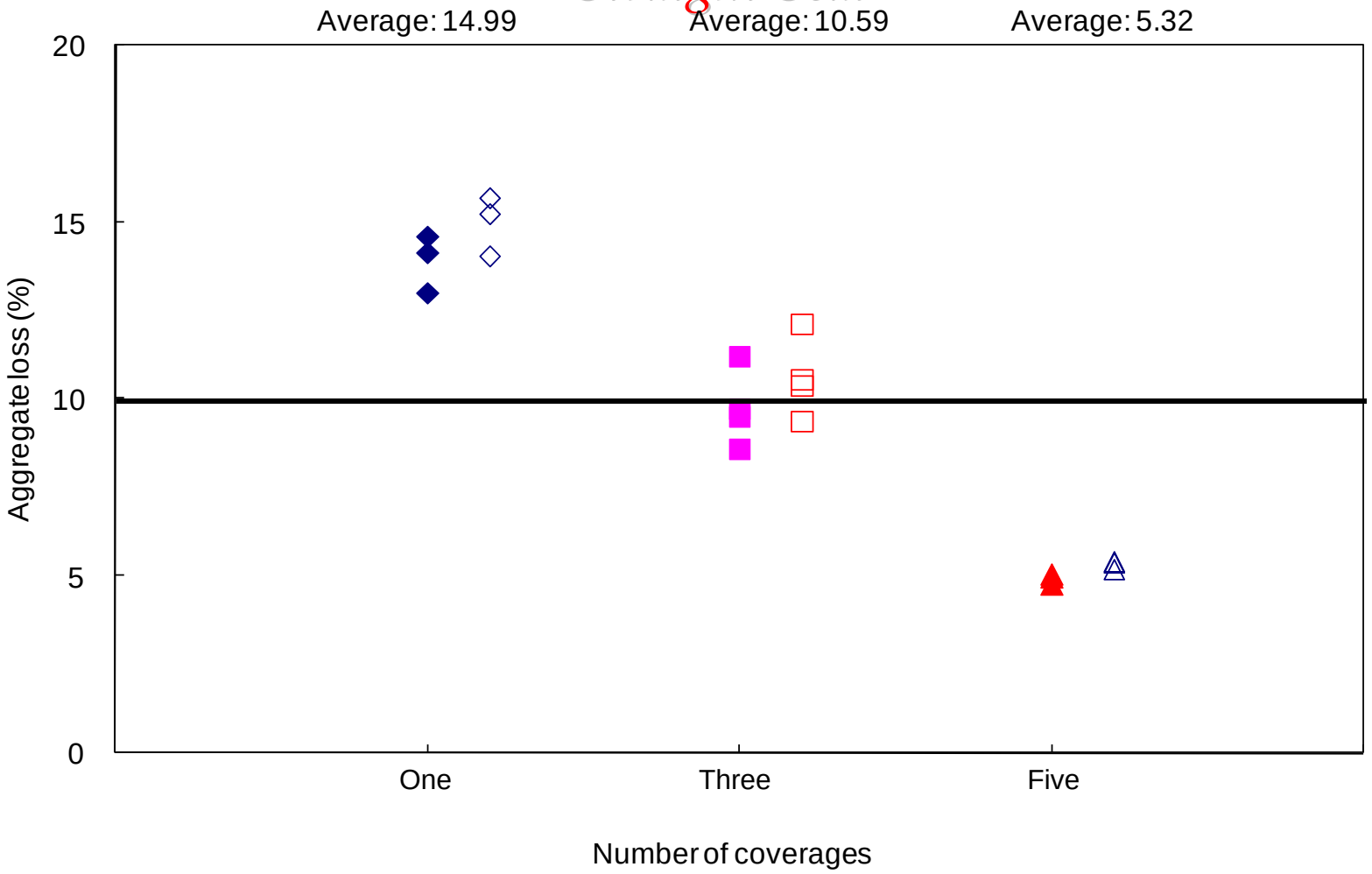
Modified Sand Circle Test

Determination of Embedment Depth (Straight seal)



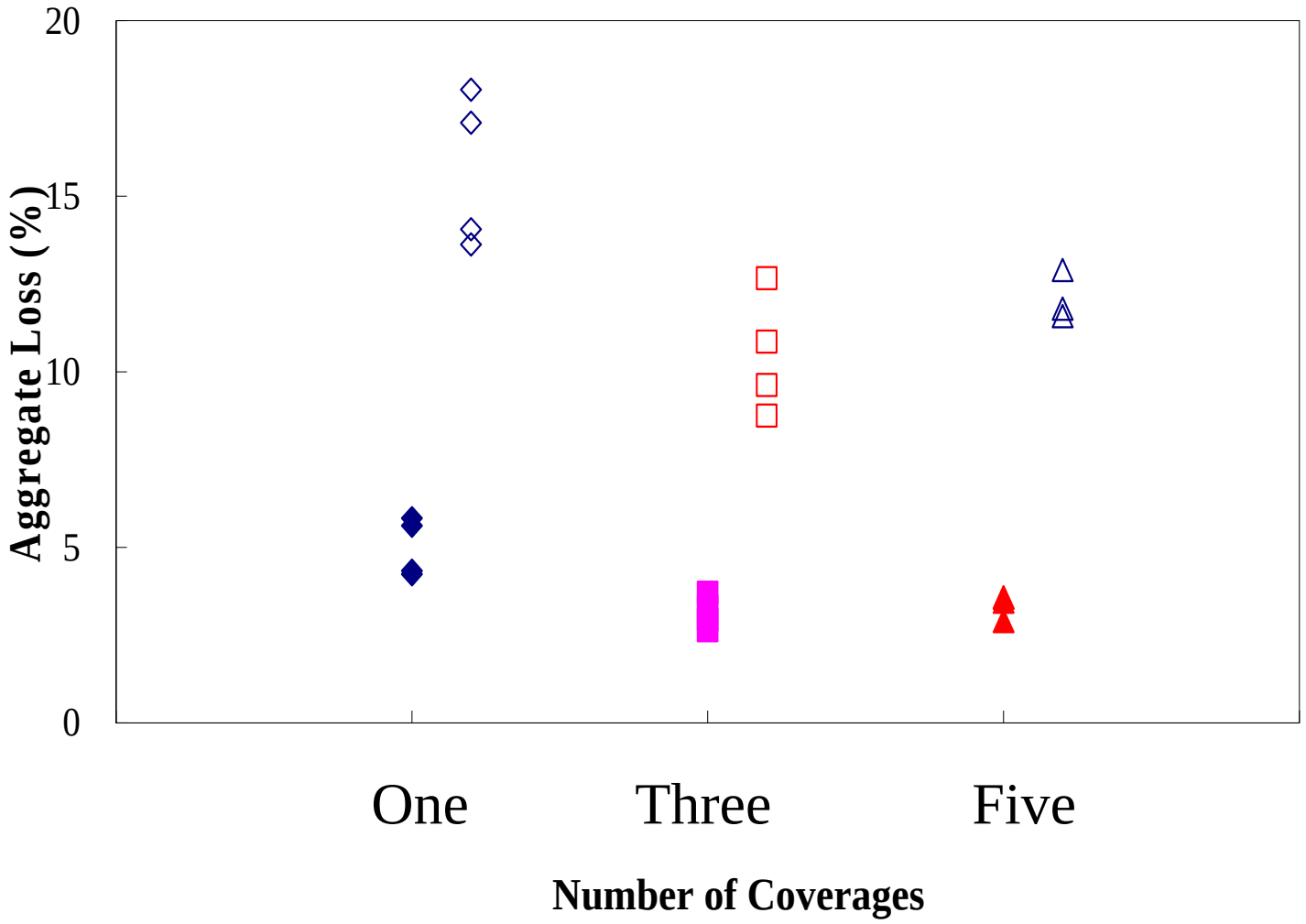
Flip Over Test

Straight Seal

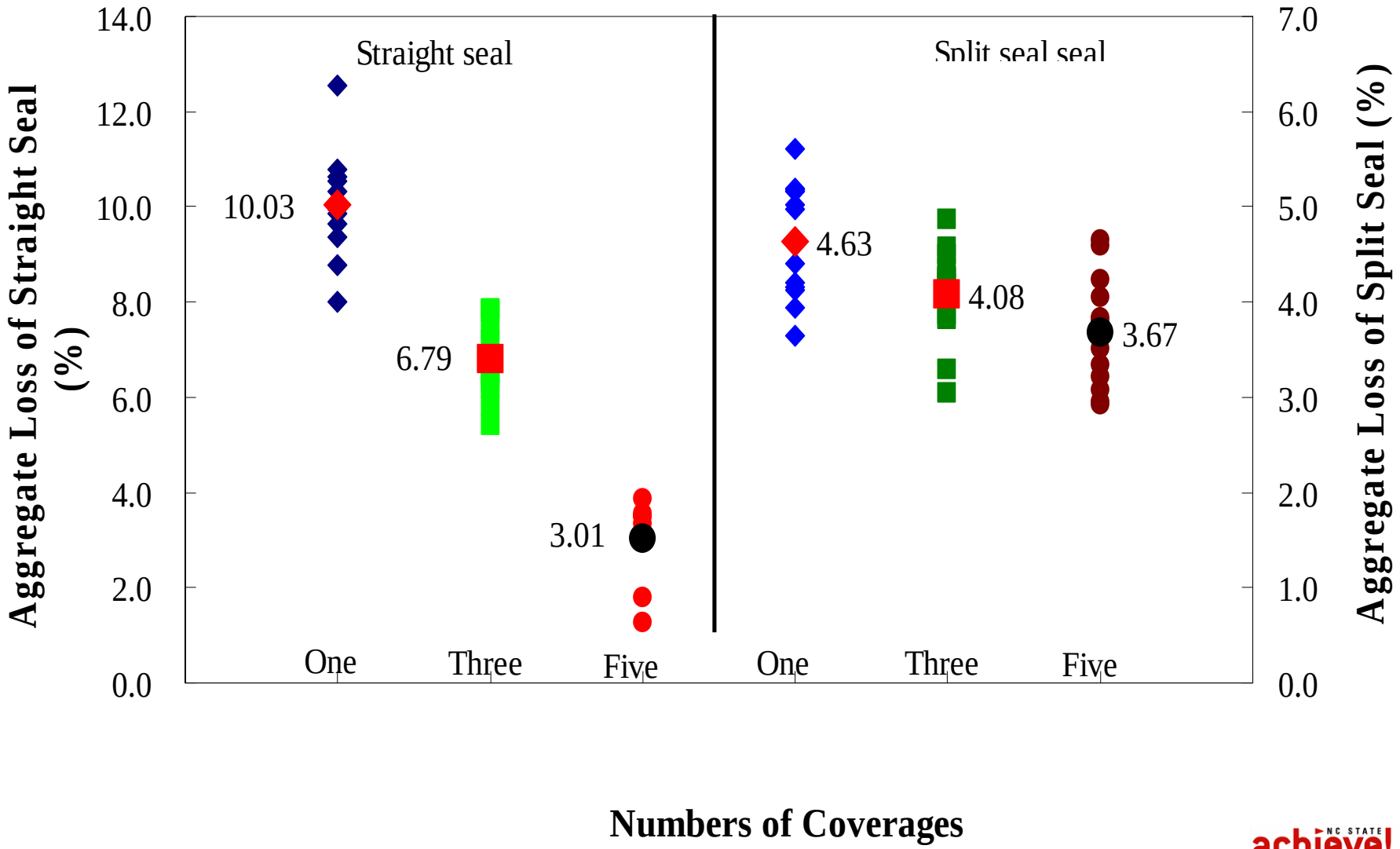


Flip Over Test

Split Seal



MMLS3 Test



Average Aggregate Loss

Test Method	Chip Seal Type	Number of Coverages		
		One	Three	Five
Vialit	Straight	15.62	6.20	4.37
	Split	2.43	1.76	1.00
FOT	Straight	14.99	10.59	5.32
	Split	15.71	10.47	12.09
MMLS3	Straight	10.04	6.79	3.02
	Split	4.63	4.09	3.68

Conclusions

- The aggregate loss decreases as the number of coverages increases.
- No significant improvement in adhesion between binder and aggregate exists between three and five coverages.
- The range of aggregate loss from the MMLS3 test is smaller than that of the other tests because some extra aggregate particles can be seated into the emulsion by the MMLS3 wheel loading.

Conclusions, Cont'd

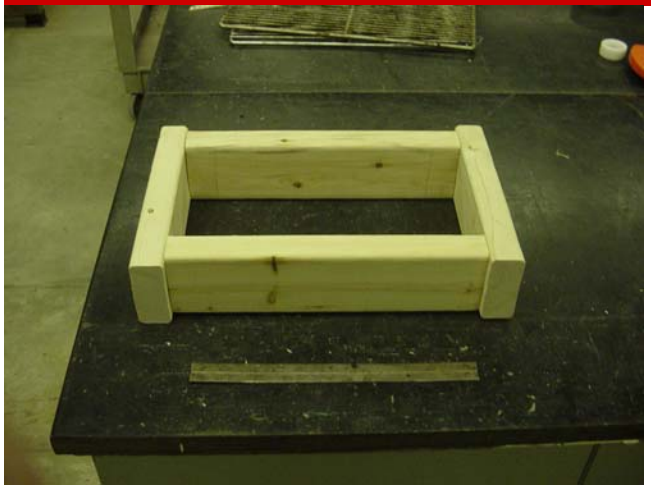
- No significant improvement in embedment depth between three and five coverages.
- Three coverages is selected as the optimum number of coverages.

Phase III Study

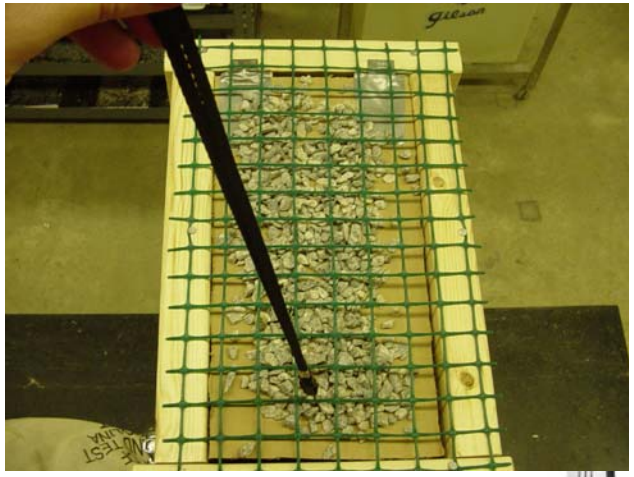
- To find the optimum rolling pattern
- Number of rollers to be investigated: 1, 2, and 3

Future Research

- Polymer modified emulsion
  - CHIPSS
  - Final Experimental Design
- Performance-based chip seal mix design method



CHIPSS



Designed to spread aggregate in a manner more similar to the field.

Final Experimental Design

Mix Design

	Agg. Combo	CRS-2	CRS-2P
Straight	#1	Done	2
	#2	Done	2
Split	#1	2	2
	#2	2	2
Triple	#1	2	2
	#2	2	2
		8	12
Total		**20 Tests**	

Final Experimental Design

Aggregate Loss and Bleeding

	Agg. Combo	PME #1	PME #2	PME #3	Unmodified Emulsion
Straight	#1	3	3	3	3
	#2	3	0	0	3
Split	#1	3	3	3	3
	#2	3	0	0	3
Triple	#1	3	3	3	3
	#2	3	0	0	3
		18	9	9	18
Total		**54 Tests**			

Final Experimental Design

Cracking

	Agg. Combo	PME #1	PME #2	PME #3	Unmodified Emulsion
Split	#1	3	3	3	3
	#2	0	0	0	0
		3	3	3	3
Total		**12 Tests**			

Thank you!