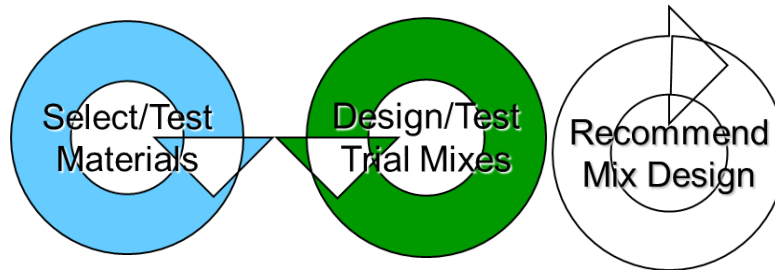


APPENDIX B: SAMPLE MIX DESIGNS

Mix Design Process (Caltrans MTAG, Chapters 8 and 9)



Select/Test Materials

- Pre-screen materials
- Check materials compatibility

Design/Test Trial Mixes

- Try different mixing proportions
- Prepare mixes at a range of emulsion contents
- Check for cohesion build-up
- Check for abrasion resistance
- Check for sand adhesion
- Additives
 - Emulsifier solutions, aluminum sulfate, aluminum chloride, borax
 - Generally act as retardants and are useful when temperatures rise during the day
- Select optimum emulsion content
- Test proposed mix to meet specification requirements

Recommend Mix Design

- Agency may make mix design recommendation or accept contractor's submittal after assurance testing

B-1 Slurry Seals (Caltrans MTAG, Chapter 9)

Materials

- Asphalt Emulsion with Polymer modification (Slurry Seals)
- Aggregate
- Mineral Filler
- Water
 - Must be compatible with the emulsion so that it doesn't separate
 - Must not have too much water, or it will possibly ravel
- Additives

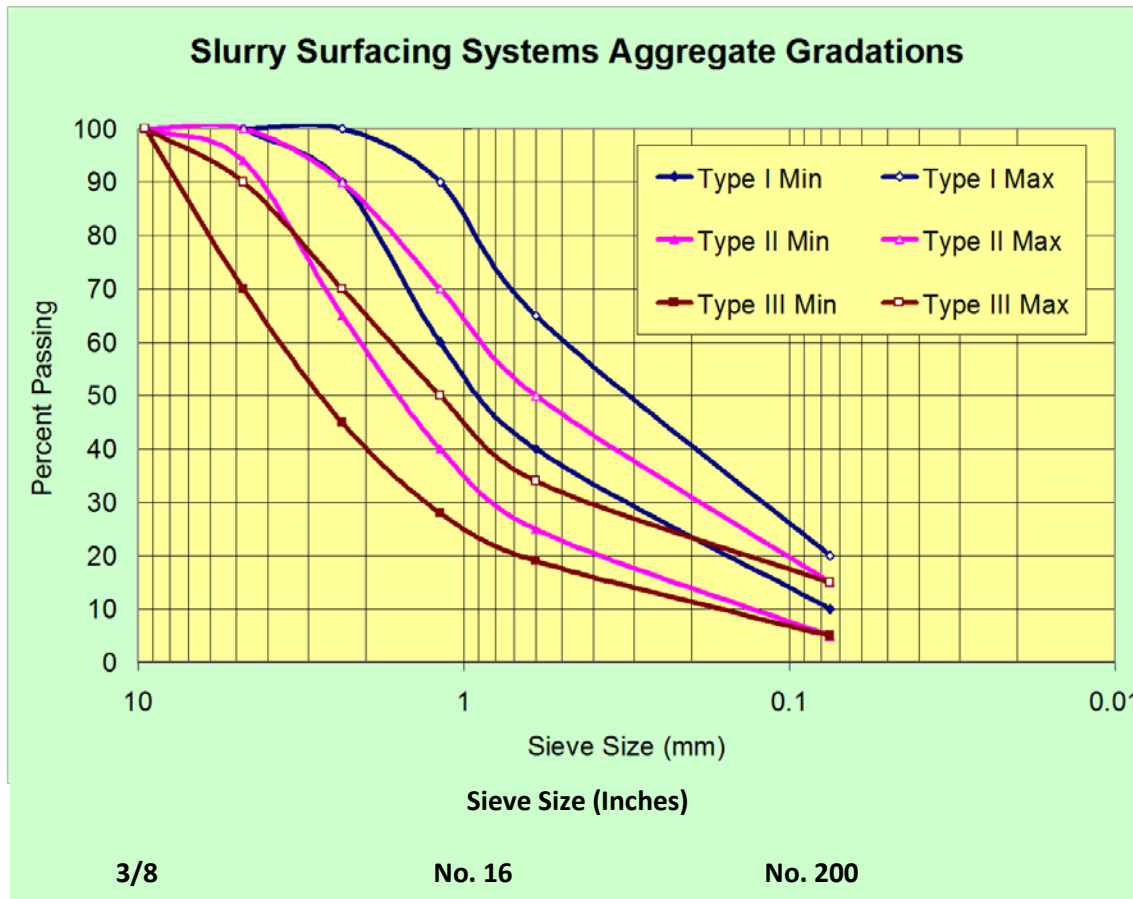
Slurry Seal Emulsions

- Type/Grade
 - Anionic/Quick Set (PMQS-1h)
 - Cationic/Quick Set (PMCQS-1h)
- Specification
 - Caltrans 2018 Standard Specifications, Section 94

Tests on Emulsion	Typical Specification (PMCQS1h)	Method
Viscosity, SSF @ 50°C, sec	15 – 90	AASHTO T 59
Sieve Test, %	< 0.30	AASHTO T 59
Settlement, 5 days, %	< 5	ASTM D 244
Storage Stability, 1 day, %	< 1	AASHTO T 59
Residue by Distillation, %	> 57	California Test 331
Particle Charge	Positive	
Tests on Residue from Distillation Test	Typical Specification	Method
Penetration, 25°C	40 – 90	AASHTO T 49
Ductility, 25°C, mm	> 400	AASHTO T 51
Solubility in trichloroethylene, %	> 97	AASHTO T 44

Slurry Seal Aggregate Gradation

Sieve	Type I Fine	Type II Medium	Type III Coarse
3/8 in (9.5mm)	-	100	100
No. 4 (4.75 mm)	100	94-100	70-90
No. 8 (2.36 mm)	90-100	65-90	45-70
No. 16 (1.18 mm)	60-90	40-70	28-50
No. 30 (600- μ m)	40-65	25-50	19-34
No. 200 (75- μ m)	10-20	5-15	5-15



Aggregate Quality

Test	Type I	Type II	Type III	Test Method
Sand Equivalent (min)	45	55	60	CT 217
Durability Index (min)	55	55	55	CT 229

- Other aspects of interest:
 - Geology
 - Shape
 - Texture
 - Age and Reactivity
 - Cleanness

Mineral Fillers

- Portland cement, hydrated lime, limestone dust, fly ash or other approved filler meeting the requirements of ASTM D242
- Considered part of the dry aggregate
- Mixing aid, improves cohesion, reacts with water from the emulsion causing it to break faster after placement

Mixing Properties

ISSA TB 102 (Mixing Test)



- Determine approximate proportions of component materials by trying different “recipes”

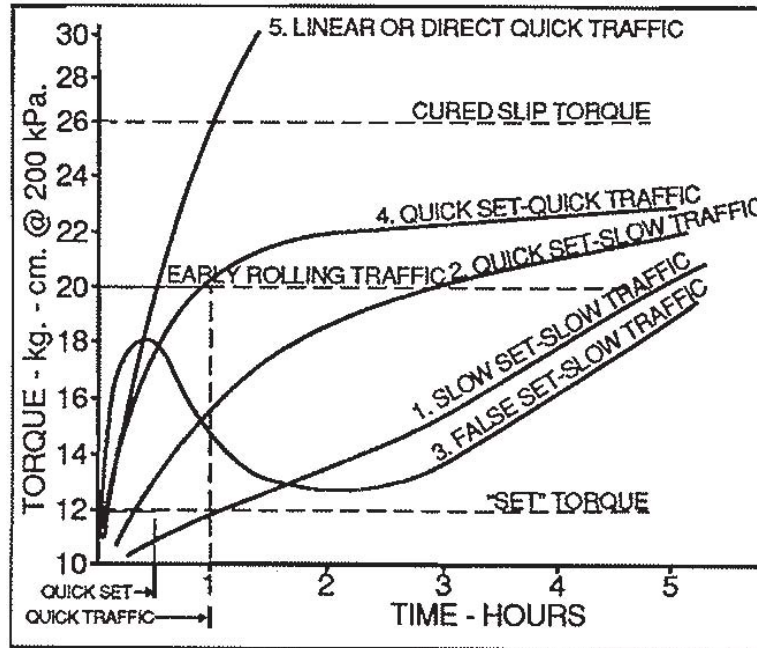
- The amount of time the slurry can be mixed and retain its homogenous consistency is recorded (mixing time)
- Foaming and coating are visually assessed
- The test can be performed at expected field humidity and temperature conditions
- Select the proportions that results in mixing times over 180 seconds for Slurry Seals or 120 seconds for Microsurfacing and good coating over the range of humidity and temperature condition expected at placement

ISSA TB 139 (Modified Cohesion Test)



- Fabricate 3 test specimens:
 1. At selected emulsion content
 2. -2% emulsion content
 3. +2% emulsion content
- Determine the build-up of cohesion with time
- Differentiate between “Quick Set” and “Slow Set”; “Quick Traffic” and “Slow Traffic” mixes

Cohesion Build UP (Slurry or Microsurfacing)

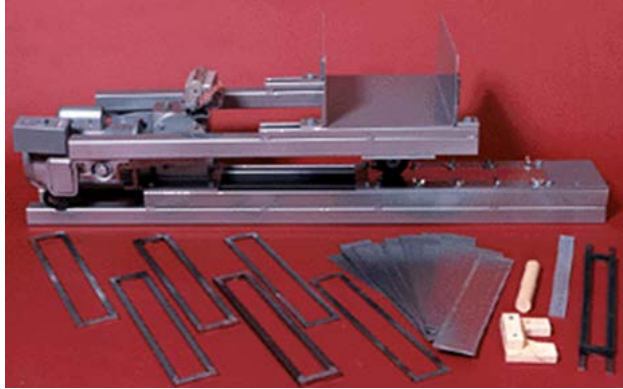


ISSA TB 100 (Wet Track Abrasion Test)



- Fabricate 3 test specimens:
 - At selected emulsion content
 - -2% emulsion content
 - +2% emulsion content
- Cure specimens for 16 hrs, then soak for 1 hr
- Determine abrasion loss under water
- Plot abrasion loss versus emulsion content

Sand Adhesion (Slurry/Microsurfacing)

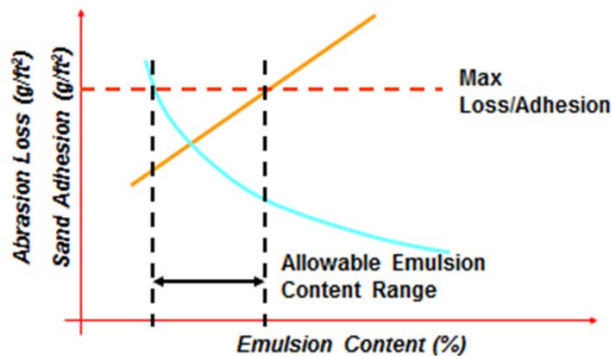


- Fabricate 3 test specimens:
 - At selected emulsion content
 - -2% emulsion content
 - +2% emulsion content

ISSA TB 109 (Loaded Wheel Test)

- Measure increase in weight of the specimen due to sand adhesion
- Plot sand adhesion versus emulsion content

Emulsion Content Selection (Slurry/Microsurfacing)



Caltrans Specification Requirements (Slurry Seals)

Property	Test	Requirement
Consistency	ISSA TB 106	< 1.2 in.
Wet Stripping	ISSA TB 114	Pass
Compatibility	ISSA TB 115	Pass
Cohesion, 1 hr.	ISSA TB 139	> 200 kg-mm
Wet Track Abrasion Loss	ISSA TB 100	< 800 g/m ²

Final Notes for Slurry Seals

- Project selection

Chip seals are also an attractive maintenance treatment for many projects. Before making a choice between slurry surfacing or a chip seal, consider the following:

- aggregate availability for project type
- location of project, i.e., rural setting vs. town or city
 - smoothness criteria for town or city may make slurry surfacing a better choice
 - rougher surface for higher skid resistance on rural roads with higher traffic speeds is one criteria for chip seals
 - in high intensity rainfall area, a chip seal may be a better choice for possible hydroplaning.

- construction equipment availability to meet scheduling needs

- slurry surfacing requires specialized equipment
- chip seals use more conventional equipment

- asphalt concrete rejuvenating treatments are more available with chip seals

Slurry surfacing is also frequently used in combination with various types of chip seals to form a “cape seal”.

- Design is generally performed by certified laboratory, Caltrans or agency will only review and accept
- Designer needs to have extensive experience with slurry systems

B-2 Microsurfacing (MTAG, Chapter 9)

Materials

- Asphalt Emulsion with Polymer Modification (Microsurfacing)
- Aggregate
- Mineral Filler
- Water
 - Must be compatible with the emulsion so that it doesn't separate
 - Must not have too much water so that it doesn't ravel
- Additives

Microsurfacing Emulsions

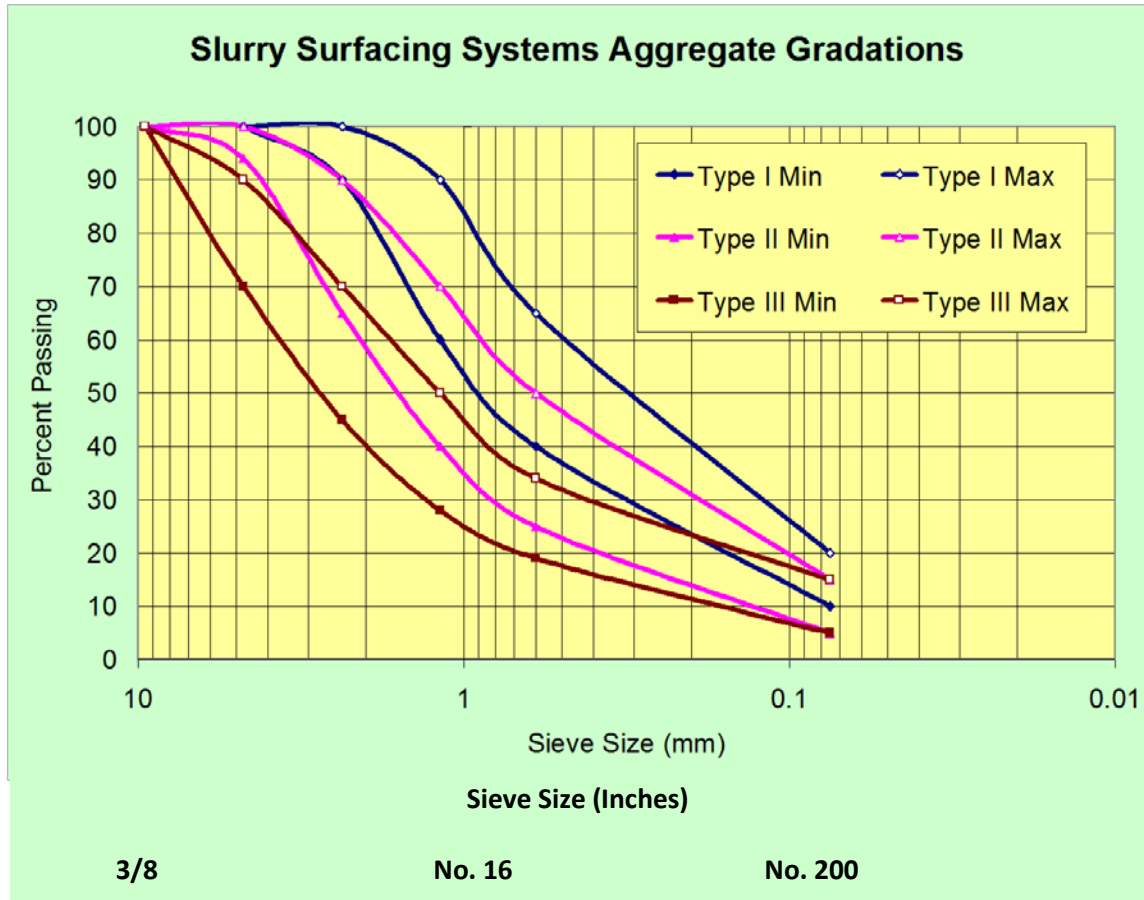
- Type/Grade
 - Polymer Modified Anionic/Quick Set (PMQS-1h)
 - Polymer Modified Cationic/Quick Set (PMCQS-1h)
 - Always polymer-modified. If Latex is used, the emulsion may be called latex-modified (LM)
- Specification
 - Caltrans proposed "Microsurfacing Emulsion" (MSE)

Microsurfacing Emulsion Tests

Tests on Emulsion	Typical Specification	Method
Viscosity, SSF @ 25°C, sec	15 – 90	AASHTO T 59
Settlement, 5 days, %	< 5	ASTM D 244
Storage Stability, 1 day, %	< 1	AASHTO T 59
Sieve Test, %	< 0.30	AASHTO T 59
Residue by Evaporation, %	> 62	California Test 331
Tests on Residue from Evaporation Test	Typical Specification	Method
Penetration, 25°C	40 – 90	AASHTO T 49
Softening Point, °C	> 57	AASHTO T 53
G* @ 20°C, 10 rad/sec, MPa	Report Only	AASHTO TP 5
Phase Angle @ 50°C, 10 rad/sec, PA(max) – PA base	Report Only	AASHTO TP 5
Stiffness @ -12°C, MPa M-Value	Report Only	AASHTO TP 1
Torsional Recovery, %	> 18% (LMCQS-1h)	California Test 332
Polymer Content	> 2.5% (LMCQS-1h)	California Test 401

Aggregate Gradation for Microsurfacing

Sieve	Type I Fine	Type II Medium	Type III Coarse
3/8 in (9.5mm)	Not currently used	100	100
No. 4 (4.75 mm)	100	94-100	70-90
No. 8 (2.36 mm)	90-100	65-90	45-70
No. 16 (1.18 mm)	60-90	40-70	28-50
No. 30 (600-µm)	40-65	25-50	19-34
No. 200 (75-µm)	10-20	5-15	5-15



Microsurfacing Aggregate Quality Tests

Test	Criteria	Test Method
Sand Equivalent (min)	> 65	CT 217
Durability Index (min)	> 55	CT 229
Abrasion (LA Rattler, 500 rev.)	< 35%	CT 211
Crushed Particles	100%	CT 205

Microsurfacing Mineral Fillers and Additives

- Any recognized brand of non-air entrained portland cement or hydrated lime that is free from lumps
- Considered part of the dry aggregate
- Mixing aid, improves cohesion, reacts with water from the emulsion causing it to break faster after placement
- Emulsifier solutions, aluminum sulfate, aluminum chloride, borax

- Generally act as retardants and is useful when temperatures rise during the day

Mix Design Procedure the Same as for Slurry Seal

- ISSA TB 102 (Mixing Test)
- ISSA TB 139 (Modified Cohesion Test)
- Cohesion Build UP (Slurry or Microsurfacing)
- ISSA TB 100 (Wet Track Abrasion Test)
- ISSA TB 109 (Loaded Wheel Test)
- Emulsion Content Selection (Slurry/Microsurfacing)

Microsurfacing Notes

- Project selection
- Design is generally performed by certified laboratory, Caltrans or agency will only review and accept
- Designer needs to have extensive experience with slurry systems

B-3 Microsurfacing (Arizona Chapter AGC Pavement Preservation Series, “Micro Surface and Slurry Seal Guide for Application and Construction)

Micro-Surfacing Treatment

Component	Proportions	Tolerances
Optimum emulsion content, % (by weight of dry aggregate)	12.0	11.0 - 13.0
Residual asphalt content, % (by weight of dry aggregate at a residue content of 66.3%)	8.0	7.30 - 8.6
Type I Portland Cement, % (by weight of dry aggregate)	0.3	0.1 - 2.0
Aluminum Sulfate, % (by weight of dry aggregate)	0.2	As Required
Mix water, % (by weight of dry aggregate)	9.0	As Required

*Temperature and wind conditions during field applications may vary from controlled laboratory conditions requiring modification of the water content to maintain a smooth, free flowing homogeneous mixture. Only as much additional water as necessary to maintain proper working consistency, without segregation and/or separation, should be used.

RESIDUE BY EVAPORATION (AI 512)

Residue by Evaporation, Average of three points:

66.3%

MICRO SURFACING MIXTURE TESTS (ISSA Methods)

Parameter	Results	Comments	Specified Limits
Consistency at 2.5cm (ISSA TB-115)	Satisfactory	Pass	2.5 to 3.0 cm
Split Consistency (ISSA TB-115)	Uniform	Pass	No Asphalt or Aggregate Migration
Slurry seal Setting test, 75°-79°F 120 sec.(ISSA TB-102)	Consistent Slurry	Pass	Uniform Aggregate and Dispersion
Slurry seal Setting test, 75°-79°F 60 minute cure (ISSA TB-102)	No Stains	Pass	No Brown Stain
Wet Stripping (TB-114)	100%	Pass	90% Minimum Coating

WET TRACK ABRASION (ISSA T8-100)

Emulsion Content (%)	Mixing Water (%)	Total Fluid (%)	Consistency Test (cm)	Residual AC Content (%)	One Hour Soak		6 Day Soak	
					Abrasion (Grams/sq.ft)	Specification	Abrasion (Grams/sq.ft)	Specification
10	11	21	2.8	6.6	17.4	50 grams/sq ft. Max	17.9	75 grams/sq ft. Max
12	9	21	2.8	8.0	11.8		11.7	
14	7	21	2.8	9.3	9.8		8.9	

SAND ABRASION (ISSA T8-109)

TACK POINT

Cycles	Load (lb)	Temperature (°C)
1000	125	22

SAND ADHESION

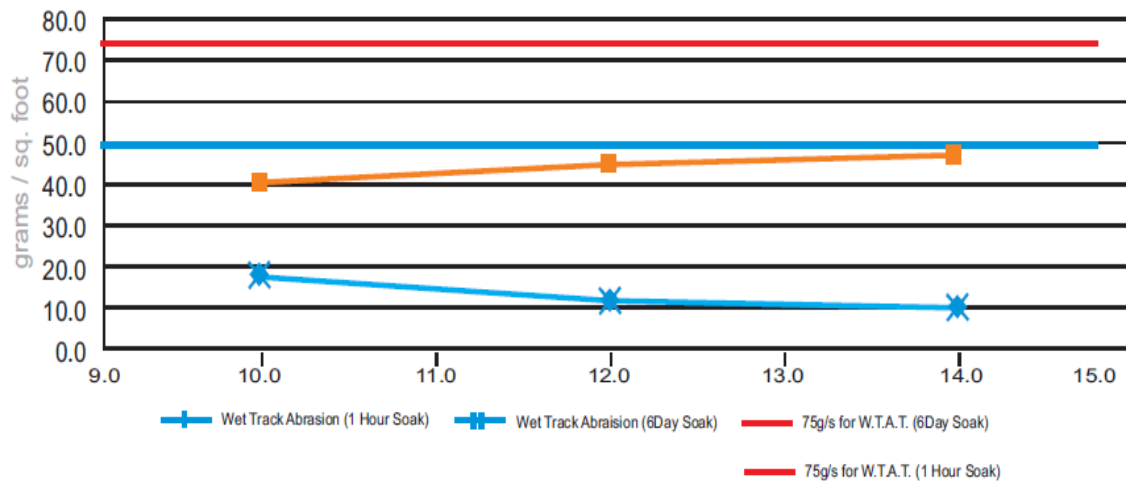
Vehicles/day
>3000

Emulsion Content (%)	Cycles	load (lb)	Temperature (°C)	Weight (grams)	Sand Adhesion (grams/sq.ft.)	Specification
10%	100	125	22	5.4	41.5	50 grams/sq.ft. Max
12%	100	125	22	5.8	44.6	
14%	100	125	22	6.1	46.9	

LATERAL DISPLACEMENT AND SPECIFIC GRAVITY AFTER 1000 CYCLES OF 125 lb. (ISSA T8-147)

Emulsion Content (%)	Lateral Displacement ISSA (TB-147)		Specific Gravity ISSA (TB-147)	
	(%)	Specification	Compacted SPGR	Specification
12.0%	1.3%	5.0% Max	1.953	2.10 Max

VARIATION OF WET TRACK ABRASION & SAND ADHESION WITH EMULSION CONTENT



COHESION (ISSA TB-139)

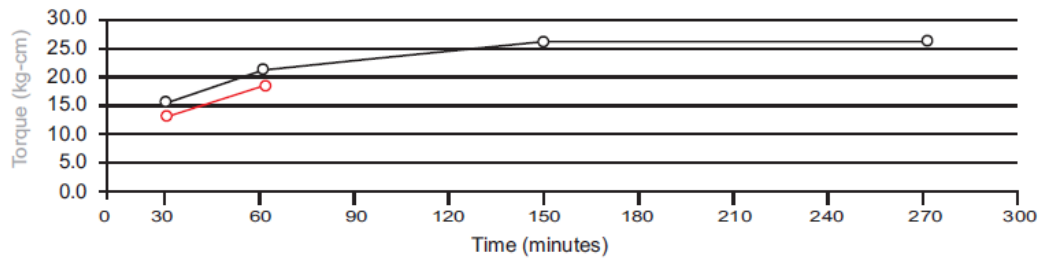
CALIBRATION

20/20 MESH OTTAWA SAND	4.8 KG-CM
-#5/16 MATERIAL	4.8 KG-CM

COHESION DATA

Time (min)	Torque (kg-cm)	Specification, min. (kg-cm)
30	15.0	12
60	22.0	20
90	23.0	-
150	26.0	-
210	26.0	-
270	26.0	-

VARIATION OF TORQUES WITH TIME



AGGREGATE

Sieve Size	% Passing	Mix Design Specs Type III	Production Band
3/8"	100	100	100
#4	81	70-90	76-86
#8	51	45-70	45-56
#16	34	28-50	29-39
#30	25	19-34	20-30
#50	18	12-25	14-22
#100	13	7-18	10-16
#200	9.1	5-15	6.1-12.1

	Mix Design Specification
Sand equivalent (MSHTO T 176)	63 Min 60
Fractured Face (AZ 212)	100% 95% (at least 1-FF)
Uncompacted Void Content (AZ 247)	47.5% Min 45.0%
Specific Gravity.(ARZ. 211b)	2.593% -

THEORETICAL BATCH PROPORTIONS

Material	Quantity (lbs)	% by Weight of Dry Aggregate	Tolerances	
			Minimum	Maximum
Type III Micro-Surfacing Aggregate	2000	-	-	-
Type I Portland Cement	6	0.3	0.1	2.0
Optimum Emulsion Content	240	12.0	11.0	13.0
Mixing Water	180	9.0	--	--
Theoretical Asphalt Content	-	8.0	7.3	8.6
Aluminum Sulfate	-	0.2	--	-

Table 1 : SB Test Results (ISSA TB 144)

Test	Result	Requirement
Aggregate #654 + 12.9% Emulsion, 10% Water, 0.5% Cement		
SB,s (TB 144) - Points	12	11 Min (12 possible)
- Absorption	1.73g	no spec
- Abrasion	0.53g	0-0.7g = 4 points
- Integrity	98.32%	90-100 = 4 points
- Ruck Adhesion	99%	>90 = 4 points
Aggrgate #654 + 12.9% Emulsion, 10% Water, 0.5% cement. 0.1% Sulfate (38%)		
SB's (TB 144) - Points	12	11 Min (12 possible)
- Absorption	1.4g	no spec
- Abrasion	0.45g	0-0.7g = 4 points
- Integrity	98.54%	90-100 = 4 points
- Ruck Adhesion	98%	>90 = 4 points
Aggrgate #654 + 12.9% Emulsion, 10% Water, 1.0% cement. 0.1% Sulfate (38%)		
SB's (TB 144) - Points	12	11 Min (12 possible)
- Absorption	1.19g	no spec
- Abrasion	0.65g	0-0.7g = 4 points
- Integrity	98.02%	90-100 = 4 points
- Ruck Adhesion	98%	>90 = 4 points

ASPHALT CLASSIFICATION SUMMARY

AMEC Lab No.: 1239827
 Grade: PMCQS-1h
 Tank No.: C-4
 Sample ID: np
 Date Received: 05-07-2012
 Sample Date: 05-07-2012
 Sample Type: Concentrate

Tests on Emulsion	Test Method	Spec	
Saybolt Furol Viscosity, (77°F), s	AASHTO T59	20-100	50
Sieve Test, %	AASHTO T59	0.10 max	0.00
Particle Charge	ASHTO 159	Positive	Positive
Storage Stability, 24 hrs, %	AASHTOT59	1.0 max.	0.12
Residue by Evaporation, %	ARIZ 512	60 min.	66.3
Tests on Residue from Distillation to 350°F			
	AASHTO T59		
Kinematic Viscosity, 275°F cSt	AASHTO T201	650 min.	4,378
Penetration, (77°F), 100o, 5s dmm	AASHTO T49	40 - 90	64
Softening Point of °F	AASHTO T53	140 min.	147
Ductility, (177°F), 5cm/min cm	AASHTQ 151	60 min.	150+
Elastic Recovery, (77°F), %	AASHTO T301	55 min.	80