TENTATIVE SPECIFICATIONS FOR SLURRY SEAL AND MICROSURFACING

Published by
INDIAN ROADS CONGRESS
Kama Koti Marg
Sector 6, R.K. Puram,
New Delhi-110 022
2008

Price Rs. 100.00
(Packing & Postage Extra)

IRC:SP:81-2008

First Published : November, 2008

Reprinted : October, 2009

Reprinted : May, 2015

Printed at Aravali Printers & Publishers, New Delhi-110 020
(1000 copies)

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STANDARDS [illegible]

(As on 28th March, 2008)

[illegible] Shipping Road Transport &

[illegible] New Delhi

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TENTATIVE SPECIFICATIONS FOR SLURRY SEAL AND MICROSURFACING

1. INTRODUCTION

1.1. Flexible Pavement Committee (H-2) of Indian Roads Congress in its meeting held on 1st August, 2003, decided to prepare a draft standard specification covering slurry seal and microsurfacing for preventive maintenance of flexible pavements under the title "Development of New Documents, Priorities and Programmes". A Sub-Group consisting of Dr P.K.Jain, S/Shri Gurdip S. Khinda, Rajesh Kumar Jain and S.K.Nirmal prepared the draft based on findings of the studies conducted by CRRI after detailed deliberations.

The draft finalised by the Sub-Group was again circulated to the members of the newly formed Flexible Pavement Committee as decided in its meeting held on 22nd April, 2006.The document and comments received were further discussed in subsequent meeting of Flexible Pavement Committee on 5th May, 2007.The Committee decided to publish the revised and updated draft in "Indian Highways" for wider circulation and for inputs of Highway profession. The document was, therefore, published in August 2007 issue of Indian Highways.

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1.2. The document was further revised by Dr P.K.Jain with the inputs from the members of the Group, experts in the area. The revised document and comments were further deliberated in the meeting of Flexible Pavement Committee on 6th October, 2007.The draft was further revised by Dr. P.K.Jain and Shri Satish Pandey, Scientists,CRRI, in the light of comments, considering studies conducted by CRRI and IIT Madras. The Committee in its meeting held on 9th February, 2008 approved the draft as Tentative Specifications. The draft document was approved by HSS Committee in its meeting held on 28th March, 2008. The draft document was finally approved by the IRC Council in its meeting held on 11th April, 2008 at Aizawl (Mizoram).

2. SCOPE

2.1. This document covers tentative specifications for design and laying of following maintenance treatments:

(a) Slurry Sealing
(b) Microsurfacing

The intent of this document is to aid highway profession in selection of applicability of slurry sealing and microsurfacing treatments for preventive maintenance/renewal treatment of flexible pavements and preservation of pavement strength besides rectification of surface defects like minor cracks, dry and hungry surface due to ageing, wear and tear due to passage of traffic.

2.2. The specifications of materials, mix design, testing methods, quality control, preparation of receiving surface, choice of the type of slurry seal and microsurfacing with respect to pavement conditions and application limitations are also dealt in this document. Repair of hair cracks by slurry seal as pre-treatment before application of rehabilitation treatments are also covered in these specifications.

3. APPLICATION LIMITATIONS

The slurry sealing and microsurfacing treatment has following application limitations:

- These shall be used only on existing bituminous surface.
- These treatments shall be laid on structurally sound pavements.
- These shall be laid on surface with satisfactory riding quality .
- The existing surface shall not have severe distress.

- The existing surface shall not have wide and deep cracks.
- Slurry seal may be used for low traffic conditions.
- Microsurfacing may be used for low and medium traffic conditions.
- These specifications can be used for preventive maintenance as well as periodic renewals.
- Slurry seal can be used to treat minor surface defects like cracks and polished surface.
- These can also be used for delay of reflection cracking as Cap Seal.
- The expected life of these treatments is three to four years.

4. SLURRY SEAL

4.1. Description

The slurry seal shall consist of a mixture of slow setting cationic bitumen emulsion, mineral aggregate, water and additives (if needed) proportioned, mixed and uniformly spread over a properly prepared surface. The finally laid slurry seal shall have a homogenous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its service life. This treatment shall be used only for preventive maintenance and renewal treatment as substitute of surface dressing, open graded premix carpet and mix seal surfacing for low traffic roads. However, slurry seal can also be used for repair of minor surface defects like hair line and fine cracks. The types of slurry seal that can be used for each of the applications, quantity of slurry seal (in terms of weight of dry aggregates), thickness and the residual binder content in each type are provided in **Table 1**.

4.2. Materials

4.2.1. Binder: The cationic bitumen emulsion shall be SS-2 and conforming to IS 8887.

4.2.2. Aggregates: The mineral aggregate shall consist of crushed stone dust, clean, hard, durable, uncoated, dry particles and shall be free from dust, soft particles, organic matter or other deleterious substances. The aggregate should satisfy the physical requirement given in **Table 2**. The target aggregate grading (including mineral filler) shall conform to one of the three types as given in **Table 3.** If more than one nominal size of aggregates is used to produce the required grading, the correct amount of each type of aggregate used shall be proportioned separately, so as to meet the requirement of grading as per **Table 3**, prior to adding other materials in the mixture, in a manner that will result in uniform and homogeneous blend.

After the target gradation has been submitted, then the percent passing each sieve shall not vary by more than the tolerance limits and still remain within the gradation band. The tolerance limits of aggregates size 600 μm to 4.75 mm shall be ± 5%, 300 μm ± 4%, 150 μm ± 3% and 75 μm ± 2% respectively. The aggregate will be accepted based on average of five gradation tests at the job location or stockpile of aggregates.

Table 1: Different Types of Slurry Sealing

Items	Type I (2-3 mm)**	Type II (4-6 mm)**	Type III (6-8 mm)**
Applications	For filling hair cracks on surface less than 1 mm.	For filling surface cracks (1-3 mm), and preventive/ renewal treatment (Upto 450 CVPD)	For filling surface cracks (3-6 mm) and preventive/ renewal treatments (Upto 1500 CVPD)
Quantity* of Slurry (kg/m^2)	4.3 to 6.5	8.4 to 9.8	10.1 to 12
Residual binder (percent by weight of dry aggregate)	10 to 16	7.5 to 13.5	6.5 to 12

* In terms of by weight of dry aggregate only ** Indicative only

Table 2: Properties of Aggregates

Properties	Test Method	Specification
Sand Equivalent Value	IS 2720 (Part 37)	Min. 50
Water Absorption*	IS 2386 (Part 3)	Max. 2
Soundness (with Sodium Sulphate) Soundness (with Magnesium Sulphate)	IS 2386 (Part 5)	Max. 12 Max. 18

* In case water absorption exceeds 2% but less than 4%, same may be permitted subject to conformity of soundness test and wet stripping test.

Table 3: Grading of Aggregates

Sieve Size	% Passing (Minimum Layer Thickness)		
	Type I (2-3 mm)	Type II (4-6 mm)	Type III(6-8 mm)
9.5 mm			100
6.3 mm		100	90-100
4.75 mm	100	90-100	70-90
2.36 mm	90-100	65-90	45-70
1.18 mm	65-90	45-70	28-50
600 micron	40-65	30-50	19-34
300 micron	25-42	18-30	12-25
150 micron	15-30	10-21	7-18
75 micron	10-20	5-15	5-15

4.2.3. Filler: Mineral filler shall be ordinary Portland cement. The quantity of filler shall be preferably in the range of 0.5 to 2% by weight of dry aggregate.

4.2.4. Water: The water shall be potable, free from harmful salts and contaminants. The pH value of water shall be in the range of 6 to 7.

4.2.5. Additive: Chemical additive may be used to accelerate or retard the break-set time of the slurry or to improve the resulting finished surface. The quantity of additive, if used, shall be decided by mix design and to be adjusted as per field/climate conditions such as humidity and temperature at site. The specification of needed additive shall be supplied by suppliers of emulsion. The additive and emulsion shall be compatible with each other.

4.3. Design of Slurry Seal Mix and Proportioning

4.3.1. The compatibility of aggregate, emulsion, filler and additive (if needed) shall be verified by mix design for a selected type and grading of aggregate as specified in **Tables 2** and **3**. The design criteria for slurry seal mixture is specified in **Table 4.** The proposed slurry seal mixture shall conform to the specified requirements, when tested in accordance with tests specified in **Table 4**. The mix design report shall clearly show the proportions of aggregate, filler, water, and residual bitumen content based on the dry weight of aggregates, additive usage (if any). The mixing time of slurry mix shall be determined by the method given in **Appendix-1.** The set time of designed mix (maximum 2 hours) shall be checked by procedure given in **Appendix-2.**

Table 4: Mix Design Criteria for Slurry Seal Mix

Requirements	Specifications	Test Methods
Mix Time, minimum	180 s	**Appendix-1**
Consistency, maximum	3 cm	**Appendix-3**
Wet Cohesion (within 60 min) minimum	20 kg.cm	**Appendix-4**
Wet Stripping, Pass %, minimum	90	**Appendix-5**
Wet Track Abrasion Loss, (One hour soak), maximum	800 g/m^2	**Appendix-6**

Aggregate, bitumen emulsion, water and additive including set control additives (if needed), shall be proportioned by weight utilising the mix design approved by the Engineer. The final mixture, after addition of water and additive (if used) shall be such that the slurry seal mixture has proper workability and permit traffic within four hours (without leading to ravelling after placement). Trial mix shall be prepared and laid at site for the designed mix and observed for breaking and setting time. Indicative limits of various ingredients for job mix of slurry seal shall be as given in **Table 5.**

Table 5: Indicative Quantity of Ingredients

Ingredients	Limits (Per cent by weight of dry aggregates)
Cationic Bitumen Emulsion	10 to 16 for Type-I 7.5 to 13.5 for Type-II 6.5 to 12 for Type –III
Water	6 to 12
Filler	1.0 to 2.0
Additive	0.5 to 2.0

4.4. Construction

4.4.1. Weather and seasonal limitations: Laying of slurry seal shall not be undertaken, if either the pavement temperature or air temperature is below 10°C. However, during a dry spell, slurry seal may be laid in rainy season also, even if the surface is wet but there is no stagnant water on the pavement surface.

4.4.2. Surface preparation: The underlying surface on which the slurry seal is to be applied shall be cleaned of all loose material, mud spots, vegetation and extraneous matter and shall be prepared and shaped to the needed profile. It is essential to pre-treat cracks on the pavement surface with an appropriate crack sealing material prior to application of slurry seal, if it is used for renewal treatment. The surface should be swept clean by removing caked earth and other foreign matter with wire brushes, sweeping with mechanical brooms and finally dusting with air jet or washing with water jet or other means approved by the Engineer-in-Charge.

4.4.3. Application of tack coat: Tack coat is not required normally for flexible pavements; unless surface is extremely hungry and dry. In case, it is needed, RS-1 emulsion conforming to IS 8887 diluted with 3 parts of water shall be used at the rate of 0.2 kg/m^2. The tack coat shall be allowed to cure before application of slurry seal mixture.

4.4.4. Machine: The machine shall be specially designed and manufactured to lay slurry seal/microsurfacing. It shall be self-propelled equipment, truck mounted, consisting of the following sub-assemblies used to manufacture and simultaneously spread these mixes on the surface.

- Aggregate Bin
- Filler Bin
- Water and Emulsion Tanks
- Additive Tanks
- Aggregates and filler conveyors to supply the mixer box.
- Pump or compressed air system to supply the emulsion/water.
- Mixer Box.
- Spreader Box to place the mixed slurry on the job.

4.4.5. Calibration of machine: Slurry seal laying machine shall be calibrated for flow of all the constituents as per job mix in presence of Engineer-in-Charge. No machine shall be allowed to work on the project until the calibration has been completed and accepted by Engineer-in-Charge. 2 kg samples of slurry seal mixture will be taken and verified for proportioning and mix consistency. The verification for application rate shall also be carried out in presence of Engineer-in-Charge. The procedure for calibration and its verification is as given in **Appendix-7.**

4.4.6. Application of slurry seal: A calibrated slurry seal machine, as per requirements of job mix, shall be used to spread the material. The surface shall be pre-wetted by fogging ahead of the spreader box (if required under extreme hot weather conditions). The rate of application of fog spray shall be adjusted during the day to suit temperature, surface texture and humidity. The mixture shall be agitated and mixed uniformly in the spreader box by means of twin-shafted paddles or spiral augurs fixed in spreader box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The spreader box and rear strike off shall be so designed and operated that a uniform consistency is achieved to produce free flow of material to the rear strike off. A secondary strike off shall have the same adjustment as the spreader box. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A sufficient amount of material shall be carried in all parts of spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling and unmixed aggregates shall be permitted. No streak, caused by oversized aggregates shall be left on the finished surface. Longitudinal joints shall correspond with the edges of existing traffic lanes. The other patterns of longitudinal joints may be permitted, if pattern will not adversely affect the quality of finished surface. In case streak is formed, it shall be corrected immediately by fresh material and with use of squeeze. Longitudinal joints, common to 2 traffic lanes shall be butt joints with overlap not to exceed an average of 60-100 mm. The mixture shall be uniform and homogenous after spreading on existing surfacing and shall not show separation of the emulsion and aggregates after setting.

4.4.7. Rate of application: As per **Table 1** (by weight of dry aggregates)

4.4.8. Rolling: Generally rolling is not required. Where rolling is felt necessary due to inadequate cohesion, a pneumatic tyred roller having individual wheel load between 0.75 t to 1.5 t shall be used. Rolling shall commence as soon as the slurry has set.

4.5. Quality Control and Surface Finish

4.5.1. To ensure quality, frequency of testing is given in **Table 6.**

The manufacturer of emulsion shall provide test certificate for each batch of the emulsion supplied at site.

Table 6: Frequency of Tests for Slurry Seal

Item	Frequency
Quality of Aggregate	One per source/site as per Table 2
Quality of Emulsion	One per lot of 20 t as per IS 8887.
Aggregate Moisture	Two per day
Aggregate Gradation	Two per day at site
Binder Content	Two per lane per km.
Calibration of Machine	Once per project
Quantity of Slurry (By weight of aggregate)	Daily (Travel time of Machine)

4.5.2. Tests on materials: The manufacturer of emulsion shall provide test certificate for each batch of the emulsion supplied at site. The following tests are required to be carried out on the aggregate and emulsion at site. Test results will be compared to specifications.

- Gradation test on the aggregates
- Sand equivalent value test on the aggregates
- Residual bitumen content, storage stability and viscosity test on the emulsion (one test/batch)
- Moisture content test for aggregates

The above tests will have a frequency as per **Table 6**. The contractor shall conduct the tests under the supervision of Engineer-in-Charge. If any two successive tests on the same machine fail, the use of machine shall be suspended till the requirements of specification are met.

4.5.3. Surface finish: The finished slurry seal surface shall have a uniform surface texture throughout the work, without variations of texture within the lane width, or from lane to lane, due to segregation of aggregates, or due to variations in the emulsion/water content of the mixture. The finished surface shall be free from blow holes and surface irregularities. The skid resistance of freshly laid slurry seal surface by British Pendulum Tester shall not be more than 65 in wet condition.

4.6. Control of Traffic

Surface shall be opened to traffic after the slurry is in completely set condition. The maximum setting time shall be 4 hours. Speed of traffic shall be restricted to 20 km per hour for next 12 hours.

5. MICROSURFACING

5.1. Description

The microsurfacing shall consist of mixture of modified (polymer or rubber latex) bitumen emulsion, mineral aggregate, water and necessary additives (if needed), proportioned, mixed and uniformly spread over a properly prepared surface. The finally laid microsurfacing shall have a homogenous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its service life. The mix is to be a quick setting system i.e. able to accept traffic after a short period of time preferably within about two hours depending upon weather conditions. This may be used as surface sealing treatment to improve skid resistance, surface durability, seal fine and medium cracks. It is applied on existing pavement surface which is structurally sound , but the surface shows signs of premature ageing, aggregate loss, cracking, high degree of polishing etc. Generally microsurfacing is laid in single layer, but when the existing surface is highly polished, cracked, it is advisable to apply in two or more layers. Microsurfacing helps in preservation of pavement strength and can be used both for preventive and periodic renewal treatment on a preferably low and medium traffic road. It can be used for pavements in urban and rural areas, primary and inter-state routes, residential streets, highways, and toll roads. This can also be used on top of single coat surface dressing (Cap Seal) or open graded premix carpet without seal coat and also on Dense Bituminous Macadam/Bituminous Macadam. The type of microsurfacing that can be used for each of the applications, quantity of microsurfacing mix and the residual binder content in each type is provided in **Table 7**.

Table 7: Different Types of Microsurfacing

Items	Type II (4 to 6 mm)**	Type III (6 to 8 mm)**
Application	For roads in urban and rural areas, residential streets, as preventive and renewal treatment. (< 1500 CVPD)	For primary and inter-state routes, highways and runways to give maximum skid resistance, preventive and renewal treatment (1500 to 4500 CVPD)
Quantity of Mix* (kg/m^2)	8.4 to 10.8	11.1 to 16.3
Residual Binder (percentage by weight of dry aggregate)	6.5 to 10.5	5.5 to 10.5

* By weight of dry aggregate **Indicative only

* ***Note:*** Type I (2 to 3 mm) is not suitable for Microsurfacing.

5.2. Materials

5.2.1. Binder: The bitumen emulsion shall be a modified (polymer modified/latex modified) bitumen emulsion conforming to requirements specified in **Table 8**. The modifier shall be polymer/ rubber preferably synthetic or natural rubber latex blended into bitumen or aqueous phase of emulsion prior to or during the emulsification process. The bitumen emulsion may also be required to be specifically designed for the purpose as per the quality and the grading of aggregates for a climatic condition.

Table 8: Requirement of Modified Bitumen Emulsion for Microsurfacing

Requirement	Specifications	Method of Test
Residue on 600 µm IS Sieve (Percent by mass), maximum	0.05	IS 8887
Viscosity by Say bolt Furol Viscometer, at 25°C, in second	20-100	IS 8887
Coagulation of emulsion at low temperature	Nil	IS 8887
Storage Stability after 24 h (168 h), %, maximum	2 (4)	IS 8887
Particle charge, + ve / - ve	+ ve	IS 8887
Tests on Residue:		
(a) Residue by evaporation, % minimum	60	IS 8887
(b) Penetration at 25°C /100 g / 5 s	40-100	IS 1203
(c) Ductility at 27°C, cm, minimum.	50	IS 1208
(d) Softening Point, in °C, minimum.	57	IS 1205
(e) Elastic Recovery*, %, minimum.	50	IS 15462
(f) Solubility in trichloroethylene, % minimum	97	IS 1216

* In case, elastic recovery is tested for Torsional Elastic Recovery as per **Appendix-8,** the minimum value shall be 20%

5.2.2. Aggregates: As per Clause 4.2.2 (Type II and Type III Grading, **Table 3).**

5.2.3. Filler: As per Clause 4.2.3.

5.2.4. Water: As per Clause 4.2.4.

5.2.5. Additive: As per Clause 4.2.5.

5.3. Design and Proportioning of Microsurfacing Mix

5.3.1. The mix design of microsurfacing shall be prepared by a competent laboratory. The compatibility of aggregate, emulsion, filler and additive shall be verified by mix design for a selected grading (Type II or Type III) as specified in **Table 3**. The design criterion for microsurfacing mixture is specified in **Table 9**. A competent laboratory capable of performing the applicable/ specified tests shall perform tests for mix design. The proposed microsurfacing mixture shall conform to the requirements specified, when tested in accordance with tests specified in **Table 9**. The mix design report shall clearly show the proportions of aggregate, filler, water, and residual bitumen content based on the dry weight of aggregates and additive used (if any).The set time shall be determined by the method given in **Appendix-2.**

5.3.2. Aggregate, modified bitumen emulsion, water and additive (if used), shall be proportioned by weight of aggregate utilizing the mix design approved by the Engineer-in-Charge. If more than one type of aggregates is used, the correct amount of each type of aggregate used to produce the required grading shall be proportioned separately prior to adding other materials of the mixture, in a manner that will result in a uniform and homogenous blend. Final completed

Table 9: Mix Design Criteria for Microsurfacing Mix

Requirement	Specifications	Method of Test
Mix Time, minimum	120 s	Appendix-1
Consistency, maximum	3 cm	Appendix-3
Wet Cohesion, within 30 min, minimum.	12 kg.cm	Appendix-4
Wet Cohesion, within 60 min, minimum	20 kg.cm	Appendix-4
Wet Stripping, Pass %, minimum	90	Appendix-5
Wet Track Abrasion loss, (one hour soak), maximum	538 g/m^2	Appendix-6

mixture, after addition of water and any additive, if used shall be such that the microsurfacing mixture has proper workability and permit traffic within one hour depending upon the weather conditions without occurrence of ravelling and bleeding. Trial mixes shall be prepared and laid for the designed mix and observed for breaking time and setting time. The wet track abrasion test is used to determine the minimum residual bitumen content. Indicative limits of various ingredients for job mix of microsurfacing shall be as given in **Table 10.**

Table 10: Indicative Ingredients in Mix

Ingredients	Limits (Per cent weight of aggregate)
Residual Bitumen	6.5 to 10.5 for Type II and 5.5 to 10.5 for Type III
Mineral Filler	0.5 to 3.0
Additive	As needed
Water	As needed

5.4. Construction: As per Clause 4.4.

5.4.1. Weather and seasonal limitations: As per Clause 4.4.1.

5.4.2. Surface preparation: As per Clause 4.4.2.

5.4.3. Application of tack coat: As per Clause 4.4.3.

5.4.4. Machine: As per Clause 4.4.4.

5.4.5. Calibration of machine: As per Clause 4.4.5.

5.4.6. Application of microsurfacing: A calibrated microsurfacing machine as per requirements of job mix shall spread the material. The surface shall be pre-wetted (if required under extreme hot weather conditions) by spraying water ahead of the spreader box. The rate of application of fog spray shall be adjusted during the day to suit temperature, surface texture and humidity. The mixture shall be agitated and spread uniformly in the spreader box by means of twin-shafted paddles or spiral augurs fixed in spreader box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be

adjustable. The spreader box and rear strike off shall be so designed and operated that a uniform consistency is achieved to produce free flow of material to the rear strike off. A secondary strike off shall have the same adjustment as the spreader box. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A sufficient amount of material shall be carried in all parts of spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling and unmixed aggregates shall be permitted. No streak, caused by oversized aggregates shall be left on the finished surface. Longitudinal joints shall correspond with the edges of existing traffic lanes. The other patterns of longitudinal joints may be permitted if pattern will not adversely affect the quality of finished surface. Longitudinal joints, common to 2 traffic lanes shall be butt joints with overlap not to exceed an average of 60-100 mm. The mixture shall be uniform and homogenous after spreading on existing surfacing and shall not show separation of the emulsion and aggregates after setting.

5.4.7. Rate of application: The microsurfacing mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The quantities of microsurfacing mix (by weight of dry aggregate) to be used shall be as given in **Table 7.**

5.4.8. Rolling: As per Clause 4.4.8.

5.5. Quality Control and Surface Finish: As per Clause 4.5.

5.5.1. Tests on materials: As per Clause 4.5.1and 4.5.2.

5.5.2. Surface finish: As per clause 4.5.3.

5.6. Control of Traffic

Microsurfacing mix requires about 2 hours to set. Traffic may be opened only after 2 hours at the speed of 20 km/h till 12 hours thereafter.

REFERENCES

1. MS 19 BASIC ASPHALT EMULSION MANUAL, ASPHALT INSTITUTE
2. Performance Study and Usage Guidelines for Maintenance of Urban Roads Using Microsurfacing Technology, Highway Research Bulletin , No 73, 2005, pp165-186.
3. ISSA TB 106, Measurment of Slurry Seal Consistency.
4. ISSA TB 111, Outline Guide Design Procedure for Slurry Seal.
5. ISSA TB 114, Wet Stripping Test for Cured Slurry Seal Mixes.
6. ISSA TB 115, Determination of Slurry Seal Compatibility.
7. ISSA TB 139, Method of Classified Emulsified Asphalt, Aggregate Mixture by Modified Cohesion Test Measurement of Set and Cure Characteristics.
8. ASTM D 3910 Design, Testing and Construction of Slurry Seal.
9. ASTM D 2172, Quantitative Extraction of Bitumen for Bituminous Paving Mixtures.
10. AG:PT/T122, Torsional Elastic Recovery of Polymer Modified Binders.

Appendix-1
(Clause 4.3.1)

Method for Determination of Mixing Time of Slurry Seal/ Microsurfacing Mixture

Scope: This test is intended to determine breaking time of emulsion in a slurry seal/ microsurfacing mixture.

Apparatus: Stainless Steel Bowl, Spatula, Beakers, Measuring Cylinders, Spoon, Balance.

Method: Take 1 kg of the graded aggregate and needed cement in a bowl. Add required quantity of mixing water containing required dose of additive (if needed), to the aggregate and cement mixture. Mix the contents in bowl vigorously with the help of spatula so that a homogenous paste is formed. Add required quantity of emulsion and mix the contents in bowl with the help of spatula till the emulsion commences breaking (colour turns brown to blackish brown) and mix begins ceasing its workability. The time required for breaking emulsion is known as mixing time.

Report: Minimum time required for initial breaking of emulsion is reported as "Maximum Mixing Time".

Appendix-2
(Clause 4.3.1)

Method for Determination of Set Time of Slurry Seal/ Microsurfacing Mixture

Scope: This test is intended to determine time required for the slurry seal or microsurfacing mixture to reach initial setting.

Apparatus: Bitumen Felt Pad of 152 x 152 mm size (13.6 kg Roofing Felt), White Paper Towel or Tissue

Method: Mix of acceptable consistency shall be used to determine setting characteristics of mix. The mixed material is poured and screeded to 6 mm thickness using a 6 mm template to prepare standard sample for testing. Sample shall be cured for 15 min at $25^0 \pm 1^0$C temperature and 50 ± 5% relative humidity. Subsequently, a white paper towel or tissue is lightly pressed on the surface of slurry seal mix/microsurfacing mix. If no brown strain is transferred to the white paper towel or tissue paper, the slurry is considered in set condition. If there is a brown spot, on white paper towel or tissue, test is repeated at the increasing intervals of 15 min till the disappearance of brown spot, to determine set time.

Report: The time needed to obtain a stain free blot is called "Minimum Set Time" of slurry seal/microsurfacing mixture.

Appendix-3
(Table 4)

Method for Determination of Consistency of Slurry Seal/ Microsurfacing Mixture

Scope: This test is used to determine the consistency of slurry seal and microsurfacing mixture.

Apparatus: Mould of metal, in the form of a frustum as a cone, 38 mm in diameter at top, 89 mm in diameter at the base and 76 mm in height. The centre of 228 mm metal plate is inscribed with a circle of 89 mm in diameter. Three to four additional circles each 13 mm greater in diameter than the preceding circle are inscribed on the metal plate around the centre.

Method: Mould is loosely filled with slurry seal/microsurfacing mixture and struck off. The mould and contents are then inverted in the centre of the metal plate by placing the inscribed surface of the metal plate on the slurry filled cone, which while holding cone and plate firmly together, is quickly inverted. The mould is removed and contents allowed to flow over the inscribed circles until flow of the slurry stops.

Report: The outflow of slurry is measured at four points 90^0 apart from each point. The average value is reported in cm.

Appendix-4
(Table 4)

Method for Determination of Cure Time of Slurry Seal/ Microsurfacing Mixture

Scope: This test is intended to determine Cure time of slurry seal/microsurfacing mix for complete cohesion.

Apparatus: Cohesion Tester capable to apply varying pressure to a slurry pad, air compressor (0 to 700 kPa), Torque meter (35 kg.cm torque), 60 mm dia. steel mould of 6 mm and 10 mm thickness, 4.75 mm and 8.00 mm size sieves, mixing pan, spatula, balance, bituminous roofing felt of 10 cm^2 size and 13.6 kg weight, 20-30 mesh standard Ottawa sand, 3-M brand sand paper.

Procedure: A suitable number of identical specimens of mix are cast in the 6 mm or 10 mm ring mould centred on the bituminous roofing felt base of square shape. Specimen shall be uniform, whose surfaces are horizontally parallel. A template is recommended to obtain uniform thickness of slurry/micro surfacing mixture mat. After setting of slurry mat, it is placed beneath the pneumatically actuated rubber foot (25.4 mm dia.) of the calibrated cohesion tester. A pressure of 193 kPa considered to be equivalent to the pressure exerted by tyres of vehicle is applied. The torque measurements are made at intervals of 30, 45, 60, 75, 90, 120, 180 and 240 min after casting of samples by means of a torque tester, till highest and stable torque reading is obtained.

Report: The time required to reach constant and maximum torque or rubber foot rides freely over slurry mat without dislodgement of aggregate particles is recorded as the Cure Time. In case of quick traffic system, a cohesion torque of 20-21 kg.cm is required to reach within 60 min. For a quick-set system, a cohesion torque of 12-13 kg.cm is required to reach within 30 min.

Appendix-5
(Table 4)

Method for Wet Stripping of Cured Slurry Seal Mix

Scope: The purpose of this test is to help in selection of compatible slurry seal/ microsurfacing system with a given aggregate. This is generally useful for screening of emulsion formulation, fillers and additives by examination of ability of system to remain coated under the specified test condition.

Apparatus: 600 ml beaker, hot plate with adjustable temperature, absorbent, high wet strength paper.

Procedure: 400 ml of demineralised tap water or distilled water is added to the 600 ml beaker placed on the hot plate and brought to a vigorous boiling condition. 10 gm mixture of cured slurry is dropped in to the boiling water for three minutes duration. After three minutes, beaker with mixture is removed from the hot plate and allowed to cool up to room temperature. Subsequently, cold tap water shall be applied on the surface of the water beaker and continued until any free bitumen on the surface of the water flows over the sides of the beaker. The water is then decanted and the contents removed from the beaker are placed on the white absorbent paper/towel. After drying, the sample shall be examined for uncoated areas.

Report: Report the estimated coated area of the aggregate surface with bitumen as a percentage of the total aggregate surface.

- 90% retained coating is satisfactory.
- 75% to 90% retained coating is judged as marginal.
- Below 75% retained coating is unsatisfactory.

Appendix-6
(Table 4)

Method for Wet Track Abrasion Test

Objective: This test procedure is used to determine the resistance to abrasion of slurry seal/microsurfacing layer and to establish minimum permissible bitumen emulsion content in the microsurfacing/slurry seal mixture.

Apparatus: The required apparatus are as under:

(i) **Balance:** Capable of weighing 5000 g to within ± 1.0 g.

(ii) **Planetary Type Mechanical Stirrer**: Such as the Hobart Model N-50, Model C-100 or Model A-120 made by the Hobart Manufacturing Co.,Troy,Ohio) equipped with a weighted rubber hose holding device having free up and down movement in the shaft sleeve.

(iii) **Flat bottom Metal pan**, Approximately 330 mm in diameter with 51 mm vertical side walls having four equispaced screw clamps capable of securing 285 mm diameter specimen to bottom of pan.

(iv) **Suitable Heavy Gauge round bottom bowl:** to contain the sample during mixes.

(v) **Long handled Serving Spoon** : of sufficient length to project 101mm or more out of the round bottom bowl during stirring

(vi) **Circular Disks**: Metal circular disk of 286 mm diameter and 6 mm and 8 mm thick.

(vii) **Oven:** Forced draft constant temperature thermostatically controlled at 60±3^{0}C.

(viii) **Water Bath :** Constant Temperature, controlled at 25±1^{0}C

Sample Preparation:

(i) The optimum ratio of Portland cement, additives, water and bitumen emulsion to the dry weight of the aggregates shall be predetermined in the laboratory.

(ii) Dry the aggregates in the oven at 105^{0}C to 110^{0}C approximately for 16 hours, until constant weight is obtained.

(iii) Remove the aggregates from oven and cool to room temperature.

(iv) Weigh the sufficient quantities of the individual components in compliance to mix design to obtain a sample of about 1000 g.

(v) Place the weighed aggregates and the filler in to the mixing bowl.

(vi) After proper mixing of dry aggregates in mixing bowl, add predetermined quantity of water and additive (if required) and mix again for one minute until all aggregate particles are uniformly wetted

(vii) Add predetermined quantity of bitumen emulsion and mix for a period of not less than 30s and not more than 180s.

(viii) Centre the specimen mould on a felt disc. Immediately pour the microsurfacing/slurry seal mix in specimen mould placed on felt disk.

(ix) Screed the slurry level on top of the mould and discard excess material.

(x) Remove the mould without disturbing the casted sample and place the moulded specimen in the oven for 24 h, at 60°C to obtain constant weight.

(xi) Cool the dried specimen up to room temperature and determine its weight.

Test Procedure:

Lock the rubber hose abrasion head on the shaft of the mixing machine. A new hose surface shall be used for each test. Place the specimen in 330 mm diameter flat bottom pan. Clamp the specimen to the pan and mounting plate by tightening the quick release clamps. Ensure that the specimen is properly centred and the rubber hose will not run close to the edge. Add water at 25°C to the pan to cover the specimen to a minimum depth of 6 mm. Elevate the bowl resting on the platform of the mixer until the rubber hose bears freely on the surface of the specimen. Operate the mixer at its low speed setting and abrade the specimen for five minutes. Remove the specimen from the pan after the abrasion cycle and wash the specimen till it is free from debris. Place the washed test specimen in the oven at 60°C and dry to constant weight. Determine the loss in weight of the specimen expressed in gram per sqm and report it as the wear value or WTAT loss value.

Report: Report the wear value (WTAT loss) in gram per square metre.

Appendix-7
(Clause 4.4.5)

Calibration of Machine

The purpose of these guidelines is to familiarize both the users of the slurry seal machine as well as the client regarding the basic features of modern slurry seal machine. Both slurry seal and microsurfacing system have three main ingredients i.e. aggregates, bitumen emulsion and cement as filler. Apart from these, water and additive, if used are other ingredients for the purpose of workability of the mix. Unlike conventional hot mix works wherein one crew is involved in mixing of the materials and the other in using it, the same crew uses machine to proportion and mix up all the ingredients while laying the finished product. The modern traffic systems are very sensitive to changes in any of the ingredients as the same can cause an unsatisfactory mix. This in turn necessitated the accurate calibration of the machine.

Each slurry seal/microsurfacing machine to be used for execution of this work shall be calibrated prior to construction. The machine is equipped with suitable means of accurately metering each individual material and is capable of delivering a predetermined proportion of aggregate, water, emulsion, cement and additive to the mixture. Since all feeding mechanism is continuous, feed and proportioning remains constant at all the time. This mechanism allows the accurate calibration of the machine so that the exact quantities of materials used during any period can be estimated.

The calibration document shall include individual calibration of each material at various settings, which can be related to the machines metering devices. Normally, counters are provided on the machine for the purpose of calibration. Weight per minute is calculated at a particular setting to determine the total outflow of individual material at that setting. Precisely, the calibration of machine for aggregate is done first as other components are related to the quantity of aggregates. Based on the job mix formula approved for the work, the calibration of machine for other ingredients i.e. bitumen emulsion, cement, water and additive (if any) is done in the proportion set out therein after making adjustment to the outflow of these ingredients at different settings to get the desired results. Bitumen emulsion is adjusted first, followed by cement, water, and additive. Flow chart diagram of outflow of various ingredients is made for future reference. Once calibrated, the contractor as well as the client notes the setting of counters for various ingredients and periodical check is made to control the quality of the mix.

Appendix-8
(Table 8)

Test Method for Determination of Torsional Elastic Recovery of Residual Binders

Scope: This test method is intended to determine torsional elastic recovery of modified residue using a simple bolt and cup assembly .

Apparatus: Bolt assembly –The bolt has a cylindrical head with diameter of 28.6 mm and thickness of 9.52 mm and threaded shank of the bolt is 44.5 mm long. A metal spider with three radial pins and two nuts can be used to centre the assembly. A pointer is required for angle measurement in the absence of the spider. Sample tin of 85 ml capacity and internal diameter of 51 to 52 mm; angle measuring device and sample clamp assembly or an alternative means of clamping the sample/bolt assembly and determining the initial and recovered angle .The recommended device shall comprise a scale of 80 mm radius graduated in degrees around at least half its circumference and a clamp capable of holding the sample cup within 3 mm of its centre and without deforming the cup by more than 3 mm in any direction; water bath capable to operate at 25°C fitted with thermometer; forced convection oven – capable of operating in the range 60°C to 200°C; stop watch, spanner to suit bolt assembly.

Method: The torsional elastic recovery apparatus operates by manually rotating an aluminium bolt previously embedded in a cup containing modified binder through an angle of 180° and measuring the extent of recovery of the original applied rotation. Initially 180° twist is applied with a spanner for period of 10s. The recovery after 30s is measured.

Pour the residue into the cup of assembly until it begins to form a meniscus on the top surface of the bolt. Allow the assembly with sample to cool for one hour by allowing it to stand at room temperature and adjust the assembly height to keep the top surface of the bolt flush with the surface of the sample. Place the assembly at constant temperature of 25°C in a water bath for one hour. Adjust the spider to a position 7 mm above the rim and return the assembly to the bath. Place the sample assembly on the base plate and fit the pointer to the 180° position without disturbing the sample. With the help of spanner, turn the bolt moving the pointer from the 180° position to Zero degree position using a steady motion for 10s. Release the bolt when the pointer reaches the zero position and commence timing. Record the recovered angle after 30s. The torsion elastic recovery in percentage is calculated by following :

$$100 \times A/180,$$

where A is recovered angle in degrees.

Report: Report the torsional elastic recovery as mean of three results together with temperature of test and recovery time.