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To

The Chief Engineers of all State PWD/UTs dealing with NHs and Centrally aided road works; Director General (Works), Central Public Works Department; Director General Border Roads

Subject: Specifications for use of slurry seal on road surfaces

Although newly laid dense bituminous surfaces are generally impervious, in due course of time they start showing signs of distresses like cracking etc., due to oxidation, and hardening of binder. The continuous exposure to environment and resultant ageing gradually leads to ravelling and failure of pavements. In such situations it is essential that the surface is resealed with an appropriate sealing material without much interruption to the moving traffic. Slurry seal is widely accepted as a suitable material for sealing of such bituminous surfaces.

2. Slurry seal is a mixture of well graded fine aggregate, mineral filler, emulsified asphalt and water applied on the pavement as a surface treatment by means of a special slurry sealing equipment. This can be used in both preventive as well as corrective maintenance of pavement surfaces. Slurry seal application is not intended to increase the structural strength of a pavement section. Any surface irregularities like ruts, humps, crown deficiencies, waves etc., which affect the riding quality should be corrected before placing the slurry seal.

3. Besides effectively sealing the surface cracks and preventing ravelling and improving the skid resistance, the slurry seal is also having various other advantages as listed below,

(i) Rapid application
(ii) No need for adjustment to manhole and other structures
(iii) Minimum loss of kerb height
(iv) No loose aggregate cover
(v) Ability to correct minor surface irregularities
(vi) Relatively low cost of treatment
(vii) Fine surface texture ideal for application of surface paint

4. Considering the above, it has been felt that introduction of slurry seal application in this country would be advantageous in many ways. With a view to aquaint the field Engineers with this new technique, efforts are being made for procurement of a slurry sealing equipment by the Ministry. A set of specifications for using this technique has also been framed in the Ministry, a copy of which is enclosed with this letter.

5. Keeping in view the above, presently there is a need for identifying suitable sections on National Highways which are ideal for slurry seal application. Proposals for applications of slurry seal on such sections shall be considered by the Ministry for introducing this technique in this country. In the long run this might also give a fillip to the industry to facilitate manufacture of the necessary equipment indigenously.

6. The Ministry will wellcome suggestions of improvement/ modifications based on past experience, if any on slurry seal specification and also feedback reports after actual application in field.

It is also requested that suitable proposals as suggested in the foregoing para may please be furnished to the Ministry for consideration.

Enclosure to Ministry's Circular letter No.RW/NH-33054/32/89-S&R dated 7-6-93

SPECIFICATIONS FOR SLURRY SEAL

Scope : The work shall consist of preparation of Bituminous Slurry Seal using design proportions of bitumen emulsion, stone aggregates, mineral filler, water and additives where required, and applying the same over a prepared bituminous surface by means of approved slurry seal machine in accordance with these specifications.

Slurry seals are primarily used on bituminous surface showing signs of excessive oxidation and hardening. They are used to seal the voids on an existing surface which is starting to show signs of cracking/ ravelling and to positively protect them from water penetration and to provide a wearing surface with wet weather skid resistance.

The Slurry seal shall not be used over an existing bituminous surface which has deteriorated badly or needing rehabilitation of pavement.

2. Materials

2.1. **Binder :** The binder shall be cationic bitumen emulsion of suitable grade complying with IS: 8887-1978 having a minimum residual bitumen content of 60% by weight.

2.2. Aggregates

2.2.1. **Physical requirements :** The aggregates shall comply with the physical requirements in accordance to Clause 504.2.2.1 of MOST specifications except that the water absorption shall be restricted to 1 per cent. The fine aggregate shall be manufactured sand/crusher run fines or other mineral aggregates. It shall be hard, angular, free from dirt, etc., and having a sand equivalency not less than 45 when tested in accordance with ASTM D-2419. The combined aggregates shall have a smooth grading within the limits recommended for the specified range of gradings as shown in Table 1. The appropriate type of grading shall be selected depending upon the type and condition of the existing surface.

2.2.2. Type 1 grading is suitable to seal cracks, fill voids and correct surface erosion condition. This type may be used on heavy duty pavement surfaces where sealing and skid resistance are the primary need. It shall be applied at a rate of 3.3 to 5.4 Kgs/Sq.m. based on dry aggregate weight.

2.2.3. Type 2 grading is suitable to fill surface voids, correct severe surface erosion condition and provide a minimum wearing surface. This type is used on pavement surface which is severely eroded or with numerous cracks. It shall be applied at a rate of 5.4 to 8.2 Kgs/Sq.m. based on dry aggregate weight.

2.2.4. Type 3 is suitable to provide a new wearing surface or to build up a crown. It shall be applied at a rate of 8.2 Kgs/Sq.m. or more based on dry aggregate weight.

Table-1 - Aggregate grading

Sieve Size	Per cent Passing by weight		
	Type 1	Type 2	Type 3
9.5 mm	100	100	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- 60	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
Residual bitumen content in percent of dry weight of aggregate	10- 16	7.5- 13.5	6.5-12

2.3. **Mineral Fillers**

2.3.1. Mineral fillers which shall be considered as part of dry aggregate are of two types, chemically active and chemically inactive. At the time of use, the mineral filler shall be sufficiently dry to flow freely and be essentially free from lumps and shall conform to the following grading as given in Table 2, below :

Table-2 - Filler's Grading

Sieve size	Per cent passing by weight
600 Micron	100
300 Micron	95-100
75 Micron	70-100

2.3.2. Chemically active mineral filler such as portland cement,hydrated lime, ammonium sulphate etc. are used to improve the workability, regulate setting time and, in some cases, to alter the aggregate gradation.

2.3.3. Chemically inactive mineral filler such as lime- stone dust, flyash and rock dust are used mainly to alter the aggregate gradation.

2.4. **Water**

Water used shall be potable and free from harmful soluble salts.

2.5. **Additives**

Additives of approved quantity may be used to accelerate or retard the break set of the slurry seal or to improve the resulting finish of the surface. The use of additives in the slurry mix shall be made in quantities pre-determined by the mix design and any field adjustments, in case required, shall be as approved by the Engineer.

3. Mix Design

3.1. The mix materials shall comprise of bitumen emulsion, aggregates including mineral filler and additives where necessary. The quantity of emulsion to be used shall be guided by the specification limits indicated under Table 1. All materials to be used shall be pre-tested for their suitability in the mixture as described in the Clause 2.

3.2. The mix design shall be done in such a way that the mixture attains an initial set in not less than 15 minutes and in not more than 12 hours. The setting time may be regulated by addition of mineral filler or chemical agents (additives). Where chemically active mineral fillers as per Clause 2.4.2 is used, their proportion shall not exceed 2 per cent by weight of the dry aggregates.

3.3. The precise proportions of each constituent shall be fixed through laboratory test as well as through trial runs conducted prior to the work using the same aggregate and gradation as proposed for the project. The consistency of the mix shall be tested as per ASTM D-8910 and the optimum flow value arrived at. A properly designed slurry mix should get completely cured at the end of 24 hours after placement.

3.4. Slurry seal mixes shall be of proper consistency at all times so as to provide the amount of mixture required by the surface condition. The average application rate shall be within a tolerance of ± 15% based on dry aggregates.

3.5. The tolerances for individual materials as well as the slurry seal mixture shall be as follows:

(a) The permitted tolerance for the design residual bitumen in the mix shall be ± 1% by dry weight of aggregate.

(b) The percentage of aggregate passing each sieve shall not vary more than ± 4% from job mix formula.

(c) The percentage of aggregate passing shall not go from the high end to the low end of the specified range of any two successive sieves.

(d) The slurry consistency shall not vary more than ± 0.5cm from the job mix formula after field adjustments.

3.6. Before the commencement of the work a detailed mix design including the properties of the constituent materials, consistency of slurry seal etc. shall be got approved. The supporting laboratory test results for the design mix shall also clearly laid down the proportion of aggregates, mineral filler (minimum and maximum), water (minimum and maximum), additives (usage) and residual bitumen based on dry aggregate weight. This information shall be the final guideline for slurry seal construction.

4. Equipment

4.1. Slurry Mixing Equipment

The slurry seal mixing equipment shall be continuous flow mixing units (pugmill type) capable of delivering accurately predetermined, properly proportioned amounts of aggregate, mineral filler, water and emulsified asphalt to an approved mixing unit and to discharge the thoroughly mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for all constituents to maintain adequate supply to the proportioning controls. The machine shall be capable of prewetting the aggregate immediately prior to mixing with emulsion. Also the fines feeder shall be approved type to provide a uniform and accurately metered quantity of mineral filler simultaneously. The mixing machine shall be equiped with a water pressure system to facilitate fogging as indicated in para 5.1.1. The emulsion pump shall be of positive deplacement type with necessary devices to determine the quantity of emulsion any time. The mixer shall thoroughly blend all materials to form a homogeneous mass. All feeding mechanism shall be continuous feed with facilities to set the proportions constant while on operation. The unit shall be equipped with approved devices for accurate calibration of the machine and estimation of quantities of used materials during any one period.

4.2. Slurry Spreading Equipment

The mixture shall be spread uniformly by means of a conventional spreader box, a mechanical type squeegee distributor, attached to the mixer and equipped to agitate and spread the material evenly throughout the box. The 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 in width. The spreader box and rear strike off shall be so designed and operated that a uniform consistancy is achieved to produce the free flow of material to the rear strike off. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometrics. A burlap drag or other approved screed may be attached to the rear of the spreader box to provide a uniformly highly textured mat.

4.3. Auxiliary Equipment

Suitable crack and surface cleaning equipment, rolling equipment, barricading equipment, hand tools and other support equipment shall be used as necessary to perform the work.

4.4. Machine Calibration and Mix Trials

The slurry mixing unit shall be calibrated for the materials to be used prior to construction. Previous calibration documents covering exactly the same materials shall be accepted only if they were made during the same calender year. The documents shall include individual calibration for each material at various settings which can be related to the machines metering devices. No machine shall be allowed to work until the calibration has been completed and accepted.

After calibration and prior to construction, test strips shall be made using the same machine and sampling of slurry seal for verification of the mix consistency and proportion. Verification of rate of application shall also be made. No machine failing to pass the test after the third trial shall be permitted for the work.

5. Construction

5.1. Preparation of Surface

5.1.1. Prior to placing the slurry seal, all dirt, mud, trash, vegetation or other loose materials shall be cleaned off by suitable power brooms, power blowers, air compressors, water flushing equipment and hand broom as warranted by site condition. Flushing with water shall not be permitted in areas where the surface is severely cracked. However, the surface receiving the slurry treatment shall be fogged adequately during hot season using water pressure system and fog spray being provided with the mixing machine immediately ahead of spreader box. Patching of the road surface shall be completed wherever necessary. All manhole covers, inspection chamber covers, gully gratings etc., shall be masked. At junctions or at places where the surface treatment is to be stopped, cleanlines shall be defined by masking.

5.1.2. Tack Coat

Normally tack coat is not required unless the surface to be covered is extremely dry and ravelled or is of concrete or brick. Tack coat where considered essential by the Engineer shall be applied using a mixture of one part bitumen emulsion, three parts of water using the same type and grade of emulsion as specified for the slurry. Tack coat shall be applied by pressure distributor at a normal application rate of 0.15 to 0.3 litre of diluted emulsion per square metre of bituminous surface and 0.4 to 0.6 litre per square metre for concrete surface.

5.2. Application

5.2.1. The slurry seal shall not be applied if either the pavement or the air temperature is below 15 ^{o}C and falling or where the surface contains standing water. The slurry may, however, be applied if the temperatures are above 7^{o}C and rising. Also the slurry seal shall not be laid if high relative humidity prolongs the curing period beyond 24 hours.

5.2.2. The slurry mixture shall be of the desired consistency upon leaving the mixer and no additional materials shall be added thereafter. Total time of mixing shall not exceed 4 minutes. Sufficient quantity of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. The spreader shall not be overloaded. No lumping, balling or unmixed aggregate shall be permitted. No streaks such as caused by over-sized aggregates shall be left on the finished surface. If segregation leading to excess oversize are observed in pockets, the job shall be stopped for appropriate remedial action. The rate of application shall be in accordance with Clause 2.2 & 3.4. The mixture shall be uniform and homogeneous after spreading and shall not show separation of emulsion and aggregates after setting. As far as possible the longitudinal joints shall be placed on lane lines. Half passes and odd width passes shall be avoided.

5.2.3. The areas which cannot be reached by the machine shall be surfaced using hand squeegees to provide complete and uniform slurry seal coverage. The finish, tolerances, etc., shall, however, be the same as when applied by the spreader box. Hand work shall be completed alongwith machine applying process.

5.3. Rolling

5.3.1. Rolling is usually not necessary for slurry seal surfacing on road ways. However, where rolling is considered essential by the Engineer, it shall be done by a self-propelled 10 Tonne pneumatic roller with smooth tyres at a tyre pressure of 3.45 kg/sq cm and equipped with a water spray system. The surface shall be given atleast 5 passes.

Rolling shall not commence before the slurry has set sufficiently to ensure that rutting or excessive movement or sticking of slurry seal to the tyres of the roller is prevented.

5.3.2. The finished surface shall be free from blow holes and surface irregularities due to scraping, scabbing, dragging, dropping, excess overlapping or badly aligned longitudinal/ transverse joints, damages by rain or other defects. Any slurry sealing which does not comply with these specifications or is non-uniform in surface texture or colour 24 hours after laying shall be made good by removal and replacement by fresh material laid to specifications or if this is considered impracticable, by having fresh material laid to specification with the approval of the Engineer. Any area so treated shall not be less than 5 metres in length in a single stretch.

6. Quality Control

6.1. Quality control shall be exercised for all constituent materials as well as for slurry seal by taking samples at the frequency specified in Table 3. The quantity of emulsion used and the rate of spread of the mixed material (in kgs per sq. m.) shall be recorded for each load of aggregate.

A copy of the test results as also the rate of spread data shall be submitted to the Engineer.

Table 3 - Control Tests

Sl. No.	Test	Frequency
1.	Wet track abrasion (ASTM D-3910)	Every second run
2.	Grading of each separate stockpile of sand and crusher run fine aggregate	Every 20 tonnes of each material
3.	Grading of samples of blended aggregates	4 times daily
4.	Percentage of bitumen in the cured seal	4 times daily
5.	Slurry Consistency Test (ASTM D-3910)	4 times daily
6.	Slurry stability test (as per Cl. 6.2)	Daily or once for each load of emulsion delivered.

6.2. Slurry Stability Test

A sample of 75 gm of the blended aggregate shall be weighed in a glass beaker or similar container and the corresponding quantities of water and emulsion in the slurry mix added. The slurry shall be stirred with a slow deliberate action (about 60 rpm) for 15-30 seconds, after which a specimen of about half the mixture shall be cast upon an impervious surface.

The test specimen shall exhibit cohesive properties in not more than 10 minutes and when set and drenched in water shall be waterfast as demonstrated by the absence of brown colour in the wash water.

7. Curing and Opening to Traffic

No traffic shall be allowed on the newly laid surface until the slurry seal is sufficiently cured to support the traffic without damage. The time for curing shall depend on the type of emulsified asphalt, mixture characteristics and weather conditions and fixed with the written approval of the Engineer.

8. Measurement and Payment

8.1. Quantities of slurry seal to be paid for shall be measured in square metres. Measurement shall be taken along the surface of the actual area sealed in square metres.

8.2. The contract unit rate paid per sq. m. of accepted quantities of slurry seal coat shall include full compensation for provision of labour, materials, tools, equipment and incidentals for doing all the work involved in preparing and laying the slurry seal in place complete in all respect including cleaning of the surface, providing water for dampening the pavement and protecting the seal until it is set, as in these specifications and as directed by Engineer.