Rural Road Preventive Maintenance with Microsurfacing

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ABSTRACT
Road transport is considered to be one of the cost-effective and preferred modes of transport for both freight and passengers. India has an extensive road network of 4.24 million km, the second largest in the world[1]. Rural roads consist over 85 percent of the road network and keeping them in serviceable condition is important to the agricultural growth and affording means of access to millions of rural people to social facilities viz. medical, education as also to market[2].

Rural road funding is inadequate to maintain current road condition under traditional maintenance and rehabilitation policies. With the preventive maintenance program the pavement can be maintain in a cost effective manner with less total cost and better pavement quality.

Microsurfacing is widely used for both pavement preservation and preventive maintenance. Microsurfacing is environmental friendly as it reduces the greenhouse gas and fuel consummation. This paper describes the construction process of wearing course of pavement through Microsurfacing which reduces the both direct and indirect cost and experience of Microsurfacing at IIT-Guwahati approaching road.

1. INTRODUCTION
Road transport is considered to be one of the cost-effective and preferred modes of transport for both freight and passengers. India has an extensive road network of 4.24 million km– the second largest in the world[1]. The National Highways have a total length of 70,934 km and serve as the arterial road network of the country. It is estimated that more than 70 percent of freight and 85 percent of passenger traffic in the country is being handled by roads. While Highways/ Expressways constitute only about 2 percent of the length of all roads, rest are state highways, major district roads, district roads and rural and other roads, which are considered as low volume roads. Rural roads consist over 85 percent of the road network and keeping them in serviceable condition is important to the agricultural growth and affording means of access to millions of rural people to social facilities viz. medical, education as also to market [2].

Microsurfacing has been used in Germany, Spain, and France since 1976 and was introduced to the United States in 1980[10]. Though microsurfacing has been in use worldwide for a very long time as a routine form of maintenance in preference to the conventional overlays of the hot mix, yet it was introduced only in 1999-2000[11] in India under the brand name of Macroseal by Yala construction and Elsamex SA, Spain. In India, a study was initiated for the use of bitumen emulsion to maintain the roads in Delhi by the State government as a suitable alternative method for maintenance of roads in light of ban on hot mix plants imposed by the Supreme Court. The study was conducted approximately ten years back, by Elsamex S.A, Spain with the active involvement of Central Road Research Institute (CRRI) Delhi. In the study report, the specifications for the use of cold emulsion for maintaining various types of roads were standardized with latest state of the art technology. The study report was utilized by Delhi public works department New Delhi municipal council and ministry of road transport and highways (MORTH). Subsequently the technology was given a go-ahead for maintaining the roads of Delhi. It has also been included the MORTH specification in clause 516 as the slurry seal and Indian Road Congress (IRC), subsequently brought out IRC: 81-2008 - 'Tentative Specification for Microsurfacing[12].'

Microsurfacing is a widely used tool for both pavement preservation and preventative maintenance[3]. Pavement preservation strategy includes all activities to provide & maintain serviceable roadways. The right treatment on the right pavement at the right time lowers life cycle costs, provides higher quality pavements and keeps good pavements good. Figure 1 shows that the pavement condition drops 40% in 75 percent of life of the pavement whereas there is another 40% drop in pavement condition in only 12 percent of the remaining life of the pavement. It is interesting to note that the distress rate of pavement is increasing with time when the pavement is not maintained timely. Furthermore, maintenance of the pavement should be done before its fair-condition is reached so that the life-cycle cost will be less. Therefore, it can be seen from the figure that if periodic maintenance is carried out, the pavement life will increase two fold than the unmaintained pavement. Microsurfacing will be the right choice here for carrying out the maintenance work and it can be applied only when the pavement condition is in excellent to fair condition since it does not increase the structural strength of the pavement but rather its functional capacity.

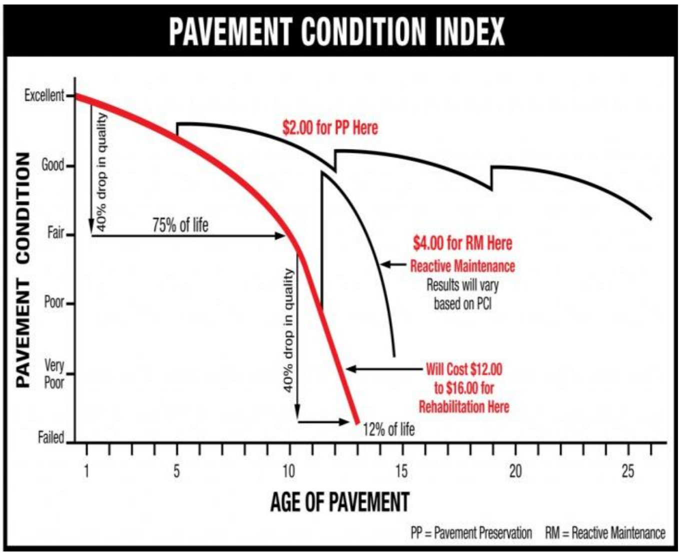

Fig 1: Pavement condition index (ISSA)

2. MICROSURFACING

Microsurfacing is a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives,

properly proportioned, mixed and spread on a paved surface in variable thick cross-section which resists compaction[4].

Microsurfacing is a fast and durable pavement preservation technique that utilizes the benefits of cold-mixes using latex/polymer modified bitumen emulsion, fine aggregates and special additive, spread on a structurally sound pavement using a special computerized paver, spread in a thin film. Microsurfacing provides cost-effectiveness, fast application and durable material which delay distresses occurrence with traffic load and where pavement life extension is required before any casualty. The technology utilizes the advancement of asphalt emulsion technology by special mix design done in laboratory with carefully graded crushed aggregate, polymerized bitumen emulsion, fillers and break control additive that provide complete sealing of surface[5]. Here this technique can be used for periodic renewals of roads in place of hot-mix treatment with excellent results and longer life to pavements.

2.1 Advantages of Microsurfacing

- Microsurfacing seals small cracks and surface imperfections, waterproofs the surface, and protects the pavement structure of both asphalt and concrete pavements.
- The high quality, crushed aggregate improves skid resistance.
- The mat provides an attractive, smooth black surface which aids in lane delineation.
- The very thin surfacing (9.5 to 15.5 mm) is ideal where curbs and overhead clearances need to be preserved.
- The microsurfacing emulsion reduces user delay by allowing traffic in about an hour after construction.
- The quick setting microsurfacing is suitable for night application on heavy-traffic streets, highways and airfields.
- Micro-surfacing fills depressions, small cracks and ruts, and provides some surface leveling.
- Microsurfacing is a cost-effective pavement preservation technique.
- Microsurfacing is environmental friendly and easy in construction.

2.2 Disadvantages of Microsurfacing

- Bituminous Microsurfacing shall not commence if either the pavement or air temperature is below 10ºC and falling.
- Microsurfacing is not placed when there is rain, or if the air temperature is expected to fall below freezing within 24 hours after application.
- Bituminous slurry may be applied when both pavement and air temperatures are above 7ºC and rising, or above 10ºC .
- Microsurfacing should be stopped if the surface or air temperature drops below 10ºC.

3. MATERIALS

The Microsurfacing shall consist of a mixture of an approved emulsified asphalt, mineral aggregate, water and specified additives which are describe below.

3.1 Emulsified Asphalt

An emulsion is a thermodynamically unstable system consisting of at least two immiscible liquid phases one of which is dispersed as globules in the other liquid phase stabilized by a third substance called emulsifying agent. Emulsion requirement for microsurfacing has to have a polymer in it and typically this polymer is co-milled with the asphalt cement and emulsifier and the emulsion produced is to have a property of CSS-1h emulsion. Different polymers, or a combination of polymers can be added to the emulsion and these tend to be proprietary. Each polymer has its own unique properties that will enhance the performance characteristics of the emulsion. These performance characteristics could be stiffness of the emulsion at high temperatures, resistance to flushing, and elasticity of the emulsion at low temperatures. The amount and type of the emulsifier will affect the setting characteristics and compatibility of the emulsion.

The emulsified asphalt shall be a quick-set polymer modified cationic type CSS-1h emulsion and shall conform to the requirements specified in AASHTO M208 and ASTM 2397[6]. It shall pass applicable storage and settlement tests. The polymer material shall be milled into the emulsion or blended into the asphalt cement prior to the emulsification process. The cement mixing test shall be waived for this emulsion. The residue of the emulsion shall have a minimum ring and ball softening point of 60°C.

MORTH[7] specified that the emulsion to be used for microsurfacing should be a cationic rapid setting conforming to the requirements set in IS: 8887 and as shown in its Appendix-V. Where special mobile mixing machines are available, emulsion used for slurry seal or microsurfacing should be capable of producing slurry that will develop early resistance to traffic and rain and is sufficiently stable to permit mixing with the specified aggregate, without breaking during the mixing and laying processes. If approved by the Engineer, a slow setting emulsion may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works [5]. In general, microsurfacing suppliers supply the emulsion to the contractor along with a mix design.

3.2 Aggregate

The mineral aggregate used shall be the type specified for the particular application requirements of the microsurfacing[7,12]. The aggregate shall be crushed stone such as granite, slag, limestone, chat, or other high-quality aggregate, or combination thereof. To assure the material is 100 percent crushed, the parent aggregate will be larger than the largest stone in the gradation to be used. The smooth textured crusher fines shall have less than 1.25% water absorption. The aggregate shall be gray in color and clean and free from organic matter, other deleterious substances and clay balls. Oversized granular material and/or presence of clay balls will require the project to be stopped and shall meet the following requirements.

3.2.1 Quality Tests

The aggregate should meet agency specified polishing values and these minimum requirements as give in “Table 1”.

Table 1. Aggregate quality test

TEST	TEST METHOD		SPECIFICATION
	AASHTO	ASTM	
Sand Equivalent Value of Soils and Fine Aggregate	T 176	D 2419	45 Minimum
Soundness of Aggregates by Use of Sodium Sulfate of Magnesium Sulfate	T 104	C 88	15% Maximum w/NA2SO4 25% Maximum w/MgSO4
Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	T 96	C 131	35% Maximum

3.2.2 Gradation

The mix design aggregate gradation shall be within one of the following bands (or one recognized by the local paving authority) which is describing below[4]:

Type I: This aggregate gradation is used to fill surface voids, address moderate surface distresses, and provide protection from the elements. The fineness of this mixture provides the ability for some crack penetration.

Type II: This aggregate gradation is used to fill surface voids, address more severe surface distresses, seal, and provide a durable wearing surface.

Type III: This aggregate gradation provides maximum skid resistance and an improved wearing surface. This type of micro surfacing surface is appropriate for heavily traveled pavements, rut filling, or for placement on highly textured surfaces requiring larger size aggregate to fill voids.

MORTH[7] specified that the aggregate to be used in microsurfacing to be a crushed rock, or slag and may be blended if required, with clean, sharp, naturally occurring sand free from silt pieces and organic and other deleterious substances to produce a grading as given in the Table 500-33 of the book. Also the aggregates shall meet the requirements of the film stripping test and a suitable amount and type of anti-stripping agent be added as and when it may be needed.

3.3 Mineral Filler

Mineral filler may be used to improve mixture consistency and to adjust mixture breaking and curing properties. Portland cement, hydrated lime, limestone dust, fly ash, or other approved filler meeting the requirements of ASTM D 242[6] shall be used if required by the mix design. Typical use levels are normally 0.0% - 3.0% and may be considered part of the aggregate gradation.

MORTH[7] specified the use of Ordinary Portland Cement, hydrated lime or other additives as filler to control consistency, mix segregation and setting rate. The proportion of the additive should normally not exceed 2% by weight of dry aggregates.

3.4 Water

The water shall be free of harmful salts and contaminants. If the quality of the water is in question, it should be submitted to the laboratory with the other raw materials for the mix design. According to MORTH [7], water shall be of such quality that the bitumen will not separate from the emulsion before the microsurfacing is in place. The pH of the water must lie in the range 4 to 7, and if the total dissolved solids in the water amount to more than 500 ppm, the Engineer may reject it, or order the Contractor to conduct a trial emulsion mix to demonstrate that it does not cause early separation.

3.5 Additives

Additives[4] may be used to accelerate or retard the break/set of the microsurfacing. Appropriate additives and their applicable use range should be approved by the laboratory staff as part of the mix design.

4. MIXING PROCESS IN FIELD

The mix of microsurfacing can be prepared at site or field. It depends mainly on the availability of material and transportation facility. The mixing procedure should follow the one obtained in laboratory. Generally in rural areas of India, the microsurfacing paver cannot be used due to lack of fund and therefore, microsurfacing mix must be mixed in concrete drum mixer and hand-laid to the required thickness as shown in Figure 2. The following types of mixing which can be employed for rural road is given below:

- Batch mixing
- Continuous mixing
- Hand mixing

4.1 Labour Based Construction:

- Use & application of Microsurfacing by hand.
- Labour requirements & production rates.
- Mixing and laying procedure
- Labour application and uses: Small areas, where the access for machine is difficult (for example walks and parking areas Residential streets in townships).
- Table 2 shows the number of labour required for mixing, handling and laying of Microsurfacing by drum mix besides and in controlling the traffic.

Fig 2: Placing of microsurfacing

Table 2. Labour based production rate for laying microsurfacing for rural roads

Activity	Labourers
Loading dust	2
Operating mixer	1
Pushing wheel barrow	3
Loading emulsion & water	2
Squeezing	3
Sweeping	1
Traffic control	2
total	14

Production rate of 5m³ or 700m^2/day by 14 labours (Sources: www.sabita.coza)

4.2 Mixing Procedure

The following points are the mixing procedures for microsurfacing when concrete mixer is used:

- Pre-wet concrete drum
- Add crusher dust
- Add cement
- Mix
- Add water

- Add emulsion
- Mix

4.3 Laying Procedure

The following points may be used as a guide for laying microsurfacing manually:

- Use rope of thickness lager than the thickness of microsurfacing to ensure uniform cover thickness
- Use straight edge and squeegee to spread the microsurfacing mix.
- Drag hessian burlap for smooth finish
- Only open to traffic once the surface is dry (about 2 or more hours)

5. EXPERIENCE OF MICROSURFACING AT IITG

Microsurfacing was laid on a 20 meter test section to fill up the spalled concrete of a Cast in Situ Concrete Block Pavement' at IIT-Guwahati approach road which joins the IIT and National Highway. Figure 3 shows the microsurfacing mix that was being laid on the spalled concrete block. Microsurface mix of Type III was selected to be used in the IIT-Guwahati approach road. The material used in the mix was Type III gradation aggregate, emulsified emulsion, water, cement and additive. Mix design method for mixing the ingredients of the microsurfacing was developed in the laboratory and the same procedure had been carried out on the field. The mixing process was done by both drum mix and hand mix because the existing plastic cell filled concrete block pavement condition was so poor for traffic to run over the section and because of noise that was generated when from vehicle passing over the section. Therefore, for repairing work, microsurfacing was chosen and was carried out in two ways for proper ridding quality. First, all of the spalled edges were filled with microsurfacing and after this, a microsurfacing layer of 15mm was laid and roller compacted with few passes to smoothen the surfaces. After eight months of traffic movements, it was seen that the pavement is still in good even though some reflection cracking were developed due to underlying cracks but still there is no spalling. The microsurfacing has provided excellent smoothness and good friction, with a very much reduced pavement noise levels. Therefore, from above experience, it can be said that, microsurfacing is suitable to repair pavements with cracked surfaces in lieu of more conventional rehabilitation methods such as crack sealing, leveling, and double surface treatments.

Fig 3. Microsurfacing at IIT-Guwahati approaching road

6. ENVIRONMENTAL IMPACT

Pavement preservation is inherently green owing to its focus on conserving energy and raw materials, and reducing greenhouse gases by keeping good roads[13]. Microsurfacing's environmental footprint is lower than most common pavement preservation and maintenance treatments. The study developed 'eco-efficiency indices' for the five categories: energy, emission, health effect, risk potential and raw materials which show that Microsurfacing had a substantially lower environmental footprint than the other options (hot mix overlay and polymer modified hot mix overlay)[9]. This study does not include the reduced greenhouse gas emissions resulting from Microsurfacing's ability to greatly reduce traffic delays in work zones[14].

7. CONCLUSION

The development of a new process or product requires substantial research and development before a sufficient level of reliability is achieved to enable implementation on a large scale.

Microsurfacing is a pavement preservation and maintenance tool with very few technical or operational limitations. Microsurfacing can be an implement for rural road maintenance. Microsurfacing's environmental footprint compared with Hot-mix Overlay and Polymer-modified Hot-mix Overlay is less.

To minimize energy use and greenhouse gas over the life of a pavement, all preservation treatment can be done by Microsurfacing.

8. REFERENCES

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