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Comparative study on Use of Foundry sand as alternative filler in Microsurfacing incorporating Type-III aggregate

KEYWORDS: Microsurfacing, Foundry sand, waste utilization

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ABSTRACT Microsurfacing is applied for Pavement Preventive Maintenance. The major materials used to create microsurfacing mix are aggregates, asphalt emulsion, control additive, water and mineral filler as ordinary Portland cement. As ordinary Portland cement is costlier and having higher environmental impact by CO2 Emission while production so there is a need of alternative filler. In this research foundry sand is used as an option for OPC to create microsurfacing Mix. Foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed used/spent foundry sand. This paper presents results obtained from laboratory investigation of microsurfacing mix prepared using foundry sand as alternative of cement. Laboratory investigation performs to determine suitability of foundry sand as mineral filler in microsurfacing mix. Laboratory investigation includes determination of setting time, cohesion (30 min), cohesion (60 min) and wet track abrasion test on proposed mix design. Results shows that foundry sand can be a suitable alternative of cement in microsurfacing mix.

Introduction

Microsurfacing treatments involve the laying of a mixture of crushed mineral aggregate, polymer-modified asphalt emulsion, mineral filler, water, and an additive to control hardening of the mixture. A self-propelled pug mill mixes the components and lays the mix immediately after mixing – no compaction of the microsurfacing layer is required (Hixon et al. 1993). A microsurfacing layer may be as thin as 3/8 inch (9.5 mm) and is capable of filling wheel ruts up to 1.5 inches (38 mm)or 2 inches (50 mm) deep. Unlike localized treatments such as crack sealing and bump grinding, microsurfacing belongs to a certain category of pavement treatments which includes seal coating and thin HMA overlays. These treatments cover the entire width of the carriageway with an aggregate-bituminous mix. Like all other pavement treatments, microsurfacing is categorized in different ways by different agencies, depending on the purpose of the application, the hierarchy of the supervising jurisdiction, the expenditure involved, and other factors. For the purposes of the present study, microsurfacing is described as a preventive maintenance activity, a categorization that is consistent with most nationwide studies (Geoffroy, 1996).

Microsurfacing is normally specified and designed according to IRC:SP:81-2008 or ISSA recommendations. In present scenario cement is used as mineral filler in mix design of microsurfacing. It enhance the breaking time of the modified asphalt emulsion and also work as filler. Improvement in microsurfacing characteristics is often done by use of such mineral filler as cement or lime. In this study, none of the above mineral filler is used; rather, a waste product, foundry sand. Foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed used/spent foundry sand. Utilization of foundry sand will reduce costlier and higher environmental impact by CO2 Emission and help us in reducing carbon footprint at some extent. In India foundry sand is settled by sedimentation and leaved directly in situ which result in ugly appearance of environment and also causes dust in the summer and threat both agriculture and health. Therefore, using the foundry sand in different sectors will help to protect the environment.

Materials

In this research type II aggregates were used for in microsurfacing mix. Type II aggregate gradation is used to fill surface voids, address surface distresses, seal, and provide a durable wearing surface. The Source of Type II aggregate was Rajeshree Stone Crusher, Sevaliya, Gujarat. Physical properties of aggregates like water absorption, Sand Equivalent Value and Soundness is determined using IS 2386 Part 3, IS 2720 Part 37 and IS 2386 Part 5 respectively at 25oC temperature. The required physical properties of the aggregate are presented in table 1.

Table: 1 Physical properties of the aggregate

Sample Type	Test Name		
	Water Absorption	Sand Equivalent Value	Soundness (With sodium sulphate solution)
Stone Aggregate (Type II)	1.4	67.5	*Not Required
Test Method	IS 2386 P 3	IS 2720 Part 37	IS 2386 Part 5
Limit as per IRC: SP: 81:2008	Max. 2	Min. 50	Max. 12

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The gradation of the aggregate mixture was within the specified limits as determined by IRC:SP:81-2008 for Type II mixture. The actual gradation of the aggregate mixture is as shown in figure 1.

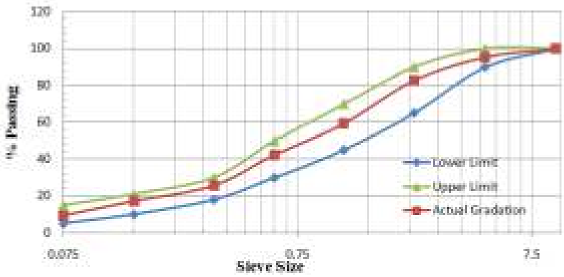

Figure: 1 Type III Gradation curve

The bitumen emulsion used was a cationic bitumen emulsion modified with latex. The Source of Polymer Modified Emulsion is Tiki Tar Industries (Baroda) Limited Its characteristics, which meet the requirements IRC:SP:81-2008 specification, are shown in Table 3.

Table: 2 Characteristic properties of polymer modified bitumen emulsion

Test Name	Test Value	Test Method	Limit as per IRC:SP:81:2008
Residue on 600micron IS Sieve (% by mass)	0.039	IS:8887	Maximum 0.05
Viscosity by Say Bolt Furol Viscometer, at 25o C , in second	23	IS:8887	20 – 100 Second
Coagulation of emulsion at low temperature	Nil	IS:8887	NIL
Storage Stability after 24h , %	1.12	IS:8887	Maximum 2
Particle charge, +ve/-ve	Positive[+v]	IS:8887	Positive [+ve]
Test on Residue:			
Residue by evaporation, %	63.9	IS:8887	Minimum 60%
Penetration at 25oC/100g/5s	47.5	IS:1203	40 – 100
Ductility at 27oC, cm	54.6	IS:1208	Minimum 50cm
Softening Point, in oC	59.5	IS:1205	Minimum 57 oC
Elastic Recovery	52.2	IS:15462	Minimum 50%
Solubility in trichloroethylene, %	98.9	IS:1216	Minimum 97%

Table 3Chemical Composition of foundry sand

PARAMETER	UNIT	Test Method Standard	Results Obtained	Specifications As per IRC:SP: 89-2010
Fe2O3+Al2O3+SiO2	%	IS-1727	74.56	70% Min
Sio2	%	IS-1727	58.96	35% Min
Reactive Slice	%	IS-1727	21.99	--
MgO	%	IS-1727	1.6	25 % Max
SO3	%	IS-1727	1.8	2.75 % Max
Na2O	%	IS-1727	1.3	--
Cl2	%	IS-1727	0.02	0.05 Max
Loss of Ing.	%	IS-1727	2.7	5 Max
CaO	%	IS-1727	0.39	--
Phosphorous (P2O5)	%	IS-1727	0.02	--
Potassium (K2O)	%	IS-1727	0.05	1.5 Max
PH	%	IS-1727	7.9	--

Mix Design

The mix design was performed according to IRC: SP: 81-2008 specifications. Based on the sieve analysis result and others recommended criteria mentioned in IRC: SP: 81-2008 the material was mix in proportion as aggregate as 100% of total ingredients, foundry sand as 1.5%, water as 12%, polymer modified emulation as 13% and Additive as 2.2% of aggregate. The different mixtures were tested for the determination of Mix Time, Consistency, Cohesion, Wet Stripping, Wet Track Abrasion loss, according to IRC: SP: 81-2008 specifications. The mixing is done at temperature of 27OC.

Results and Discussion

The results obtained from the use of optional fillers in microsurfacing are showed in Table 6. As it can be seen that Foundry sand gave satisfactory results under IRC: SP: 81-2008. The results obtained from experimental investigation shows that Foundry sand gives relatively Better results than that of OPC. Laboratory evaluation Results shows that foundry sand provide better cohesion than OPC. After this experimental analysis we can say use of foundry sand as alternative mineral filler leads to not only reduce the Overall cost of microsurfacing technology but also reducing the amount of dump of foundry sand from earth. Results shows that the mixing time is somehow similar to as of OPC and wet cohesion of Foundry sand is more than OPC which shows that it can be suitable filler for microsurfacing mix. The use of foundry sand makes microsurfacing technology cost-effective and eco friendly.

Table 4 Mix Design Criteria for Micro Surfacing

Requirement/Test names	Cement	Foundry sand	Limits as per IRC:SP:81-2008	Test Methods [IRC:SP:81-2008]
Mix Time (seconds)	135	129	120s Minimum	Appendix – 1
Consistency (cm)	2.4	2.5	3cm, Max	Appendix – 3
Wet Cohesion, within 30min; (kg.cm)	14	17	12 kg.cm Min	Appendix - 4
Wet Cohesion, within 60min; (kg.cm)	22	25	20 kg.cm Min	Appendix - 4
Wet Stripping, Pass%	99.5	98.4	90 Min	Appendix – 5

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Conclusions

The use of Microsurfacing in India for preventive maintenance and surface improvement increased during the last few years. OPC is used in microsurfacing as filler for good mixing purposes and adhesion. In this paper foundry sand was used as optional fillers in order to replace cement in the production of microsurfacing. The results showed that foundry sand as optional fillers can be used in place of cement for producing microsurfacing complying with specifications. The use of foundry sand in microsurfacing results in decreasing of their dump in India. It not only reduces the cost of microsurfacing technology but also improve low environmental profile.

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