AN EXPERIMENTAL INVESTIGATION ON BITUMINOUS CONCRETE BY USING IRON ORE TAILINGS AS FILLER MATERIAL

Abhishek S A[1], Rachitha P[2], Rahul[3], Sachin M Nayak[4], and Mr. Vinay A[5].

[1,2,3,4]UG Student, Department of Civil Engineering, DSCE, Bengaluru, Karnataka, India. [5]Assistant professor, Department of Civil Engineering, DSCE, Bengaluru, Karnataka, India.

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Abstract - *Waste material management is one of the powerful concepts in recent year. To overcome the iron ore tailings (waste) by leaps and bond requires reuse of waste materials in road construction. Being semi degradable in nature, the iron ore tailings is a serious threat to environment. This threat has emphasized the need to find appropriate solutions for effective waste management. Rapid growth of infrastructure in road construction needs natural resources. In recent year escalation of prizes of natural resources, so that required reuse of waste material in road construction. Now-a-days disposal of different wastes (iron ore tailings) produced from different Industries is a great problem. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. Reuse of wastes material is a very simple but powerful concept. In this paper we use low density filler material as iron ore tailings in road construction. The waste iron ore tailings of size 150micron to 300micron was used to partial filler material in bitumen mix. There is a need to explore the feasibility of use of iron ore tailings in road construction. This paper deals with study on the various test performed on aggregates, bitumen and methodology of using iron ore tailings in bituminous mixed. Warm mix asphalt (WMA) is an emerging technology that can allow asphalt to be produced and compacted at a significantly lower temperature. Several new processes have been developed to reduce the mixing and compacting temperatures without scarifying the quality of resulting pavement. One of the processes is by adding chemical additives in the mix. Sasobit® can be blended with the binder at a terminal or in the asphalt tank. Sasobit® was shown to improve the compactability of mixtures and overall reduction in air voids. The addition of Sasobit® increases the strength of asphalt mix. In this thesis warm mix asphalt is designed for Dense Bituminous Macadam (DBM) of grade 2 with the addition of Sasobit® is carried out.*

Key Words: *Iron ore tailings, Sasobit®, Bituminous concrete moulds, Stability, Flow Air voids and density characteristics etc.*

1. INTRODUCTION

Most of the Highways in India constructed with flexible pavement having wearing course/surfacing course with bituminous concrete. This BC should be constructed to satisfy the recommendation and requirements of MORTH Section 509. This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade 60/70(VG 30) for nominal aggregate size 19 mm with bitumen content 5-6% has layer thickness 50-65 mm and for nominal aggregate size 13 mm with bitumen content 5-7% having layer thickness 30-45mm.

1.1 HOT-MIX ASPHALT CONCRETE (HMA)

This is produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Mixing is generally performed with the aggregate at about 300 °F (roughly 150 °C) for virgin asphalt and 330 °F (166 °C) for polymer modified asphalt, and the asphalt cement at 200 °F (95 °C). Paving and compaction must be performed while the asphalt is sufficiently hot. In many countries paving is restricted to summer months because in winter the compacted base will cool the asphalt too much before it is able to be packed to the required density.

1.2 WARM-MIX ASPHALT CONCRETE (WMA)

This is produced by adding either zeolites, waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosol and vapours. not only working conditions improved, but the lower laying-temperature also leads to more rapid availability of the surface for use, which is important for construction sites with critical time schedule. The usage of these additive in hot mix asphalt (above) may afford easier compaction and allow cold weather paving longer haul. Use of warm mix is rapidly expanding. A survey of US asphalt producers found that nearly 25% of asphalt produced in 2012 was warm mix, a 416% increase since 2009.

2. OBJECTIVES

Study has been carried out to satisfied following objectives:

- Comparing the properties of HMA with partial replaced filler material
- Compare the volumetric properties and stability of bituminous mix produced using HMA and Sasobit® as warm mix additive.

- Improving the volumetric properties of BC mix.
- To utilize sasobit® in bimanous mixes to reduce the temperature and also increase the stability
- To utilize iron ore tailings as filler material in bituminous mixes.

3. LITERATURE REVIEWS

In 1956, Prof. Ladis Csanyi, Lowa State University, realized the potential of foamed bitumen for use as a soil binder. Since then, foamed asphalt technology, which allows lower mixing temperatures, has been used successfully in many countries.

In the early 1970s, Chevron developed mixture design and thickness design methodologies for paving mixtures (base, open-graded, and dense-graded) stabilized with Emulsified asphalt. In 1977, Chevron published their "Bitumuls Mix Manual" as a practical guideline, which contains much valuable information for specifying, designing, and producing emulsion-stabilized mixtures.

Kuennen reported that emulsified asphalt mixes are popular in rural settings where distances from HMA plants and lower traffic volumes may preclude HMA.

In 1994, Maccarone and others, studied cold-mixed asphalt-based foamed bitumen and very high binder content emulsions and concluded that the use of cold mixes for use on roads was gaining acceptance worldwide due to energy efficiency and lower emissions.

In 1995, Shell Bitumen filed a patent to cover a warm-mix asphalt technique that used a two-component technique, of Shell Global Solutions, described an innovative WMA process that was tested in the laboratory and evaluated in large-scale field trials (in Norway, the United Kingdom, and the Netherlands) with particular reference to the production and placement of dense-graded wearing courses

Jenkins and others, introduced a new process involving a half- warm foamed bitumen treatment. They explored the concepts and possible benefits of heating a wide variety of aggregates to temperatures above ambient but below 212°F before the application of foamed Bitumen.

4. METHODALOGY

The purpose of this study was to evaluate the laboratory performance of warm mix asphalt mixtures with additives (Sasobit®) for Dense bituminous macadam (DBM) Grade-2. After the determination of gradation, Marshall stability tests were conducted to determine the volumetric properties of the specimens. The coarse aggregates used in the present study are crushed hard rock passing 16mm, 12.5mm, 10mm and 6mm sieve sizes. The iron are tailings passing 2.36mm sieve is used as filler material. Various tests conducted to determine basic properties of aggregates and the tests conducted to determine the basic properties of bitumen

Table 4.1: Physical properties of Coarse aggregates

SI. No.	Properties	Test method	Obtained Values
1	Crushing value	IS-2386 part IV	34.44%
2	Abrasion value	IS-2386 part IV	17.06%
3	Impact value	IS-2386 part IV	23.36%
4	Combined Flakiness and elongation index	IS-2386 part I	4.2%
5	Water absorption test	IS-2386 part III	0.75%

Table 4.2: Physical properties of Bitumen

SI. No.	Properties	Test Method	Obtained Values
1	Penetration(mm) (100g, 25°C, 5 sec)	IS: 1203 -1978	54.6
2	Softening point (°C)	IS: 1205 -1978	53°C
3	Ductility at 25°C (mm)	IS: 1208 -1978	63 cm
4	Specific gravity	IS: 1202 -1978	1.01
5	Flash point test (°C)	IS: 1209 -1978	318°C
6	Fire point (°C)	IS: 1209 -1978	296°C

Table 4.3: Physical properties of Fine aggregates

SI. No.	Properties	Test method	Obtained values
1	Fineness modulus test	IS-2386 part I	2.98
2	Bulking of sand	IS-1963 part III	26%
3	Specific gravity test	IS-1963 part III	2.74

4.1 Rothfuch's Method

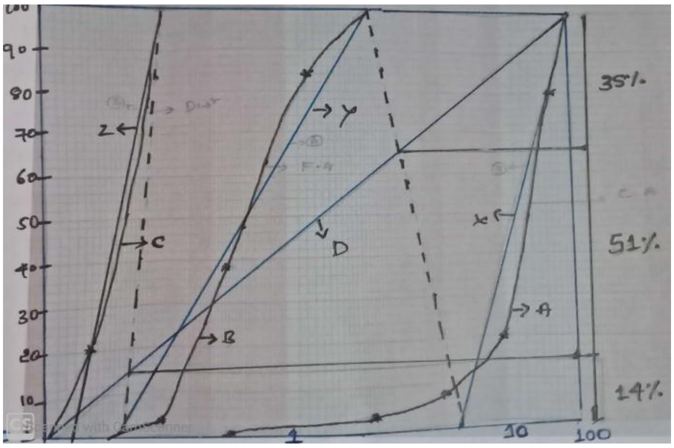


Figure 4.1: Rothfuch's graphical method

Where,

- A, B, C are coarse aggregate, fine aggregate and stone dust respectively
- X, Y, Z are balancing straight lines
- D is desired gradation
- X and Y axis are particle size (in mm) and percentage of passing respectively

Obtained aggregates proportion is

MATERIALS	PERCENTAGE (%)
CA (20mm down size)	35
FA (4.75 down size)	51
FILLER (iron or tailings)	14

We checked proportion by MORTH Section 509

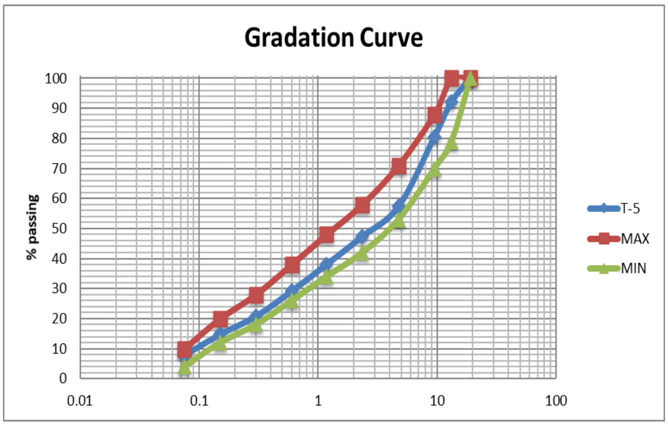


Figure 4.2: gradation curve

4.2 Marshall Stability Test

The Marshall stability tests were conducted with varying percentage of binder content to determine the optimum binder content for HMA. Tests were also conducted for WMA to determine its volumetric properties with Sasobit® as additive at OBC for temperature 120˚C. and also semi degradable waste material (iron ore tailing). The tests were conducted according to IS specifications. The Marshall stability test results obtained are presented in Table 4.4 to Table 4.6.

Figure 4.3: Marshall stability test

Table 4.4: Marshall Stability test results for HMA at 140⁰ C

SI. No	Properties	HMA
1	Optimum binder content in (%)	5.5
2	Stability (KN)	11.05
3	Flow (mm)	4
4	Bulk density (gm/cc)	2.285
5	Volume of air voids in (%)	8
6	VMA (%)	20.5
7	VFB (%)	60.97

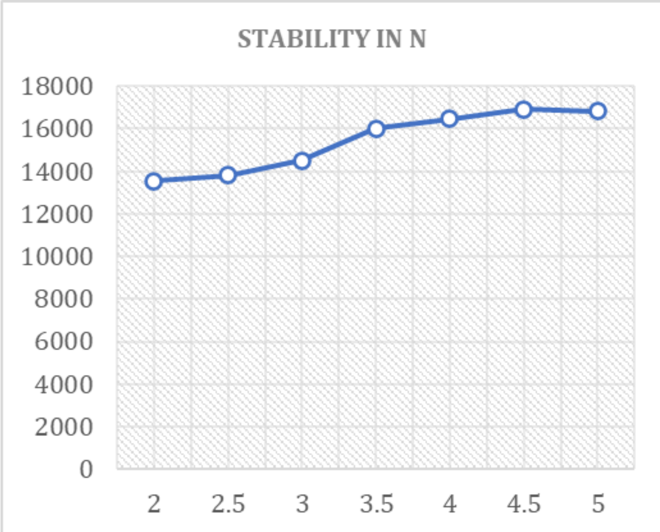
Table 4.5: Marshall Stability test results for WMA at 120˚C

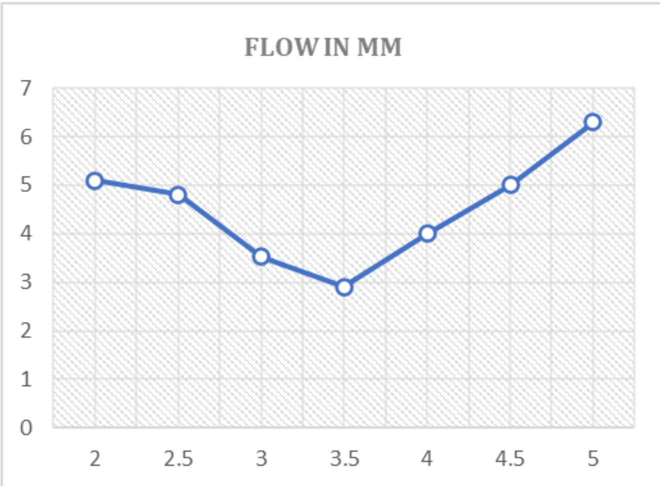
SI. No	Properties	WMA AT 120˚C						
		Sasobit® percentage						
		1.5%	2%	2.5%	3%	3.5%	4%	4.5%
1	Stability (KN)	15.43	15.53	16.6	15.54	15.49	14.35	13.73
2	Flow (mm)	7.066	5.66	5.03	4.8	5.866	5	6.3
3	Bulk density (gm/cc)	2.285	2.291	2.307	2.284	2.289	2.257	2.255
4	Volume of air voids in (%)	5.29	5.8	6.3	6.7	5.3	7.1	6.8
5	VMA (%)	17.79	18.3	18.8	19.2	17.8	19.6	19.3
6	VFB (%)	70	68.3	66.4	65.1	70.2	63.38	64.7

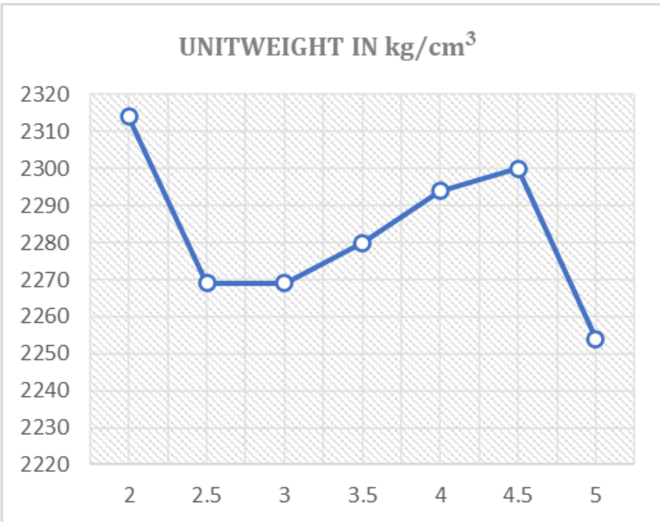
Table 4.6: Marshall Stability test results for WMA at 120⁰C Iron ore tailings as filler material

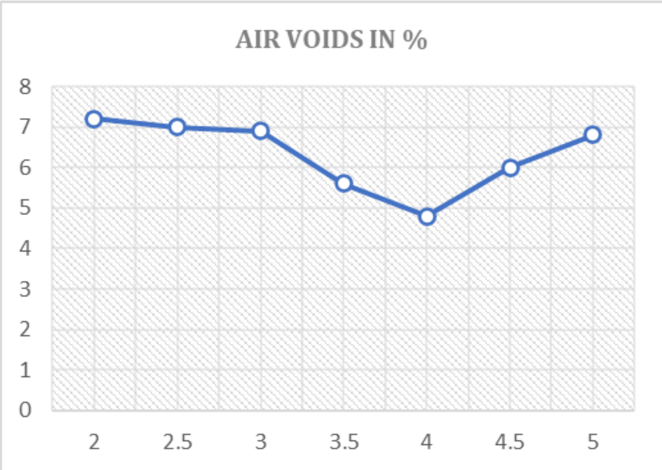
SI. No	Properties	WMA AT 140˚C						
		percentage						
		2%	**2.5%**	**3%**	**3.5%**	**4%**	**4.5%**	**5%**
1	Stability (Kg)	13.57	13.81	13.51	16.18	16.463	16.91	16.81
2	Flow (mm)	5.1	4.8	3.53	2.9	4	5	6.3
3	Bulk density (gm/cc)	2.314	2.269	2.269	2.280	2.294	2.3	2.254
4	Volume of air voids in (%)	7.2	7	6.9	5.6	4.8	6	6.8
5	VMA (%)	19.7	19.5	19.4	19.1	17.3	18.5	19.3
6	VFB (%)	63.5	64.1	64.4	65.4	72.2	67.6	64.7

we achieved at 5.5 OBC, Sasobit® at 2.5% in 120⁰C and iron ore tailings at 3.5%. finally, we obtained.









Line chart: Final Marshall Stability test valve

5. CONCLUSIONS

In the present study, the importance was to add the warm mix additives to Dense Bituminous Macadam (DBM) mix and to evaluate the various mix properties like Marshall Stability, flow, bulk density, voids in the mix and VFB. Marshall stability test was done for various field temperatures.

- The OBC was found to be 5.5% for HMA at 140˚c temperature.
- The maximum stability for 60/70 grade bitumen is achieved at 120˚C temperature with 2.5% dosage rate. In 120˚C temperature shows better and maximum sasobit®
- From Marshall stability test, it can be concluded that there is an increase in stability up to 60% at 120˚C for 60/70 grade bitumen after adding Sasobit® to the mix Hence the warm mix additive of 2.5% Sasobit® at 120˚C temperature can be used as an alternative for HMA.
- The addition of WMA additive Sasobit® improves the bulk density of the mix by 2.5%. Hence 120˚C temperature with additives shows better and maximum bulk density.
- Waste material (iron ore tailings) can be used as filler material in bituminous concrete mixture for road construction.
- Use of the innovative technology not only strengthened the road construction but also increased the road life.
- Help to improve the environment.
- Sasobit® was used in road would be a boon for India's hot and extremely humid climate where durable and eco-friendly roads.

This small investigation not only utilizes beneficially, the waste semi-degradable iron ore tailings but also provides us an improved pavement with better strength and longer life period.

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