International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Utilization of Manganese Slag as Replacement of Coarse Aggregates in Bituminous Concrete Mix Grade II

Pramodh A[1], Praveen Kumar P[2], Dr. B V Kiran Kumar[3]

[1]*M.Tech Student, Highway Technology, Civil Engineering. Department, Govt. SKSJTI, Bengaluru, Karnataka, India*
[2]*Assistant Professor, Civil Engineering. Department, Govt. SKSJTI, Bengaluru, Karnataka, India*
[3]*Associate Professor, Civil Engineering. Department, Govt. SKSJTI, Bengaluru, Karnataka, India*

Abstract - *Bituminous concrete is a composite material which is used in the top layer of the flexible pavement. It comprises of fine aggregates, coarse aggregates and bitumen. The aggregates used are virgin and non-renewable in nature. On the other hand, waste materials are generated by the Industries, construction sites, mines and so on. To reduce its stock, avoid environmental pollution and protect valuable landscape from dumping huge wastes, waste materials are used in the construction activities. Indian Steel Industries produces nearly 0.62 lakh tonnes of manganese slag per year. In this study manganese slag is used as a replacement of coarse aggregates in bituminous concrete mix grade-II at different percentages. This study evaluates the performance of the virgin aggregates used in the conventional bituminous mix and manganese slag of size between 19 mm-4.75 mm used as replacement of coarse aggregates in the bituminous mix. Basic tests and gradation for different types of materials used in this study is done as per Indian standards. Bituminous mixes used in the preparation of Marshall specimens to determine optimum binder content fulfilled the standard requirements. Marshall Stability and Indirect Tensile Strength tests are used as parameters to check the mechanical properties of bituminous mix. From laboratory tests it can be concluded that 75% and 100% replacement of virgin coarse aggregates by manganese slag in the bituminous mix exhibits better strength and resistant to moisture susceptibility than the conventional mix and thus recommending its use in pavement construction.*

Key Words: **ITS (Indirect tensile strength), Marshall Test, Manganese slag, Bituminous Concrete grade II, Gradation, Optimum Binder Content, TSR (Tensile Strength Ratio).**

1. INTRODUCTION

Manganese has better allotropic qualities, so it is used in steel manufacturing industries which in return generates slag. And it is increasing in a faster rate nowadays posing a threat to environment by causing disposal problem. Natural aggregates which are used traditionally in road construction are depleting because of its exhaustible nature. Manganese slag is used in this study as replacement of coarse aggregates in bituminous mix. This may help in reducing disposal problem created by slag to a certain extent and also the occupancy of useful land in nearby time. Waste products that are used in road construction can be divided into three basic group of reusable construction materials, industrial wastes and natural construction materials with a less utility value.

Rock, sand, gravel can be classified under re-usable materials. Examples for the industrial by-products are fly-ash, slag etc. while the natural products with less utility value is depicted mainly from excavation and quarry.

The concept of using manganese slag is relatively new in the flexible pavement construction. The strength and life of flexible pavements can be enhanced by the addition of Slag. It can be easily mixed with bituminous mixtures and no modification of existing plants or plant technologies is required. Manganese Slag added bituminous mix is water and temperature resistant. The use of slag predominantly consists of aggregates in plain bituminous concrete mixtures has showed improved strength.

In practice, Manganese Slag has been using by some local agencies as construction material in Bellary district. Its application in flexible pavement construction is a new technique in which we can increase the performance of the road and this can solve the problem of environmental pollution by manganese slag in a small amount. Main benefits from this work are reduction in cost of materials which is suited to be used as highway material.

The main objective of the present study is to evaluate the performance of manganese slag as a highway material compared to natural aggregates by taking parameters such as stability, flow, air voids, tensile strength, moisture susceptibility.

2. MATERIALS, METHODOLOGY AND EXPERIMENTAL STUDY

2.1 MATERIALS

NATURAL AGGREGATES:

Aggregates in the form of fine and coarse are used in the bituminous mix after obtaining job mix formula using gradation. The used aggregates in this study are collected from Quarry near Peresandra, Chikkaballapura District.

MANGANESE SLAG:

Manganese slag aggregates of size 19mm-4.75mm is used as replacement to virgin coarse aggregates. It is collected from Bellary.

Fig -1: Manganese slag used for the study

BITUMEN:

Bitumen of VG- 30 collected from asphalt plant in Bellary has been used for the present study.

2.2 METHODOLOGY

All the laboratory tests conducted for aggregates such as basic tests to analyse their physical properties, sieve analysis in table 1, gradation to obtain job mix formula mentioned in table 2. Marshall Stability test is conducted at different percentages of bitumen (4.5% to 6.5%) to get Optimum binder content using JMF is mentioned in table 3.

At OBC the replacement of natural aggregates is done by manganese slag at various percentages such as 25%, 50%, 75%, 100% to determine Marshall properties.

For similar percentages of replacements, Indirect Tensile strength test is conducted to evaluate tensile properties of bituminous mix. Marshall test results and tensile properties test results obtained are mentioned in table 4 and table 5 respectively. Basic tests were conducted as per Indian standards. Gradation is done as per MoRT&H standards. Marshall stability test was conducted as per ASTM D 6926. Indirect tensile Strength test was conducted according to ASTM D 6931.

2.3 EXPERIMENTAL STUDY

Table -1: Sieve analysis of aggregates used

IS Sieve mm	A (20mm down)	B (13.2mm down)	C (Dust)	D Slag (19-4.75mm)
19	100	100	100	100
13.2	57	93.6	100	78
9.5	20.5	51	100	38
4.75	7.4	16	95.1	12
2.36	-	-	78.5	-
1.18	-	-	55.9	-
0.6	-	-	41.5	-
0.3	-	-	28.6	-
0.15	-	-	19.2	-
0.075	-	-	6.4	-

Table 2: Job Mix Formula for different types of percentages of replacement.

Manganese slag added to Bituminous mix (%)	A (%)	B (%)	C (%)	D (%)
0 (Conventional mix)	15	20	65	-
25	11	15	65	9
50	6	11	65	18
75	2	6	65	27
100	-	-	65	35

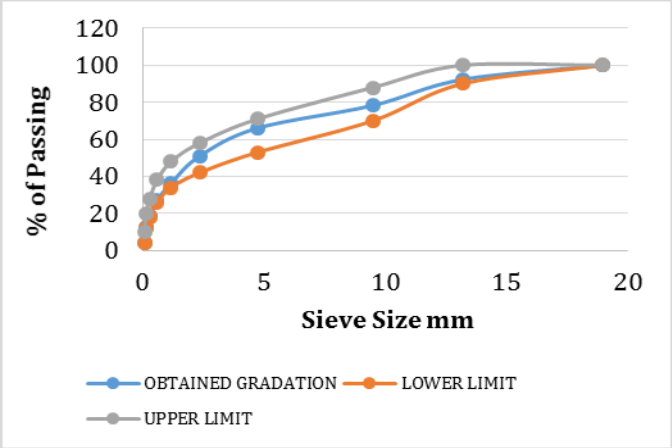

Chart -1: Gradation Curve

3. RESULTS

3.1 TEST RESULTS OBTAINED FOR MARSHALL TEST

Table- 3: Optimum Binder content obtained

Sl. No.	Properties	OBC From graphs	OBC in Average
1	Max. stability, kg	5.95 %	5.51 %
2	Max. density, g/cc	5.5 %	
3	Air voids (%)	5.1 %	

Table- 4: Marshall results for different mixes at OBC

Marshall Property	Conventional mix	Manganese Slag added to mix (%)			
		25	50	75	100
Stability, kg	1490	1458	1969	2612	3081
Flow, mm	3.5	4.34	3.78	3.17	2.63
Density, g/cc	2.19	2.19	2.2	2.21	2.2
Air Voids, %	4.72	4.56	4.38	3.86	3.6
VMA, %	16.7	11.9	12.5	13.1	14.1
VFB, %	71.7	61.5	65	70.3	74.3

3.2 COMPARISION OF MARSHALL PROPERTIES AT DIFFERENT PERCENTAGES

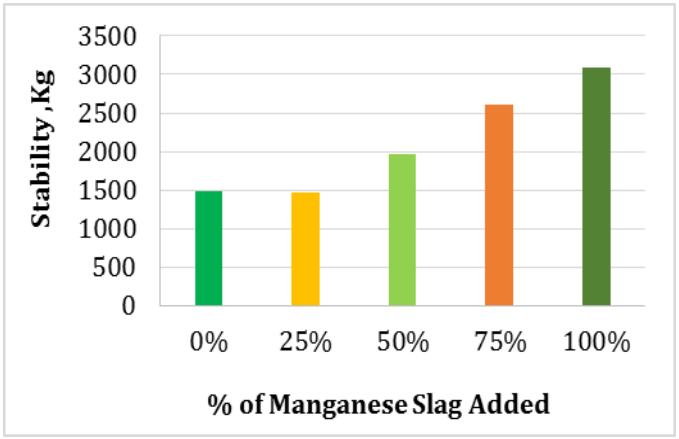

Chart – 2: Graphical Representation of stability values at different % of replacement.

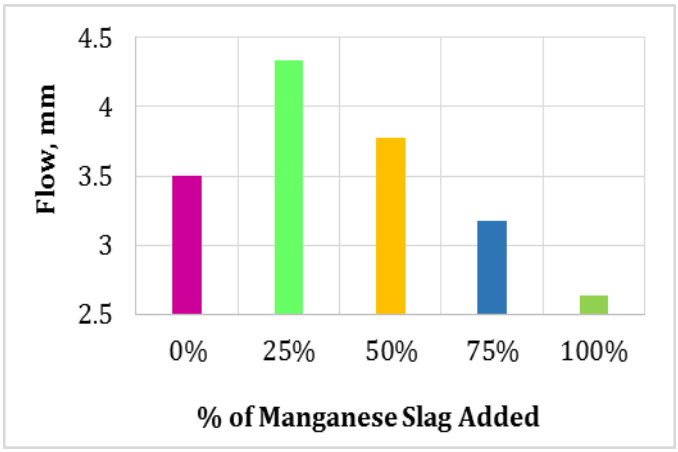

Chart -3: Graphical Representation of flow values at different % of replacement.

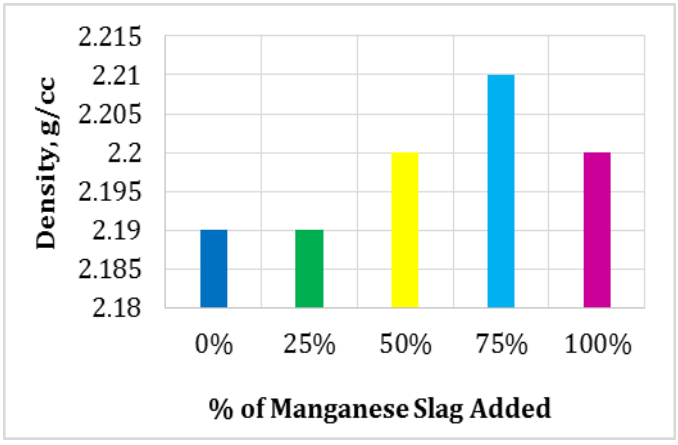

Chart -4: Graphical Representation of density values at different % of replacement.

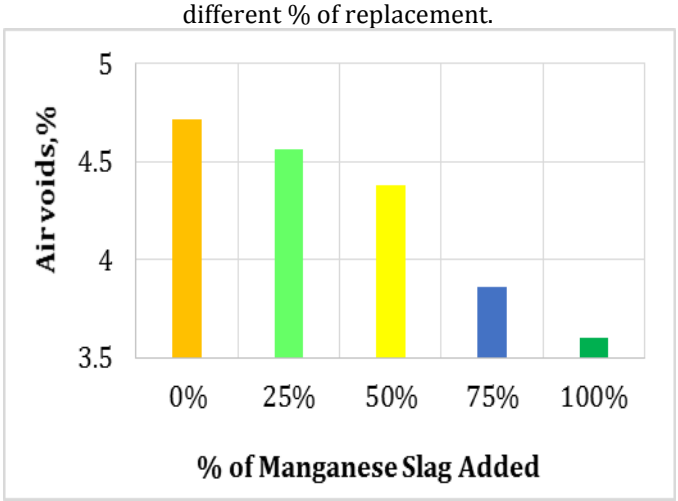

Chart -5: Graphical Representation of air voids values at different % of replacement.

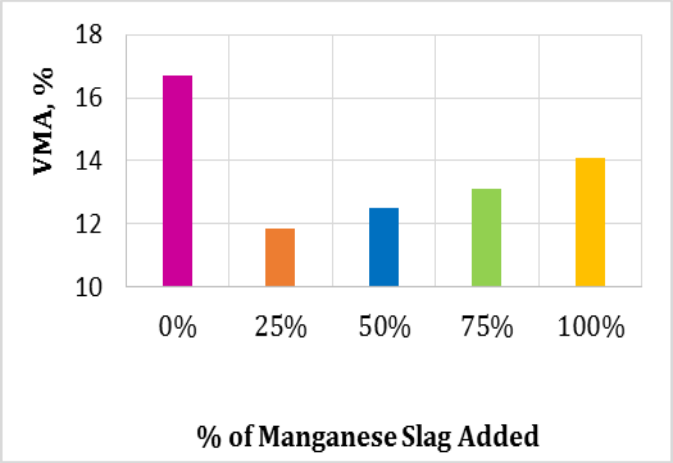

Chart -6: Graphical Representation of VMA values at different % of replacement.

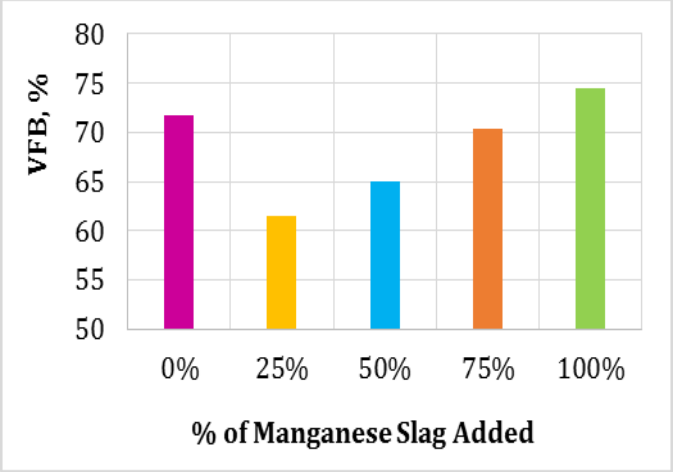

Chart -7: Graphical Representation of VFB values at different % of replacement.

3.3 INDIRECT TENSILE STRENGTH RESULTS FOR DIFFERENT MIXTURES

Table 5: Tensile properties of replaced and conventional samples

Manganese Slag added	ITS, MPa		TSR
	Conditioned	Dry	
0 %	1.41	1.68	0.84
25 %	1.07	1.49	0.72
50 %	1.27	1.66	0.77
75 %	1.47	1.68	0.88
100 %	1.57	1.74	0.90

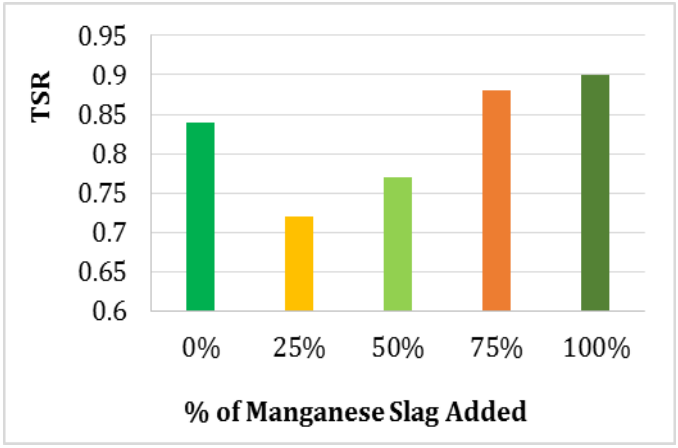

Chart -8: Graphical Representation of TSR at different % of replacement.

4. DISCUSSION

The objective of present study is to compare Marshall, tensile properties of bituminous mixes prepares by conventional and slag aggregates at optimum binder content by conducting Marshall stability, Indirect tensile strength test. Replacement of coarse aggregates is done at 25, 50, 75, 100 percentages respectively.

75% and full replacement (100%) of coarse aggregates by slag aggregates are showing improved results than the conventional mix.

Stability is increasing with increase in % of replacement except for 25%, which is less than 0% replacement (conventional mix).

Flow value is less for 75% and 100% replacement than conventional mix.

Density is same or more for all replacement mixes than conventional mix.

Air voids is less for all % of replacement than 0% (Conventional mix).

5. CONCLUSIONS

The present work was carried out to find out the behaviour of manganese slag as a highway material in terms of Marshall and tensile properties. The conclusion is based on test results obtained in the Laboratory. Replacement of coarse aggregates by manganese slag by 75% and 100% has better results compared to the mix prepared by natural aggregates.

- From Marshall test conducted for various % of Bitumen i.e. 4.5% to 6.5%, Optimum Binder content obtained is 5.51%.

For OBC, Bituminous mixes were prepared as per Marshall procedure.

- Stability, Density values are increasing for 75% and 100% than 0% replacement mixtures samples.
- Flow value, Air voids (Vv) are decreasing for 75% and 100% replacement mixture than 0%.
- Indirect Tensile Strength of 75% and 100% replacement mixture samples is improving compared to other mixture samples.
- TSR values shows that 75% and 100% replacement mixtures samples are better resistant to moisture. Thus increasing performance of the mix.

ACKNOWLEDGEMENT

I would like to express my gratitude and appreciation for all those who provided me the support and guidance. I would like to thank my parents for their consistent support and blessings.

REFERENCES

[1] R. Deepak, Dr. Suji and P. Prabhakar (2016): Experimental study on mechanical properties of Bituminous Paving mixes using steel slag, International Journal of Civil and Structural Engineering Research, Vol. 4, pp 150-158.

[2] Kavyashree L Magadi, Anirudh N, K M Mallesh (2016): Evaluation of Bituminous concrete mixture properties with steel slag, Transportation Research Procedia 17, pp. 174-183.

[3] A. Behnood, M. Ameri (2012): Experimental investigation of stone matrix asphalt mixtures containing steel slag, Scientia Iranica, Vol. 19, pp. 1214-1219.

[4] Pawan Kalla, Pradeep Kumar Gantam , Ravindra Nagar, Rahul Agarwal, Ajay Singh Jethoo (2018), Construction and Building materials, Vol. 168, pp. 143-152.

[5] S. K. Khanna, C. E. G. Justo, A. Veeraraghavan, Highway Engineering, 10th Edition; Nem Chand & Bros: Roorkee, 2015.

BIOGRAPHY

Pramodh A received a Bachelor degree in Civil Engineering from Nitte Meenakshi Institute of Technology, Bengaluru in 2017 and Master degree in Highway Technology from VTU, Belgaum in 2019. He is currently interested in the field of Highway materials.