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REPLACEMENT OF COARSE AGGREGATE WITH STEEL SLAG IN HOT MIX ASPHALT

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Abstract

Flexible pavement is a structure consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of suitable nature in layers over the subgrade. The pavement should possess some characteristics such as riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The main aim is to distribute of vehicular load to sub-grade. Hot mix asphalt (HMA) is a merger of 95% stone, sand, or gravel bound together by asphalt cement. Steel slag is a byproduct of the steel making process. The use of Steel slag in HMA can have a large economical, environmental, and engineering impact in pavement construction. Introduction of steel slag as aggregates reduces the demand for primary aggregates in nearby areas allowing the preservation of resources and reducing the indirect environmental impact caused by quarrying activities.

Keywords: *Hot Mix Asphalt, Steel slag*

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1. INTRODUCTION

Bituminous concrete mixture is a combination of aggregate and binder. The aggregate acts as the structural skeleton of the pavement and bitumen acts as the glue of the mixture. The properties of the aggregate have direct and significant effect on the performance of the pavement. The utilization of industrial by-products and recycled materials in road construction as secondary and alternative materials has gained widespread acceptance and is becoming more important. The demands for industrial by-products and recycled materials are increasing every year. Using industrial by-products in pavement engineering not only provides construction materials with possible savings over new materials, but it also reduces demands on natural construction materials. It also can protect the environment and save money through reducing the amount of waste materials requiring disposal. The use of secondary aggregates like steel slag is increasing. It is still very limited if comparison is made with use of primary crushed stone aggregate. The resulting large quantities of slag produced and their potential impact on the environment have prompted materials scientists and civil engineers to explore the technically-sound, cost effective and environmentally-acceptable use of a wide range of slag in civil and highway construction.

2. CHARACTERIZATION OF MATERIALSAND METHODOLOGY

2.1 Characterization of Aggregates

Aggregates used in project work was collected at quarry in Anjanapura, Bengaluru. Themddleaggregate gradation for each type of mix was adopted as per MORTH specifications.

- Middle limit of gradation range: The nominal maximum size of this gradation is 13.2mm for BC.

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Aggregate gradation curve for Mid gradation rangs is plotted as below:

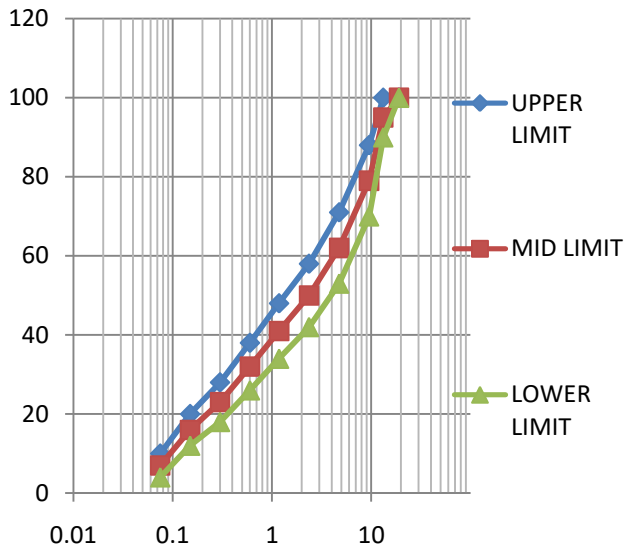

Fig-1: Gradation adopted

Basic properties of aggregates were determined in laboratory and are within the specification in accordance with MORTH.

Table 1: Basic properties of aggregates:

SI. No	Test	Result	MORTH specification Limits
1	Aggregate Impact value	22%	24% max
2	Los Angeles Abrasion value	27%	30 %max
3	Aggregate Crushing value	25%	30% max
4	Specific gravity		
	12.5mm down	2.7	-
5	Water absorption (%)		
	12.5mm down	0.5	-

2.2 Characterization of Bitumen

The type of binder used for preparation of bituminous mixture is VG-30 and this was tested for its physical properties and it satisfies all requirements as per MoRTH specification.

Table 2: Properties of VG – 30 grade bitumen

Sl No	**Test**	**Code**	**Results**	**Requirements as per MORTH**
1	Penetration at 25°c (mm)	IS 73:2006	65	50-70
2	Ductility at 25°c (cm)	IS 73:2006	85	Min 75
3	Softening point (°c)	IS 73:2006	62	Min 47 °c
4	Specific gravity at 25 °c	IS 73:2006	1.01	0.97 – 1.02
5	Flash & Fire point (°c)	IS 73:2006	285 °c 310 °c	Min 220°c Min 270°c

2.3 Characterization of Steel Slag

Table 3: Properties of steel slag.

SI. No	Test	Result	MORTH specification Limits
1	Aggregate Impact value	25%	45% max
2	Los Angeles Abrasion value	24%	30 %max
3	Aggregate Crushing value	30%	30% max
4	Specific gravity		
	12.5mm down	3.24	2.1-3.2
5	Water absorption (%)		
	12.5mm down	1.5	Max 5%

3. OPTIMUM BITUMEN CONTENT (OBC)

Optimum Bitumen content was determined for Middle limit gradation with Combined Flakiness and Elongation Indices of 30-35% and results are tabulated:

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Table 4: OBC results

Marshall Properties	Virgin mix	50% replace-ment	100% replace-ment
Bulk Density g/cc	2.325	2.372	2.383
Optimum bitumen content (^{0} c)	5.8	5.5	5.3
Voids in mineral aggregate (VMA) (%)	15.95	16.52	18.43
Air voids {V_a}(%)	3.45	3.6	5.08
Voids filled with bitumen {VFB} (%)	78.39	78.21	72.44
Stability (KN)	20.9	21.8	18

4. COMPARITIVE PLOTS FOR MARSHALL PROPERTIES FOR DIFFERENT MIXES AT OBC

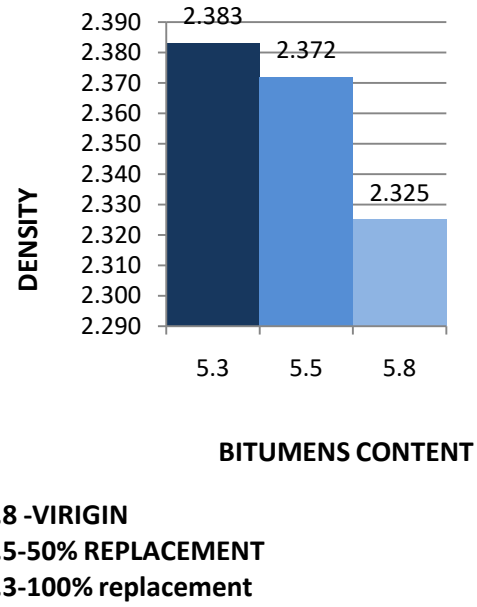

Fig 2: Biumen vs Density

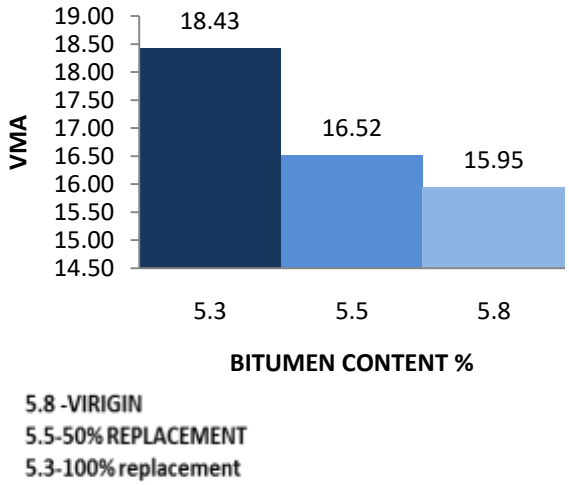

Fig 3: Bitumen vs VMA

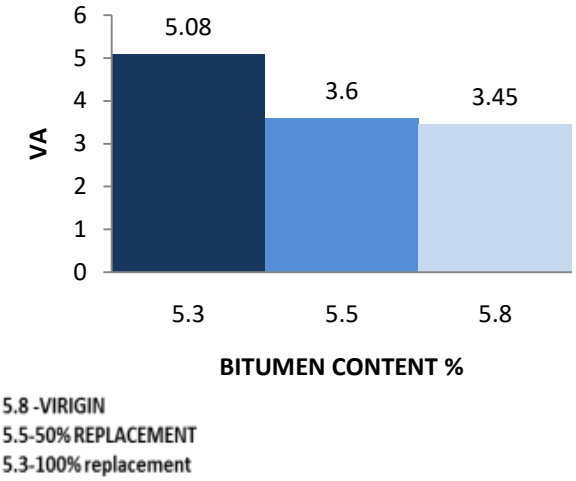

Fig 4: Biumen vs Air Voids

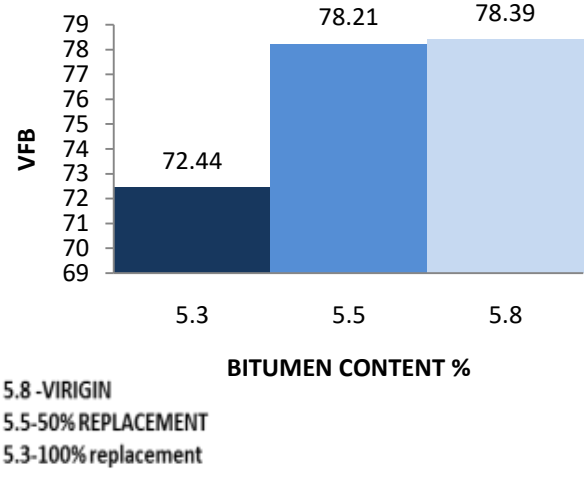

Fig 5: Biumen vs VFB

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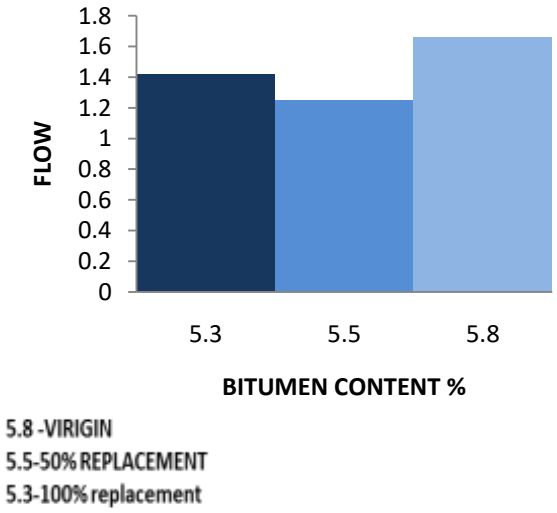

Fig 6: Biumen vs Flow

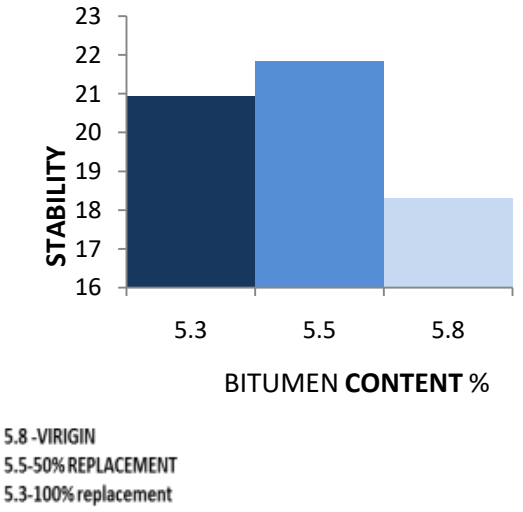

Fig 7: Biumen vs Stability

5. CONCLUSION

- This study revealed that the use of steel slag as a replacement to coarse aggregate in Hot Mix Asphalt greatly improves its density, stability and strength.
- This study also shows that the use of steel slag in HMA reduces the optimum bitumen content, thus making the flexible pavement construction more economical and eco-friendly.
- The incorporation of steel slag in flexible pavement construction improves its efficiency, serviceability and durability.
- It also reduces the negative impact on environment caused due to overexploitation of natural sources of coarse aggregate, thus making the flexible pavement construction practices more sustainable.

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