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Use of Steel Slag Aggregate in Open Graded Bituminous Mixes

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Abstract: ***Most of the bituminous roads are damaged during rainy season due to poor cross sectional design, improper drainage and its maintenance. One of the better alternative solutions is use of Open Graded Friction Course (OGFC). OGFC mixes consist of large percentage of interconnected air voids which improves the permeability. These mixes composed of single sized coarse aggregate with small portion of fine aggregate and relatively high percentage of binder. Steel Slag Aggregate (SSA) is a byproduct of the production of steel in an electric arc furnace. SSA is very angular and porous material with high iron oxide results in about 20% to 30% heavier than naturally occurring aggregates such as basalt and granite. It also contains a high content of calcium and magnesium oxides, which make it expand when it comes into contact with moisture. In the present study, Crumb Rubber Modified Bitumen (CRMB) is used as binder and conventional aggregate is replaced by different percentages of SSA in Bituminous mixes. The mixes are tested for Abrasion loss for aged and unaged, air voids, and draindown characteristics. The optimum binder content is determined for each percentage replacement of coarse aggregate replaced with different percentages of SSA. From the experiment results, it is found that the bituminous mix prepared with 6% binder and 50% of coarse aggregate replaced with SSA performed better.***

Keywords: Open Graded Friction Course, Steel Slag Aggregate, Aged and Unaged Abrasion Loss, Draindown.

I. INTRODUCTION

Open Graded mixes provide a higher degree of permeability to the surface of the pavement which intern improves frictional behavior during wet weather while reducing the dangers of splash and spray and hydroplaning due to increased drainage from the pavement surface. In addition, open graded friction courses are generally quieter than conventional pavements [1]. Modified binders are used to counter the problem of draindown and aging. Although OGFC are more expensive (6 to 30%) than conventional mixes because of high quality aggregate and higher binder percentage, there are special benefits related to drainage and maintenance cost aspects [2].

A. Steel Slag Aggregate

It is a by product of the production of steel in an electric arc furnace. The slag produced is very angular and porous with a rough surface texture. The chemical properties of the aggregates vary depending on the furnace, feed stock and slag formers used to produce the steel. The aggregate formed from the slag is comprised of calcium oxide (CaO), silicon oxide (SiO_2), iron oxide (Fe_2O_3), magnesium oxide (MgO), manganese oxide (MnO), aluminum oxide (Al_2O_3) and sulfur oxide (SO_3).

Laboratory testing of mixes with SSAs, natural aggregates and mixtures of the two indicated that the mixes with higher contents of SSA had higher resilient modulus values, less deformation, higher tensile strengths, and were less susceptible to moisture damage than the mixes with the higher natural aggregate contents. Mixes with 100% SSA required 25 percent more asphalt binder than the other mixes.

The SSA had a porous structure that required 24% more asphalt binder than the basalt aggregate. Expansion rates were below 1% confirming the use of the extended moist curing process. Rutting tests and indirect tensile tests showed that the 10% SSA mix was more resistant to rutting and low temperature cracking than the basalt mix.

II. METHODOLOGY

The materials used are Crumb Rubber Modified Bitumen, Steel Slag Aggregate, normal Coarse Aggregate, River sand, and Water. SSA used in the study is collected from SDV Steels, Kondapalli, Vijayawada and Andhra Pradesh. Table 1 and Table 2 provide information on the Physical properties and chemical composition of SSA used in the present study respectively.

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Table 1. Physical Properties of Steel Slag Aggregate

S.No	Description	Value
1	Specific Gravity	3.32
2	Water Absorption (%)	0.87
3	Los Angeles Abrasion (%)	19
4	Impact (%)	21
5	Soundness (Sodium Sulfate) %	10

Table 2. Chemical Composition of Steel Slag Aggregate

S.No	Description	Value (%)
1	Iron	96.5
2	Carbon	0.4
3	Manganese	0.65
4	Phosphorous	0.05
5	Silicon	0.2

Bituminous mixes prepared with 25%, 50%, 75%, and 100% of the coarse aggregate replaced by steel slag aggregate are tested for Abrasion loss for aged and Unaged, air voids, and draindown characteristics. Marshall Test was performed on compacted specimens at various binder contents (5.5%, 6%, 6.5% and 7%) based on Ministry of Road Transport and Highways (MoRT&H) specifications.

III.RESULTS AND DISCUSSIONS

The Steel Slag Aggregate (SSA) used in the study and the bituminous mix samples prepared for Marshall test are shown in Fig.1.



Fig. 1 Steel Slag Aggregate and Samples prepared for Marshall Test

Following are the results obtained from the experimental investigation. Fig.2 to Fig.5 show the trend of percentage air voids, draindown (%), Unaged abrasion loss (%) and Aged abrasion loss(%) against bitumen content respectively.

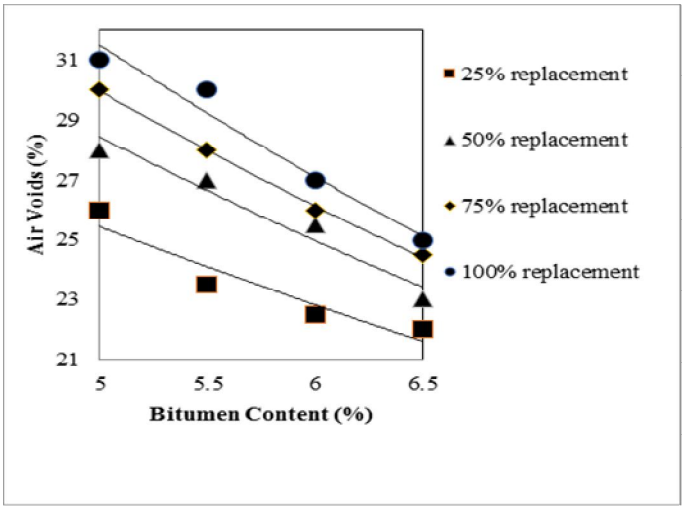


Fig. 2. Binder (%) Vs Air voids (%)

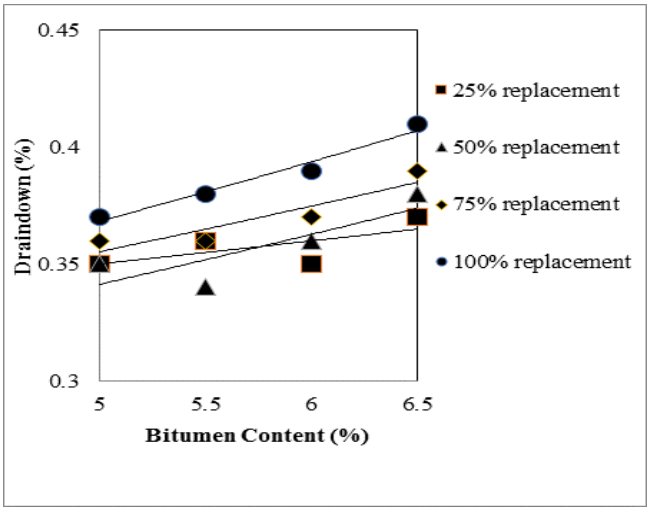


Fig. 3. Binder (%) Vs Draindown (%)

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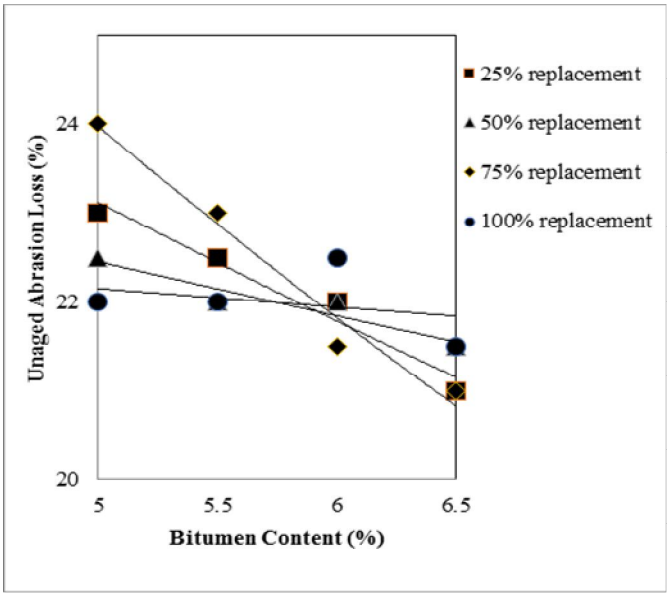


Fig. 5 Binder (%) Unaged Abrasion Loss (%)

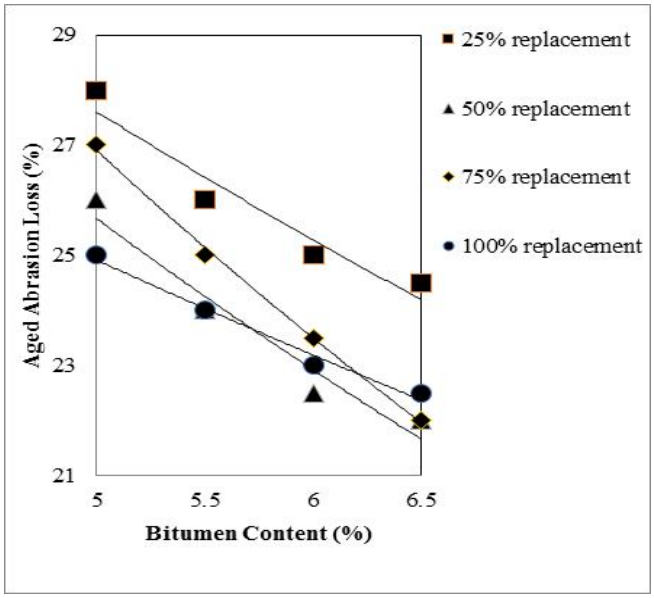


Fig. 6 Binder (%) Aged Abrasion Loss (%)

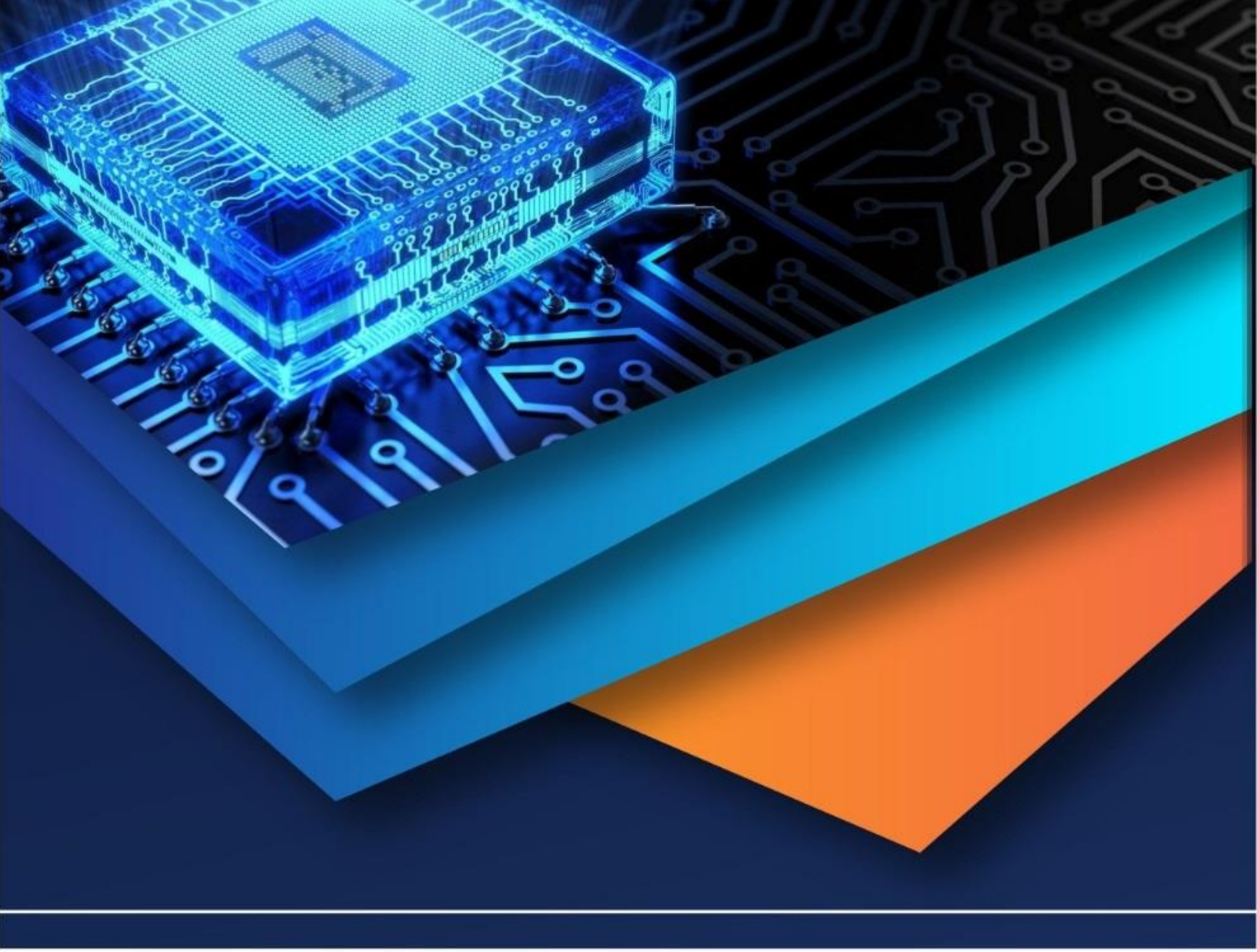
IV. CONCLUSIONS

According to the results obtained from laboratory tests, it has been observed that the percentage air voids is increasing with increase of SSA in coarse aggregate. This can be due to the structure and angularity of steel slag aggregates. An increasing trend was observed in draindown of bitumen with increase of bitumen content and SSA in coarse aggregate. From the results of unaged and aged abrasion loss values, it is observed that 50% replacement of coarse aggregate with SSA performed better and the optimum bitumen content is 6%.

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