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An Experimental Study on Marshall Properties of Bituminous Concrete Mix Prepared Using E-Waste and GGBS(as Filler)

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Abstract: ***Bituminous roads are defined as the roads in the construction of which bitumen is used as binder. It consists of an intimate mixture of aggregates, mineral filler and bitumen. The quality and durability of bituminous road is influenced by the type and amount of filler material is used. The filler tends to stiffen the asphaltic cement by getting finely dispersed in it. Various materials such as cement, lime, granite powder, stone dust and fine sand are normally used as filler in bituminous mixes. Cement, lime and granite powder are expensive and used for other purposes more effectively. Fine sand, ash, waste concrete dust and brick dust finer than 0.075 mm sieve size appear to be suitable as filler material. The use of waste powder as filler in asphalt mixture has been the focus of several research efforts over the past few years. Phosphate waste filler Jordanian oil shale fly ash, bag house fines recycled waste lime, municipal solid waste incineration ash and waste ceramic materials have been investigated as filler. It was proved that these types of recycled filler could be used in asphalt mixture and gave improved performance. So the present study has been taken in order to investigate the behaviour of bituminous mixes with different types of filler materials locally available.***

Keywords: Bituminousconcrete,GGBS,E-waste,Marshall properties of Bitumen..

I. INTRODUCTION

Viscosity Grade Bitumen (Asphalt) is a standard grade Bitumen usually used as a paving grade Bitumen suitable for road construction and for the production of asphalt pavements with superior properties. This grade of Bitumen is mainly used in the manufacture of hot mix asphalt for bases and varying courses and possesses characteristics and qualities unique sand quite different from other agent. They achieve flexible and tenacious connection with other materials due mainly viscoelastic response of Bitumen, which behaviour depends on how fast charges are applied.Viscosity Grade Bitumen, manufactured from fractional/vacuum distillation of crude oil, which practical appliance and behaviour varies according to its temperature.

There are two methods of grading:
Standard Viscosity Grade Bitumen (AC-Grades), in which the viscosity of the standard Bitumen (asphalt) is measured at 60°C(140°F). RTFOT Viscosity Grade Bitumen (AR-Grades), in which the viscosity of the standard Bitumen (asphalt) is measured at 60°C (140°F) after the roll on thin film oven test.
Viscosity grade bitumen have a thermal plastic property which causes the material to soften at high temperatures and to harden at lower temperatures. This unique temperature/viscosity relationship is important when determining the performance parameters such as the adhesion, rheology, durability and application temperatures of Bitumen. In the viscosity graded bitumen specification further emphasizes is placed on the bitumen ductility.

Standard Viscosity Grade Bitumen Binders include:

- Viscosity Grade Bitumen 10
- Viscosity Grade Bitumen 20
- Viscosity Grade Bitumen 30
- Viscosity Grade Bitumen 40

II. OBJECTIVES

The main objectives of present study are:

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- To determine the properties of aggregate and assess the test results as per MORTH specification.
- To determine the properties of viscosity grade bitumen (VG-30) and assess the test result as per IRC SP: 53-2010 requirements.
- To determine the optimum bitumen content in the prepared bituminous concrete mix.
- To determine the Marshal Properties of bituminous concrete mix prepared using E-waste and GGBS as filler material.
- Comparison of Marshal Properties of Conventional and non-conventional bituminous concrete mix.
- To workout the cost requirement of bituminous concrete mix for 1KM road construction.

In the present study, the aggregate gradation (grade-II) has been selected for Bituminous Concrete as per Table 500-18 recommended by MoRT&H (Fourth Revision) specifications. Viscosity Grade Bitumen (VG-30) is used as a binder in the preparation of bituminous concrete mix. Basic engineering tests on aggregates and binder were conducted in the laboratory to assess their properties. Optimum bitumen content for the bituminous mix is determined by Marshall Method of mix design. The bituminous samples are prepared by using GGBS as filler material.Marshall Stability test was conducted on prepared bituminous mix samples to assess the marshal properties.

A. Aggregates

The coarse aggregates shall consist of clean, hard, durable, crushed rock free of disintegrated pieces, organic and other deleterious matter. Aggregate mainly consisting of both coarse and fine aggregates. The coarse aggregate is the fraction of the aggregate components retained on a 2.36mm test sieve. Fine aggregate is the fraction of the aggregate components passing the 2.36mm test sieve and retained on 0.075mm test sieve. Basic engineering tests are conducted on aggregates used in this study and the properties of aggregates are given in Table 3.1.

Table 3.1:Test results of aggregates

Particulars of Tests	Test results	Requirements as per Table 500-17 of MORT&H (IV revision) Specifications
Aggregate impact value (%)	21%	Max 30%
Los Angeles abrasion value (%)	21.16%	Max 40%
Flakiness and Elongation Index (Combined) (%)	20.51%	Max 30%
Water absorption (%)	0.35%	Max 2%
Aggregate specific Gravity		
• Coarse aggregate	2.66	Min 2.5
➢ Fine aggregates	2.63	Min 2.5

B. Binder

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Binder provides durability to the mix. The characteristics of bitumen which affects the bituminous mixture behaviour are temperature susceptibility, visco-elasticity and aging. The behaviour of bitumen depends on temperature as well as on the time of loading. It exhibits both viscous as well as elastic properties at the normal pavement temperature. Though at low temperature it behaves like an elastic material and at high temperatures its behaviour is like a viscous fluid.

In this study VG-30 (Viscosity Grade Bitumen grade 30) is used as binder. Source of this Bitumen is "HINCOL'' Bitumen plant Mangalore.The test results satisfy the requirements as per IS Specification-53. The test results are
presented in table 3.2

Particulars of tests	Test Results	Requirements as per IS:72-1992
Penetration at 25°C, 100gm, 5 Seconds, 0.1mm	62	55mm-75mm
Softening point (Ring & Ball), °C	64	Min 55
Flash point, °C	248°C	Min 220°C
Fire point, °C	280°C	Min 220°C
Ductility @27 °C ,cm	94	Min 50cm
Specific gravity	1.02	Min 0.97

C. Filler

Filler is the material passing 0.075 mm IS sieve. The filler which was selected for this study was Ground Granulated Blast Furnace Slag (GGBS)(2%). Filler content of about 2% by weight of total aggregates is added to mix. Thesource of the GGBS is "RaichurThermalPowerPlant".





D. E-WASTE(Electronics Waste)

In the present study E-Waste or Electronics waste such as waste parts of Televisions, Mobile, Computers, Telephone and other Electronics waste will be used as replacement of Aggregates (4.75mm) in the Bituminous concrete mix and analysis will be done to determine the Marshall Properties of Bitumen Mix.





E. Gradation

The aggregate gradation (grading-2) was adopted for bituminous concrete mix as per MORT&H (IV revision 2001) specification.

Table 3.5 Aggregate gradation for bituminous concrete mix (grading-2)

Sieve Size, mm	Wt. in grams
19	-
13.2	156
9.5	72
4.75	192
2.36	132
1.18	120
0.6	108
0.3	204
0.15	84
0.075	108

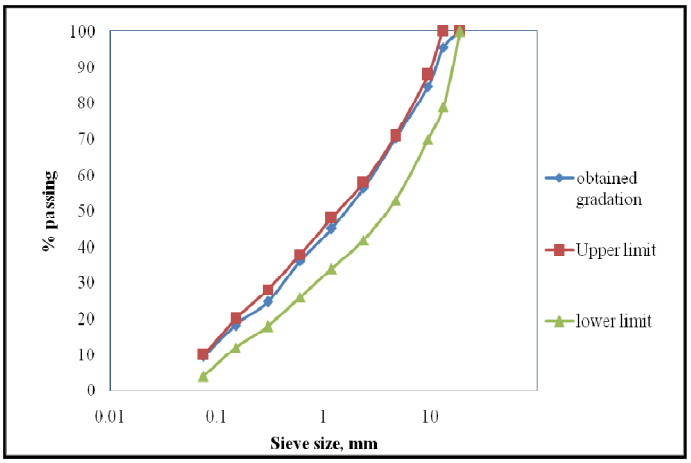


Fig. Gradation of aggregate

F. Marshall Method Of Mix Design

Marshall Stability test of a mix is defined as maximum load carried by a compacted specimen at a standard test temperature at 60 degree Celsius. The flow value is the deformation the Marshall Test specimen under goes during the loading up to the maximum load in 0.01mm units. The Marshall Stability test is applicable for hot mix design using bitumen and aggregates with maximum size of 13.5mm. In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measurement when the same is loaded.

There are two major features of Marshall Stability method of designing mixes are:

- Density voids analysis
- Stability flow test.



Fig. Marshall Test apparatus

G. Binder Optimization By Marshall Method

In order to determine the optimum binder content for this type of mixture four different percentages of bitumen content are used (4.5, 5.0, 5.5, 6.0) % respectively by weight of aggregate. The optimum binder content is determined by the ability of a mix to satisfy the Mechanical properties and volumetric properties. The data obtained from Marshall Stability-Flow test are used to plot the Marshall Properties versus Bitumen Content, from these plots optimum bitumen contents are determined corresponding to Maximum Stability, Maximum Bulk density and 4% air voids in total mix. The optimum bitumen content of the mix is the numerical average of the three values for bitumen contents determined as above.

Marshall Test were conducted on bituminous concrete mix with GGBS, 2% filler to determine optimum bitumen content, Marshall Stability, Flow, bulk density, total air voids, voids in mineral aggregates and voids filled with bitumen. Test results are presented from Table 4.1.

Table 4.2.1 Marshall Properties of Bituminous Concrete mix with GGBS (2%) filler

Bitumen content %	Marshal stability, kg	Flow, mm	Bulk density, g/cc	Total air voids, %	Voids in Mineral Aggregates,%,	Voids filled with bitumen, %
4.5	3900	4.1	1.959	8.421	29.527	30.03
5	4365	4.4	2.342	6.899	16.227	71.473
5.5	4170	3	2.328	5.306	17.231	76.802
6	4335	5.5	2.34	3.824	17.334	80.317

The graphs are plotted for marshall properties of prepared specimen using GGBS (2%) as a filler material are shown below.

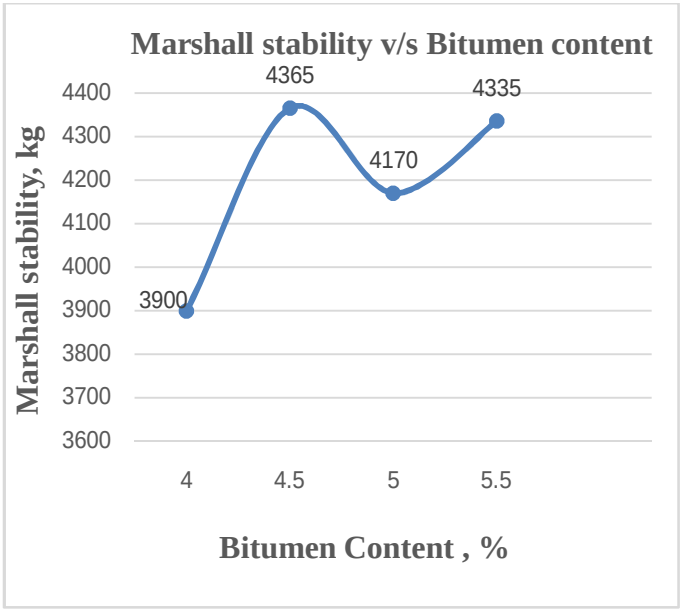


Fig. Marshall Stability v/s Bitumen Content

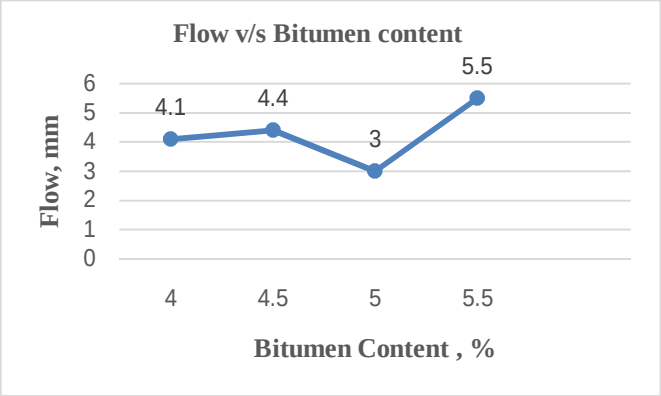


Fig. Flow v/s Bitumen Content

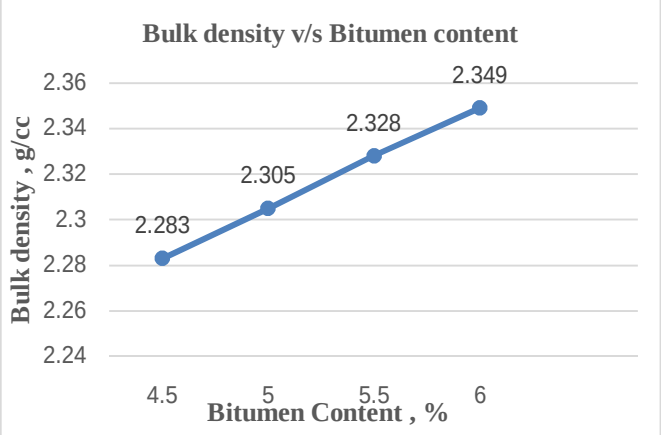


Fig. Bulk Density v/s Bitumen Content

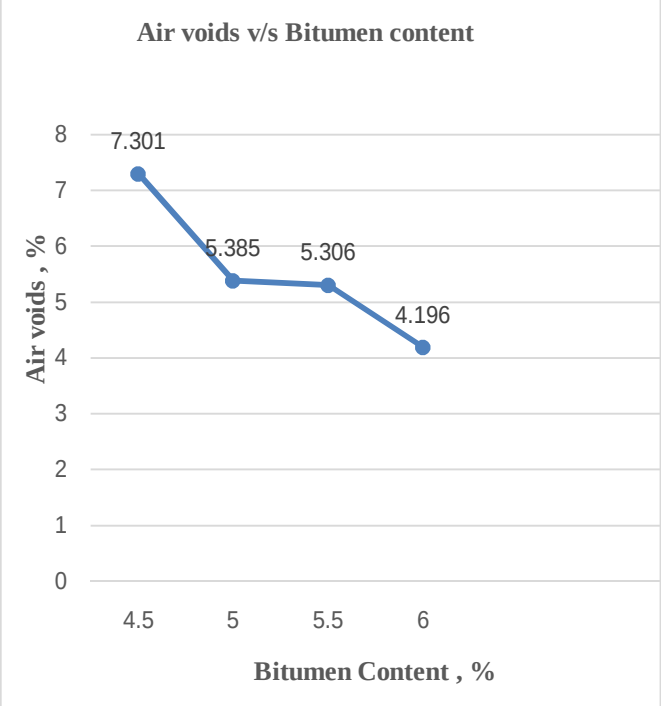


Fig. Air Voids v/s Bitumen Content

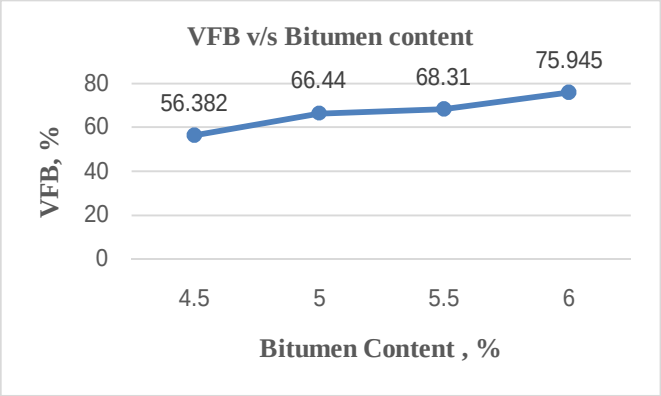


Fig. Voids Filled with Bitumen v/s Bitumen Content

Table 4.2Marshall Properties of Bituminous Concrete Mix prepared using E-Waste and GGBS 2% at Optimum Bitumen Content

SL. No.	Marshall Properties	Test Results	Requirements as per IRC SP 53 2010
1	Optimum Bitumen Content, %	5.38	-----
2	Marshall Stability, kg	2740	1200
3	Marshall Flow, mm	3.01	2.5 - 4.0%
4	Air voids(Vv), %	4.48	3.0 - 5.0%
5	Bulk density, g/cc	2.342	-----
6	Voids in Mineral Aggregates(VMA), %	15.96	-----
7	Voids filled with Bitumen (VFB), %	71.929	-----

III. COMPARISON OF CONVENTIONAL AND NON-CONVENTIONAL MIX

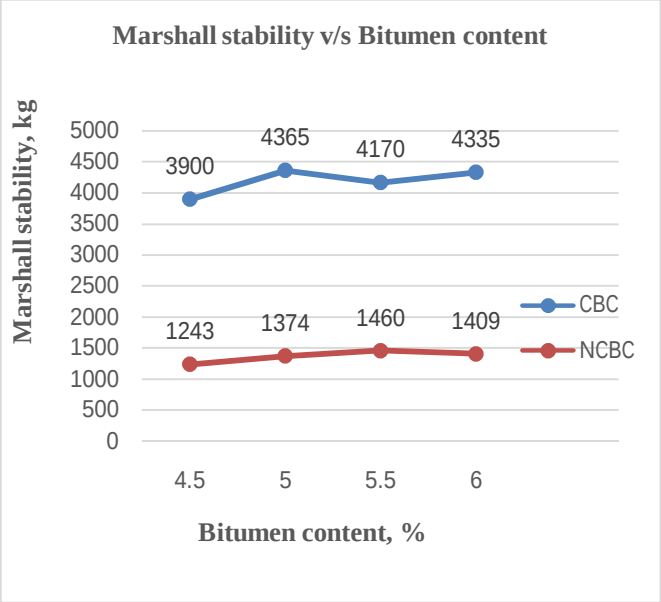


Fig. Marshall Stability v/s Bitumen Content

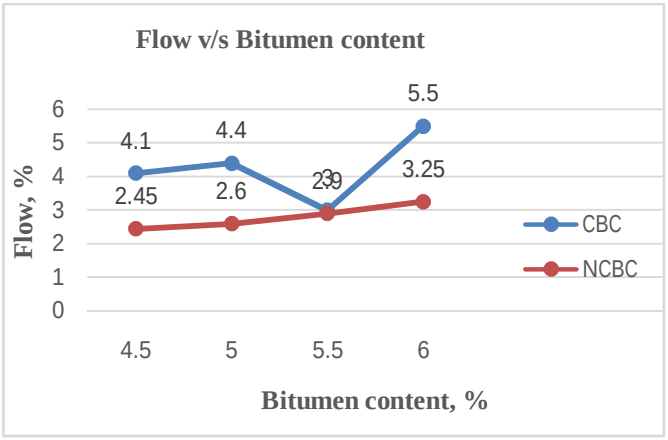


Fig. Flow v/s Bitumen Content

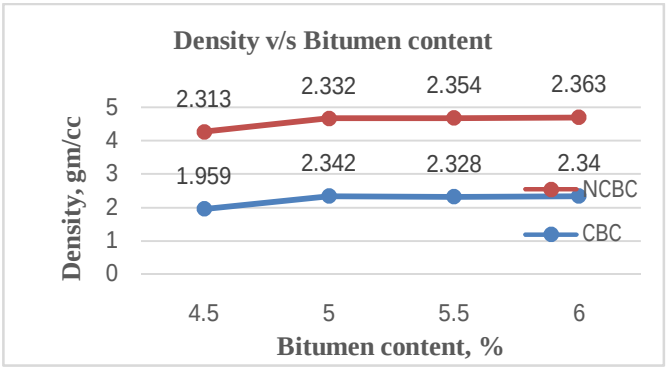


Fig. Bulk Density v/s Bitumen Content

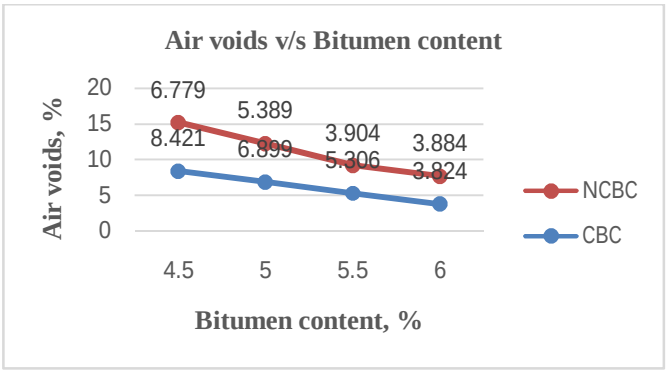


Fig. Air Voids v/s Bitumen Content

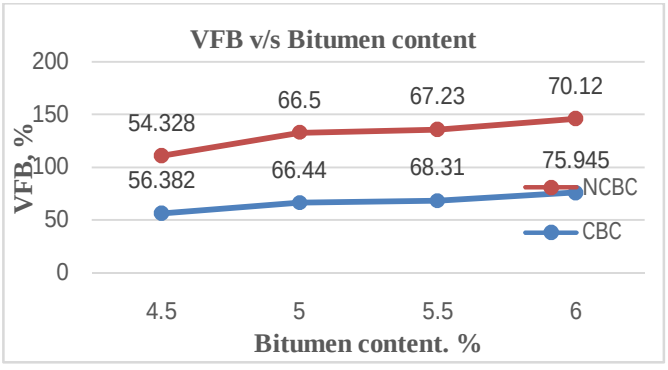


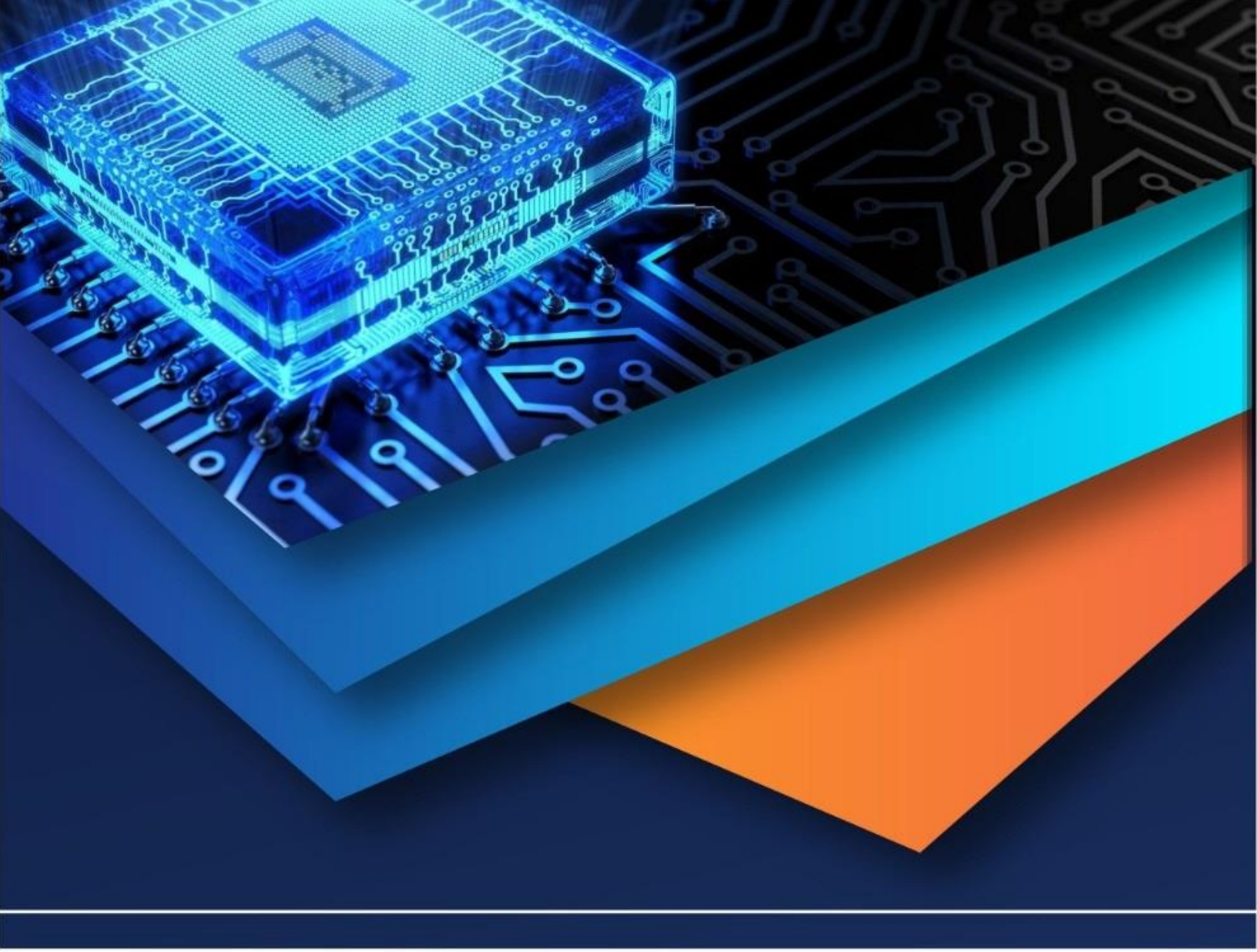
Fig. Voids Filled with Bitumen v/s Bitumen Content

IV. CONCLUSION

1) The physical properties of aggregates satisfy the requirements as per Table 500-17 of MoRT&H (IV revision) specification.
2) The physical properties of VG30(Viscosity Grade Bitumen VG-30) satisfy the requirements as per IRC SP-53 2010.
3) The Marshall Properties of Bituminous Concrete Mix prepared using E-waste and GGBS has satisfied the results as per MoRT&H Specification 4th revision.
4) The Marshall Properties of Bituminous Concrete Mix prepared using E-waste and GGBS are superior when compared to Conventional BC mix.
5) Based on experimental work carried out on BC mix prepared using E-waste and GBBS ,the Marshall properties are found to be superior when compared to normal BC mix.

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