PERFORMANCE ASSESSMENT OF COPPER SLAG AND JUTE FIBER ON BITUMINIOUS CONCRETE MIXES

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***Abstract*- The performance of flexible pavements is significantly influenced by traffic load, temperature, and environmental variations. Conventional bitumen often underperforms under such conditions, leading to early distress. This study aims to enhance the properties of bituminous concrete (BC) by partially replacing fine aggregate with copper slag and incorporating jute fiber as an additive. Optimum copper slag content was determined based on Marshall Properties. BC mixes were then prepared with varying jute fiber content (0% to 0.5%) and a constant binder content of 0.1%. The combination was found to improve the engineering characteristics of the pavement mix.**

***Index Term*- Bituminous Concrete (BC), Copper Slag, Jute fiber, Marshall test**

I. INTRODUCTION

Flexible pavements are widely used in highway construction due to their ease of maintenance and cost-effectiveness. However, their performance is often affected by factors such as increasing traffic loads, temperature variations, and early pavement distresses like rutting and cracking. To address these issues, improving the bituminous mix design has become essential.

This study focuses on enhancing the properties of bituminous concrete (BC) by partially replacing fine aggregate with copper slag and incorporating natural jute fibre as an additive. The aim is to develop a durable, eco-friendly, and economical mix that meets the growing demands of modern highways while utilizing industrial and agricultural waste materials effectively.

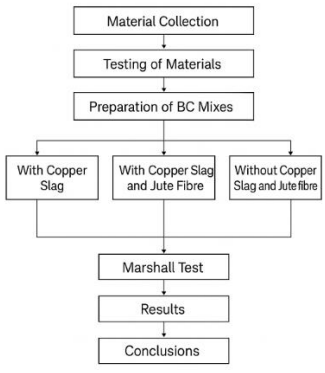
II. LITERATURE REVIEW

Remo and Margarida (2020) Conducted a comparative study on Stone Mastic Asphalt (SMA) and Dense Graded Mixes using jute and steel fibers. Their results showed that SMA with fiber reinforcement provided better resistance to rutting and deformation due to its high binder and aggregate interaction. This research supports the use of fibers to enhance the mechanical properties of bituminous mixes under high traffic conditions.

Peter Justina et al. investigated the effect of polymer fibers on the performance of bituminous mixtures. They concluded that the addition of fibers improved resistance to rutting, increased Marshall Stability, and reduced permanent deformation. The study emphasized that the optimum fiber content enhanced overall durability, especially under varying temperature conditions.

Prafulla er al. (2021) evaluated the use of copper slag as a replacement for fine aggregate in bituminous mixes. The findings showed improved stability, reduced voids, and enhanced resistance to moisture damage when copper slag was used at an optimum percentage. This supports the use of industrial waste in pavement construction to improve performance and sustainability.

III. METHODOLOGY



IV. EXPERIMENTAL WORK

In this study, experimental work was carried out to evaluate the performance of bituminous concrete mixes using copper slag and jute fiber. Materials were first collected and tested for their properties. Bituminous mixes were then prepared in three sets: one with copper slag, another with both copper slag and jute fiber, and a control mix without any additives. All mixes were tested using the Marshall Stability method. The results were analyzed to assess improvements in strength and durability due to the inclusion of copper slag and jute fiber.

V. RESULTS

Based on the detailed laboratory investigations conducted on the materials, the following results were observed.

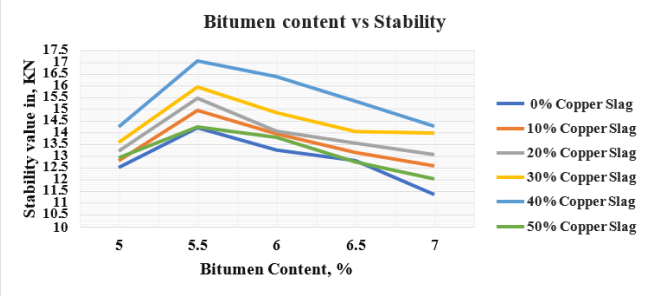
Table 1: Physical properties of coarse and fine aggregate

Properties of Aggregates	Test Result			
	Coarser Size Aggregate	Aggregate finer size	Copper Slag	Stone Dust
Impact value	14	-	-	-
Crushing value	13.5	-	-	-
Abrasion value	18	-	-	-
Soundness test (five cycle in sodium	3	2.5	-	8.2
Flakiness index, %	11.9	-	-	-
Elongation index, %	12.5	-	-	-
Water absorption, %	1.80%	1.50%	-	0.40%
Specific gravity	2.74	2.57	0.9	2
Apparent specific gravity	2.52	2.65	1.86	2.1

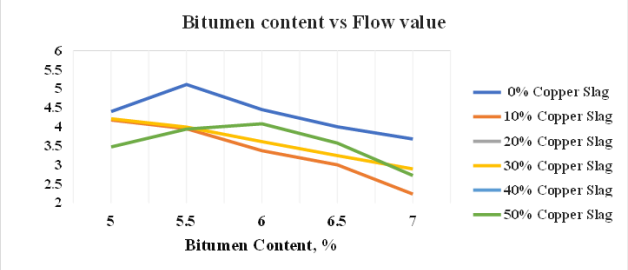
Table 2: Properties of VG 30 bitumen

Physical Properties	Test Result
Penetration at 25°C/100gm/5s,0.01 mm	66
Softening Point, °C	44
Ductility, mm	54
Specific gravity, at 27°C	1.01
Absolute viscosity, Brookfield at 160°C, Centi Poise	200
Flash point	165 °C

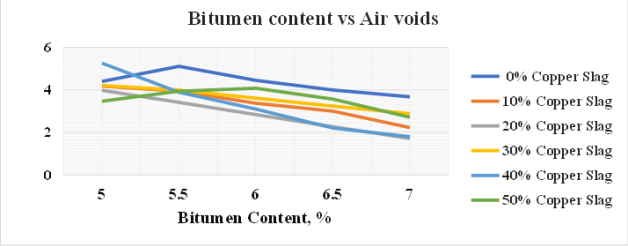
EFFECT OF COPPER SLAG ON BC MIX



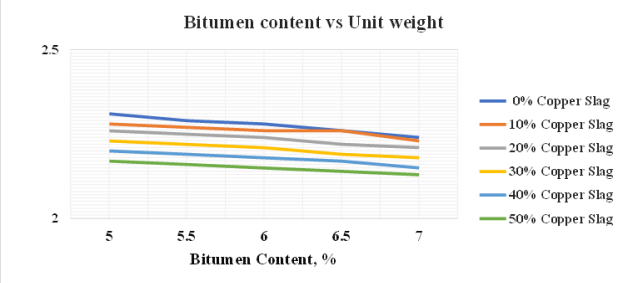
Graph 1. Variation of Stability value with bitumen content at different Copper Slag content



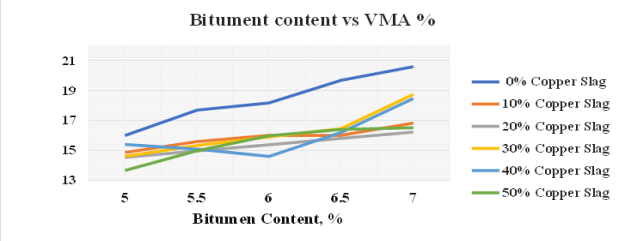
Graph 2. Flow value variation with bitumen content at Different Copper Slag content



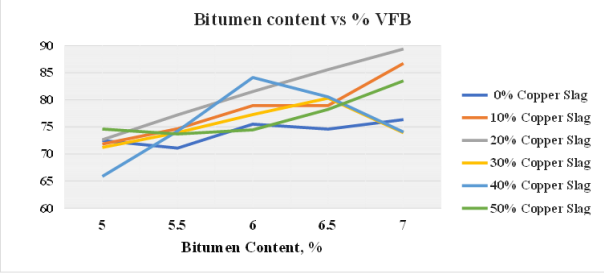
Graph 3. Air voids variation with bitumen content at Different Copper Slag content



Graph 4. Unit weight variation with bitumen content at Different Copper Slag content



Graph 5. VMA % variation with bitumen content at Different Copper Slag content

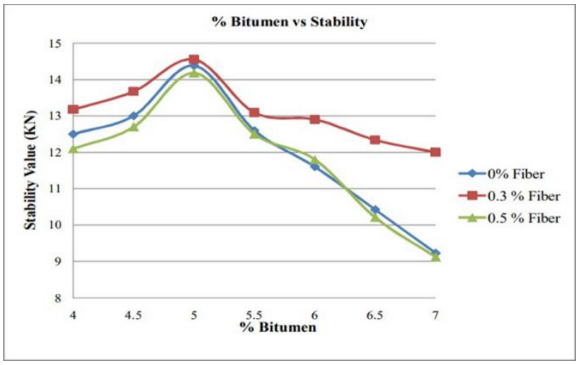


Graph 6. VFB% variation with bitumen content at Different Copper Slag content

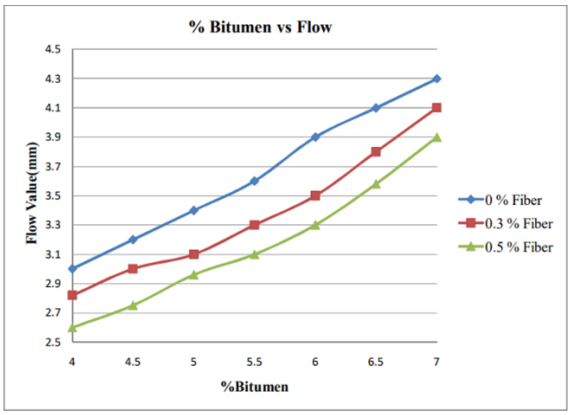
Optimum bitumen content = $\frac{5.5+6.0+5.5}{3}$ = 5.7 %

Optimum Copper Slag content = 40 %

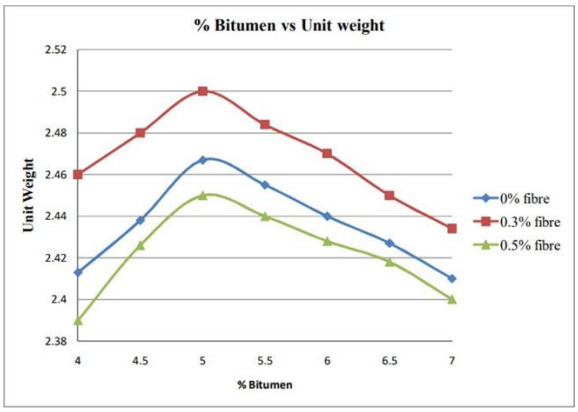
EFFECT OF JUTE FIBRE ON BC



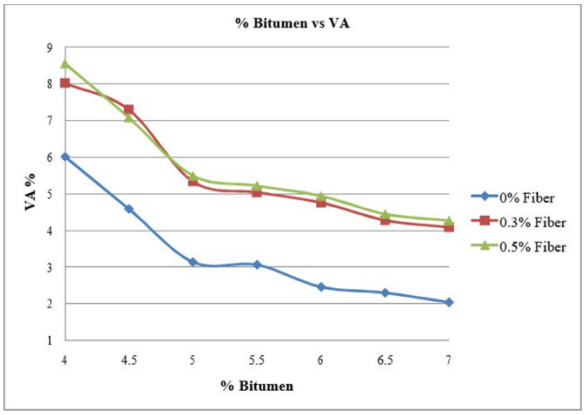
Graph 7. Variation of Marshall Stability of BC with different binder content with different fiber content



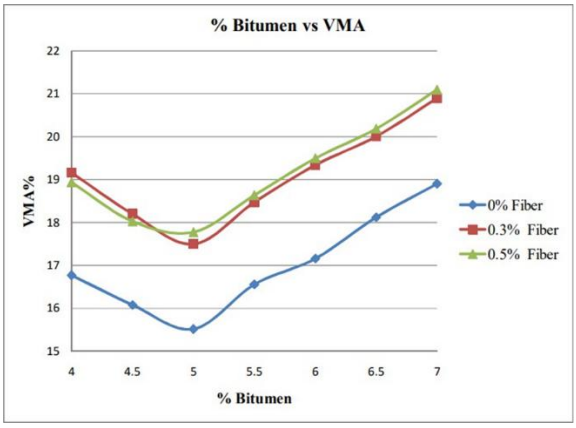
Graph 8. Variation of Flow value of BC with different binder content with different fiber content



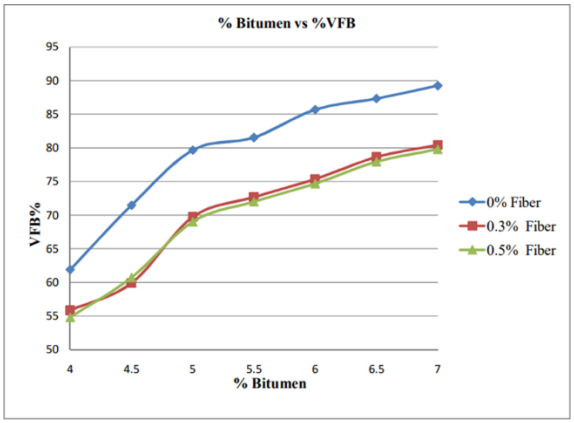
Graph 9. Variation of unit weight of BC with different binder content with different fiber content



Graph 10. Variation of Air Void of BC with different binder content With different fiber content



Graph 11. Variation of VMA of BC with different binder content with different fiber content



Graph 12. Variation of VFB of BC with different binder content with different fiber contents

VI. CONCLUSION

The objective of this study was to determine that the bituminous concrete combination was suitable as a partial substitution for fine aggregates by introducing Copper Slag. The study of bituminous concrete mixes was given based on the findings and evaluation of the route; a successive conclusion has been drawn. This analysis focuses on the major impact of the mix of binder content and Copper Slag quantity and an additive quantity i.e., jute fiber content.

1. The optimum sample binder content produced using Copper Slag was found to be 5.7 percent in the stability diagrams.
2. The stability versus bitumen graph reveals that the marshal stability value rises to 40 percent with partial substitution of the fine aggregate by Copper Slag When 40 percent of the Copper slag by weight of the fine unit with 5.5% bitumen material; a maximum stability value of 17.05 ken was achieved.
3. It is also observed that the air-ray and flow values in the bituminous blends decreased by an improvement in copper slag content of up to 40% relative to traditional mixes from 5.11 percent to 3.88 percent and 3.95 mm to 2.38 mm, respectively.
4. At 5.5% bitumen, we were able to achieve 20.07% strength compared to traditional mixes by replacing a fine compound with 40% Copper Slag. With an increase of 40% in the copper slag by 10%, a reduction in strength was found to be 19.5%.
5. In present case it is seen that VMA increases as binder increases.
6. Increasing the bitumen content reduces the VA of the Marshall sample as bitumen replaces the air vacuums in the mix and the VFB increases as the bitumen content increases. In this case, the results are shown to correspond to the above argument.
7. Here OBC is 5%, OFC is found as 0.3%.
8. By addition of fiber up to 0.3% Marshall Stability value increases and further addition of fiber it decreases.

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