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Experimenting with the Utilization of Recron3S Fiber and Steel Slag in Fresh Concrete for Analysis

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Abstract: Concrete is well-known for being the most frequently utilized construction material due to its affordability, longevity, and adaptability. However, traditional concrete production requires a large amount of cement and aggregate, raising concerns about its environmental impact and depletion of natural resources. In order to address these issues and promote sustainability, we have been exploring alternative materials like Recron3s polyester fiber and steel slag. Recron3s fiber can enhance the flexibility of concrete, making it a valuable addition. On the other hand, the steel industry generates a byproduct known as steel slag, which presents environmental challenges and disposal issues. Nonetheless, when incorporated into concrete, steel slag can improve the mechanical and physical properties of the material, increasing its durability. Our research focuses on replacing OPC 53 grade cement and natural aggregate with Recron3s fiber and steel slag aggregate, respectively. Different percentages of steel slag aggregate (0%, 20%, 25%, 30%) and Recron3s fiber (0%, 1.25%) were used as substitutes for traditional materials in M30 grade concrete with a water-cement ratio of 0.44. We created concrete mixes by partially replacing OPC 53 with Recron3s fiber and substituting natural aggregate with steel slag aggregate to evaluate the performance of eco-friendly concrete. We then evaluated the performance of these mixes through workability tests such as slump cone, vee-bee consistometer, and compaction factor test. Overall, incorporating Recron3s fiber and steel slag aggregate into concrete has yielded positive results in enhancing mechanical properties and reducing environmental impact.
Keywords: Recron3S Polyester Fiber, Fiber Reinforced, Slump Cone, Vee-Bee Consistometer, And Compaction Factor Test and Steel Slag.

I. INTRODUCTION

Concrete plays a crucial role in civil engineering research as a fundamental building material. Efforts have been made to improve its strength, quality, and durability in order to achieve greater cost efficiency in construction. With the increasing demand for environmentally friendly and high-performance construction materials, researchers and engineers are exploring new additives and alternative aggregates to enhance the quality of concrete. The construction industry has recently shifted towards sustainable practices, leading to interest in using recycled materials and synthetic fibers to reduce environmental impact and improve the performance of concrete structures. Recron3S polyester fibers, known for their strong tensile strength and durability, provide a promising option for reinforcing concrete to enhance its mechanical properties and crack resistance. Similarly, steel slag, a byproduct of the steel manufacturing process, has gained attention as a potential alternative to traditional aggregates due to its favorable engineering properties and its ability to address environmental concerns related to disposal. However, despite its versatility and widespread use, it is crucial to acknowledge that concrete does have its limitations, particularly in terms of slump height. These limitations can result in subpar performance and potential issues such as segregation and bleeding, which can in turn make the concrete more prone to spreading fractures. This is especially true in the context of rigid pavements, where low workable concrete is essential for achieving the desired outcomes. It is therefore important to carefully consider these factors when working with concrete to ensure optimal results. Fiber-reinforced concrete (FRC) has been proposed as a solution to tackle obstacles in concrete construction by adding fibers to enhance resistance to segregation and improve overall characteristics. This approach has shown promising results in enhancing workability and concrete performance. The primary objective of this research paper is to greatly improve the workability of fresh concrete. In this investigation, polyester fibers were added to.0%,and 1.25% of the cement content, while steel slag aggregate was employed at 0%, 20%, 25% and 30%, Instead of using coarse aggregates, a detailed comparison analysis was carried out to determine the significant percentage change in workability when fibers and steel slag aggregate are added. The research paper provides a succinct yet persuasive comparison between Fiber Reinforced Concrete (FRC) pavements and conventional concrete pavements.

The following test considered for finding concrete workability

1) *Slump Cone Test:* The slump test is widely used to measure the consistency of concrete, and can be done in either a laboratory or at a worksite. However, it is not appropriate for extremely wet or dry concrete. This test does not account for all factors affecting workability, and may not always accurately reflect how easily the concrete can be placed.
2) *Vee- Bee Consistometer:* The main objective of the Vee Bee Consistometer test is to evaluate the ease of working with newly mixed concrete. This test evaluates the flow and suitability of the concrete by measuring the effort required as the material changes from a conical to cylindrical shape through vibration. The remolding effort, measured in seconds, reflects the level of work needed for this transformation. The test procedure for measuring the workability of the concrete mix is done as per IS 1199:1959[1].
3) *Compaction Factor Test:* The compaction factor test is conducted to determine the workability of concrete when the maximum size of coarse aggregate is 38mm. This test can be utilized in both field and laboratory settings, depending on the situation.

II. LITERATURE REVIEW

Pan *et al.* [2] examined the strength of hardened self-compacting concrete and the workability of new mixtures with varying steel slag sand replacement rates. Steel slag self-compacting concrete with optimal workability can be achieved by varying the water–binder ratio, paste–aggregate ratio, fine–coarse aggregate ratio, and the quantity of superplasticizer. This can help achieve the workability design target. Additionally, steel slag sand improves the hardened concrete's interfacial transition zone, which increases the concrete's strength. We may infer that this is one of the best methods for preparing self-compacting concrete using steel slag sand as fine aggregate. Subathra Devi and Gnanavel [3]studied that The ideal replacement ratio for coarse aggregate is 30% and for fine aggregate is 40%; any higher replacement percentage will result in a reduction in compressive strength. Concrete becomes less workable as the replacement percentage rises. When compared to coarse aggregate replacement, fine aggregate replacement exhibits superior workability. Awoyera *et al.* [4] obtained from the slump test. For both the concrete made with SSA and NA, it was observed that the slump increases with increasing aggregate sizes. This could be as a result of constant water-cement ratio used in the mixing of the concrete. It was an indication that large size of aggregates increases fluidity or consistency due to low aggregate-cement ratio. More so, the increment in the size of aggregate increases; fluidity, consistency and workability due to the reduction in surface area. A few things need to be taken into account for steel slag to be successfully included as aggregates in construction products. First, can steel slag be used for construction. It was an industrial byproduct that was dumped in landfills until recently. The material's technical attributes are then looked at because steel slag has certain physicochemical properties that make it demand special handling, but when used for the right purposes, it can also yield maximum value. Using a by-product can increase the added value of a product when it is used in certain applications, primarily where it is more cost-effective than using standard resources[5].
In Jordan, there are three significant steel factories. Steel slag, its sole byproduct, is haphazardly disposed of in open spaces, posing numerous environmental hazards. The purpose of this study was to determine whether adding steel slag aggregate (SSA) to locally produced asphalt concrete (AC) mixes may enhance their engineering qualities. Assessing the steel slag's toxicity as well as its chemical and physical characteristics was the first step in the investigation. Next, SSA was used to replace 0%, 25%, 50%, 75%, and 100% of the limestone coarse aggregate in the AC mixes. The enhancement of the AC samples' indirect tensile strength, resilient modulus, rutting resistance, fatigue life, creep modulus, and stripping resistance served as a gauge for the efficacy of the SSA. The mechanical characteristics of the AC mixes were shown to be enhanced when up to 75% of the limestone coarse aggregate was substituted with SSA[6]. Slag's potential as a useful addition to concrete mixtures, exhibiting its favorable effects on stiffness, toughness, energy absorption capacity, and static and dynamic compressive strength. Finding the ideal steel slag composition is essential, highlighting the need for careful thought to be put into the design of concrete mixes. Furthermore, the benefits to the environment associated with the usage of steel slag suggest a viable path forward for the adoption of sustainable building techniques.

III.MATERIALS AND METHODS

A. List of Materials

1) *Cement:* Grade 53 Ordinary Portland cement was used in a research study. Specific gravity 3.14.
2) *Coarse Aggregates:* For the study, 20mm sized coarse aggregates that are available locally were utilized. The coarse aggregates have a specific gravity of 2.76, water absorption rate of 0.16%, and their sieve analysis meets the standards of IS 2386:1963 [7]
3) *Fine Aggregates:* Materials like sand, silt, and clay are classified as fine aggregates. These fine aggregates were subjected to several tests, and the results are reported in accordance with IS 383:2016 [8]. The specific gravity of the sand is 2.66, and the fineness modulus is 2.62.

4) *Steel Slag Aggregate:* While manufacturing steel, steel slag is produced as a beneficial byproduct. It forms as a mixture of silicates and oxides that solidifies during the cooling process. In our research paper, we utilized the optimal amount of steel slag from Iron and Steel Plant. Specific gravity gravity 3.08, water absorption 0.98%.
5) *Recron3s fiber:* Recron3 fibers, made from polyester, have been used in rigid pavements to control cracking and enhance durability. By adding them to concrete mixes, these fibers can improve the pavement's resistance to temperature fluctuations and drying, reducing shrinkage cracks. The inclusion of these fibers strengthens the concrete, reducing random cracks and enhancing its overall performance. They are produced by Reliance Industries Limited, measuring 12mm in length and white in color, with a specific gravity of 1.39.

B. Sample Preparation:
1) Sample-01 is being prepared for plain cement concrete, while the remaining samples involve partial replacement of cement and coarse aggregate.
2) Specifically, Sample-02 includes 1.25% Recron3s fiber and 20% steel slag, and Sample-03 includes 1.25% Recron3s fiber and 25% steel slag, Sample-04 includes 1.25% recron3s fiber and 30% steel slag.

C. Mix Design for M30 grade of concrete
This entails the determination of the minimum strength that must be attained by the concrete mix. To design an M30-grade concrete mix, we meticulously consulted as per the IRC: 44-2017 [9].

IV. RESULTS AND DISCUSSIONS

A. Experiment Results
In this study, we have used 1.25% recron3s fiber as a partial replacement for cement, while also substituting 20 mm coarse aggregate with steel slag. Several tests were conducted to evaluate the overall performance of the concrete. The results and discussions for fresh concrete are outlined below.

1) Slump Cone Test on Fresh Concrete

TABLE 1
SLUMP VALUE (MM) AT W/C OF 0.44.

S. No.	1	2	3	4
Concrete Mix	M0	M20	M25	M30
Slump Value (in mm)	56	44	41	36

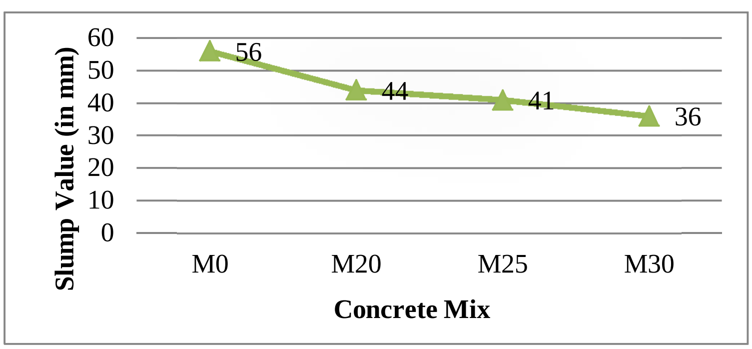

Fig 2. Slump Value Vs Concrete Mix


Fig. 3 Slump Test Specimen

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2) Vee-Bee Consistometer Test

The procedure includes the following steps:

a) Initial measurement taken from the graduated rod before demolding (a) in millimeters.

b) The final measurement on the graduated rod after removing the mold (b) in millimeters.

c) Slump is determined by calculating a - b in millimeters. At the same time, the duration for complete remolding is noted in seconds.

d) As a result, the consistency of the concrete is measured in Vee-Bee seconds.

TABLE 2
VEE-BEE VALUE (SEC) AT W/C OF 0.44.

S. No.	1	2	3	4
Concrete Mix	M0	M20	M25	M30
Vee-Bee Seconds	5sec	7sec	9sec	11sec

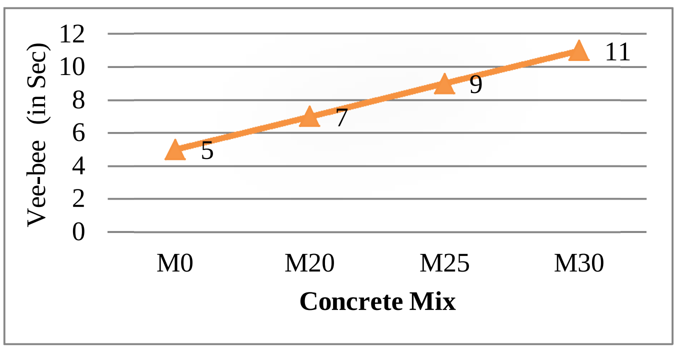

Fig.4 Vee-bee Vs Concrete Mix

Fig.5 Vee-Bee Consistometer

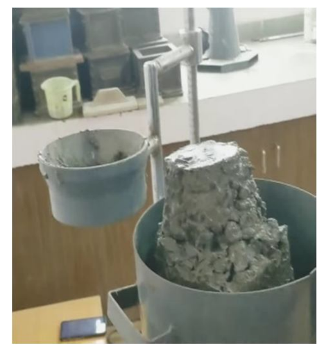
Fig.6 Vee-Bee Sample

3) Compaction Factor Test

The compacting factor is the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete.

Compaction Factor Value= (W1-W)/(W2-W) (1)

Here, W- empty cylinder weight, W1-weight of partial compacted concrete. W2- weight of fully compacted concrete.

TABLE 3
COMPACTION FACTOR VALUE AT W/C OF 0.44.

S. No.	1	2	3	4
Concrete Mix	M0	M20	M25	M30
Compaction factor Value	0.84	0.81	0.79	0.77

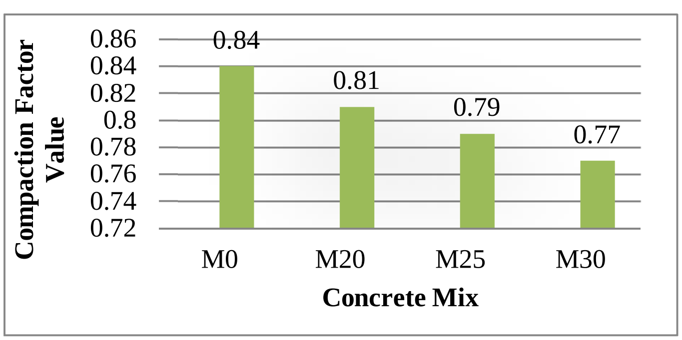

Fig.7 Compaction Factor Vs Concrete Mix


Fig. 8 Compaction Factor Test

B. Results Discussion

The workability of the concrete decreases as the percentage of steel slag in the mixture increases. This is because steel slag is a byproduct of steel production and its presence can affect the overall properties of the concrete, including its workability. As more steel slag is added to the mix, the concrete may become less fluid and harder to work with, making it more challenging to place and finish. It is important to carefully consider the amount of steel slag used in the concrete mix to ensure that the desired workability is maintained.

V. CONCLUSION

Based on the experimental investigations, it can be inferred that as the percentage of slag aggregate is increased, the workability of plain cement concrete with polyester fibers and slag aggregate in place of cement and coarse aggregates is reduced.

Declaration Statement

Conflicts of interest: The author states that there are no conflicts of interest in the publication of this paper.

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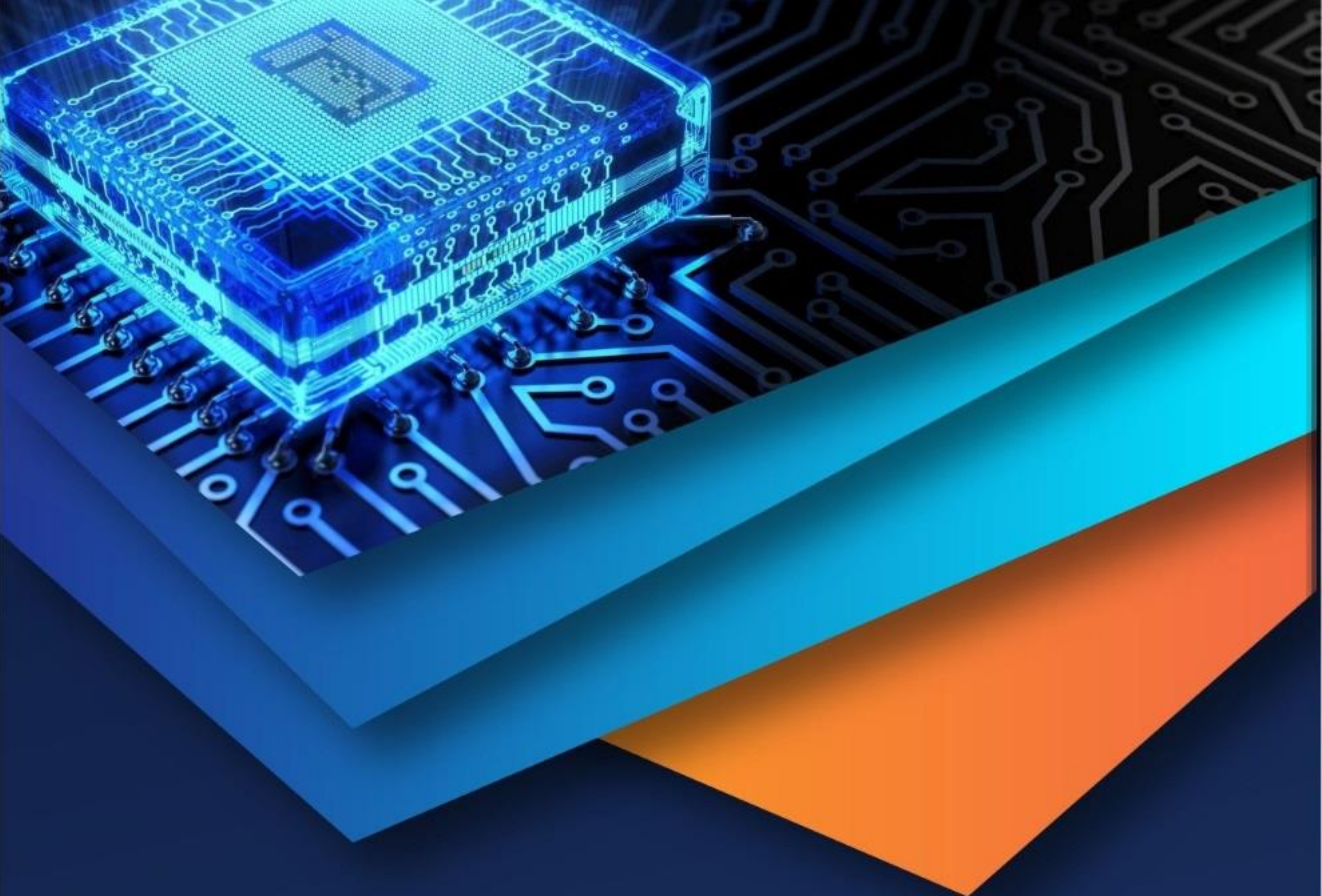

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