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Utilization and Experimental Analysis of Steel Slag in Sustainable and Eco-Friendly Rigid Pavement

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ABSTRACT: This presents the Experimental investigation carried out to evaluate the effects of concrete by replacing the normal coarse aggregate by steel slag on properties of concrete. Concrete is used more than any other material in the world so the use of concrete is unavoidable at the same time scarcity of aggregate is also increased nowadays. The industrial waste has been encouraged in construction industries because it contributes to reduce the usage of natural resources for many years by product such as fly ash, silica fume and steel slag were considered as waste materials. They have been successfully used in the construction industry for the partial and full substitution in concrete. In this study concrete of M20, M30, M40, M50 grades were considered for a W/C ratio of 0.55, 0.45, 0.37, 0.32 respectively for the replacement of coarse aggregate 30% 60% and 100% by steel slag. This study revealed that there is a improvement in compressive strength 5 to 10% for all the grades of concrete.

KEYWORDS: Experiments, Results, Analysis and Discussion

I. INTRODUCTION

Pavement and its types:

Pavement is one type of hard surface made from durable surface material laid down on an area that is intended to carry vehicular or foot traffic. its main function is to distribute the applied vehicle loads to the subgrade through different layers. The types of pavements

- Flexible pavement
- Rigid pavement

Rigid Pavement:

A Rigid pavement, primarily made of concrete, provides a strong, durable surface suitable for heavy traffic loads. Its stiffness allows for effective load distribution over the subgrade, minimizing deformation and damage.

II.LITERATURE SURVEY

M.J ABDEN ET AL., 2021^[1]

The study introduces carbon table concrete (HPCC) as a variant of concrete that effectively utilizes steel slag. HPCC has a densely packed particle size distribution with steel slag accounting for 90% of the binder. It demonstrates high fluidity and manageability. After predrying treatment, HPCC achieves compressive strengths of 104.9 MPa and 173.7 MPa after 12 hours and 7 days of carbonation curing, respectively. This increased strength is attributed to the consolidation of the densely packed structure, evident from microstructure and pore characteristics. HPCC exhibits minimal moisture absorption similar to ultra-high-performance concrete (UHPC), indicating resistance to harmful external substances. Additionally, HPCC shows lower moisture absorption from carbonation-induced deformation compared to UHPC, leading to improved volume stability. This is due to the consumption of calcium oxide (CaO) and periclase during carbonation. Overall, HPCC has great potential for efficiently utilizing steel slag while maintaining efficacy.

Amr M. Ibrahim et al., 2021^[2]

The research project aimed to evaluate the impact of aggregate substitution on the mechanical, gamma- ray shielding, and thermal properties of high-density concrete. Different amounts of hematite and iron slag were used as substitutes for crushed limestone aggregate in concrete mixtures. The results showed that incorporating hematite and iron slag improved the shielding properties of concrete when exposed to point sources of radiation. Additionally, the inclusion of 30% hematite or iron slag significantly enhanced compressive strength, with concrete mixtures containing 30% slag exhibiting the highest specific intensity limit.

III.METHODOLOGY

Incorporating steel slag into concrete as a partial replacement for cement or aggregates is a sustainable practice that can enhance certain properties of concrete. The methodology for incorporating 5%, 10%, and 15% steel slag typically involves the following steps:

Material Selection:

Steel Slag: Obtain steel slag from steel manufacturing processes. Ensure it is properly processed to remove impurities and reduce potential for expansion due to free lime content. Processing methods may include washing, drying, and grinding to achieve the desired particle size.

Cement: Use Ordinary Portland Cement (OPC) as the primary binder.

Aggregates: Select natural aggregates (fine and coarse) that conform to standard specifications.

Mix Design: M20 grade of concrete

Water-Cement Ratio: Adjust the water-cement ratio to maintain the desired workability and strength. The water-cement ratio significantly influences the concrete's compressive strength and durability.

Mixing Process:

Dry Mixing: Combine the dry ingredients—cement, steel slag, and aggregates—thoroughly to ensure uniform distribution.

Casting and Curing:

Casting: Pour the concrete into molds of the desired shape and size.

Curing: Cure the concrete under controlled conditions to achieve optimal hydration and strength development. Curing methods may include water curing, steam curing, or curing with wet coverings.

Testing and Evaluation:

Compressive Strength: Conduct compressive strength tests at various ages (e.g., 7, 14, 28 days) to assess the concrete's performance.

IV. EXPERIMENTAL RESULTS

Figures 1 shows the Different Experiments conducted on 5%,10%,15% of Steel Slag in Concrete.



a) Preparation of concrete mix



b) Slump test



c) V B consistency test



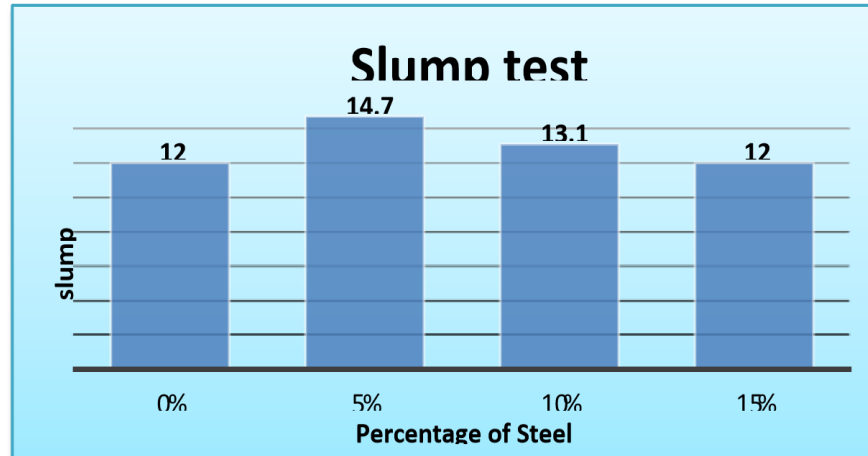
d) Compactor Factor



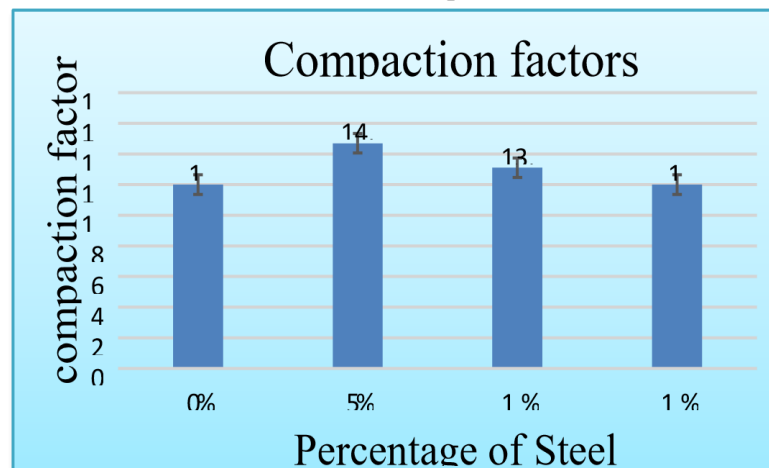
e) Compression strength test machine

Fig 1: Tests conducted for Concrete various percentage of Steel slag replacement

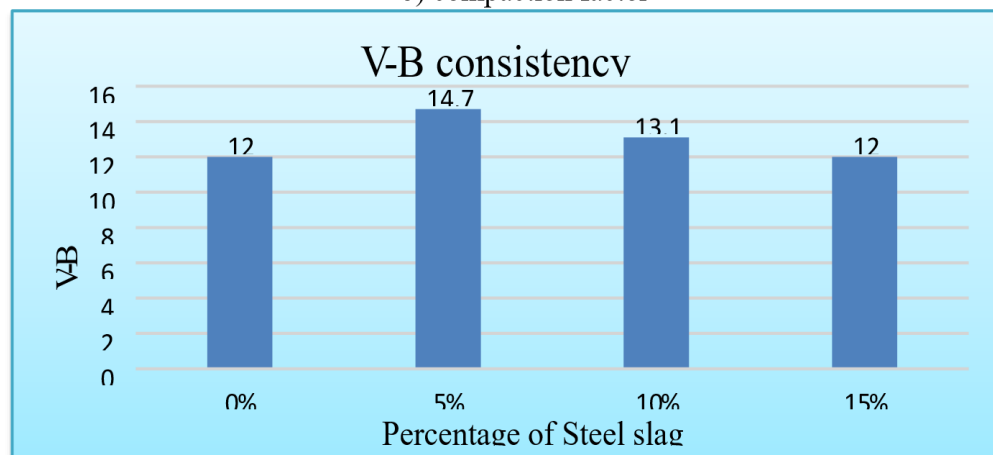
Fig 2 Indicates that results obtained from the different test conducted on concrete from above Experiments.



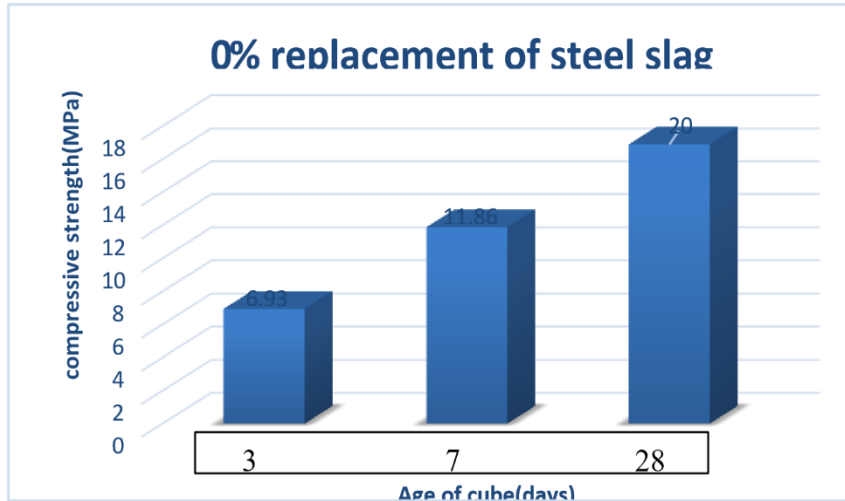
a) slump test



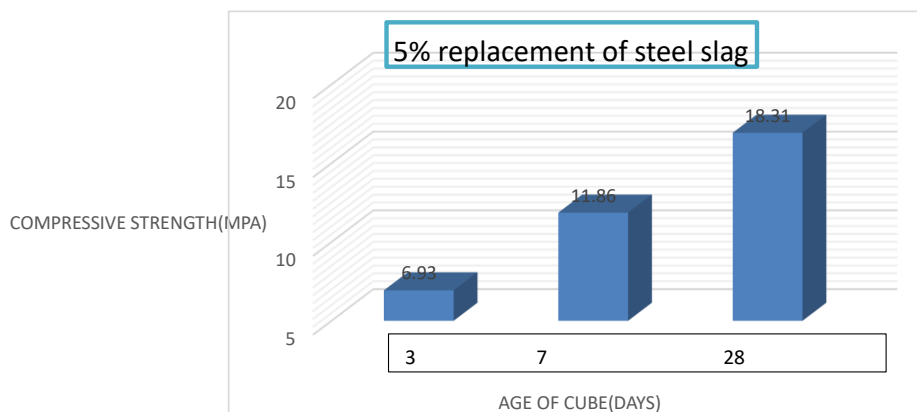
b) compaction factor



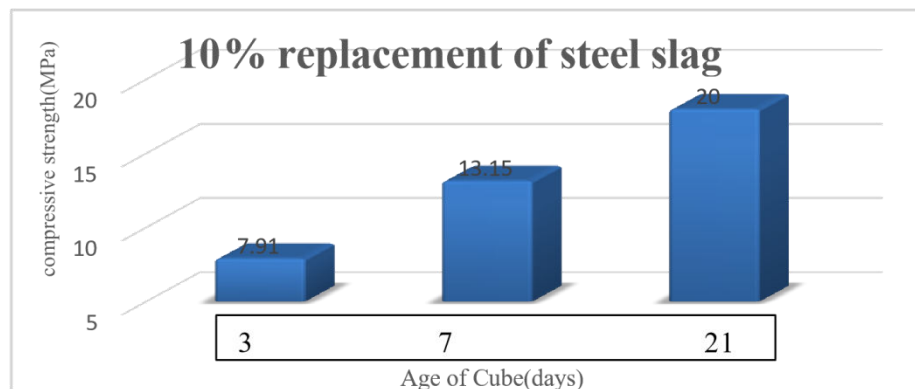
a) V-B consistency



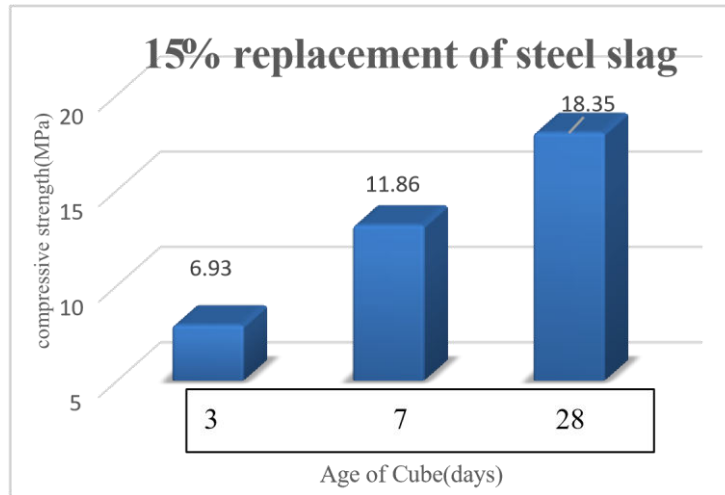
b) 0% replacement of steel slag in Compression strength test



c) 5% replacement of steel slag Compression strength test



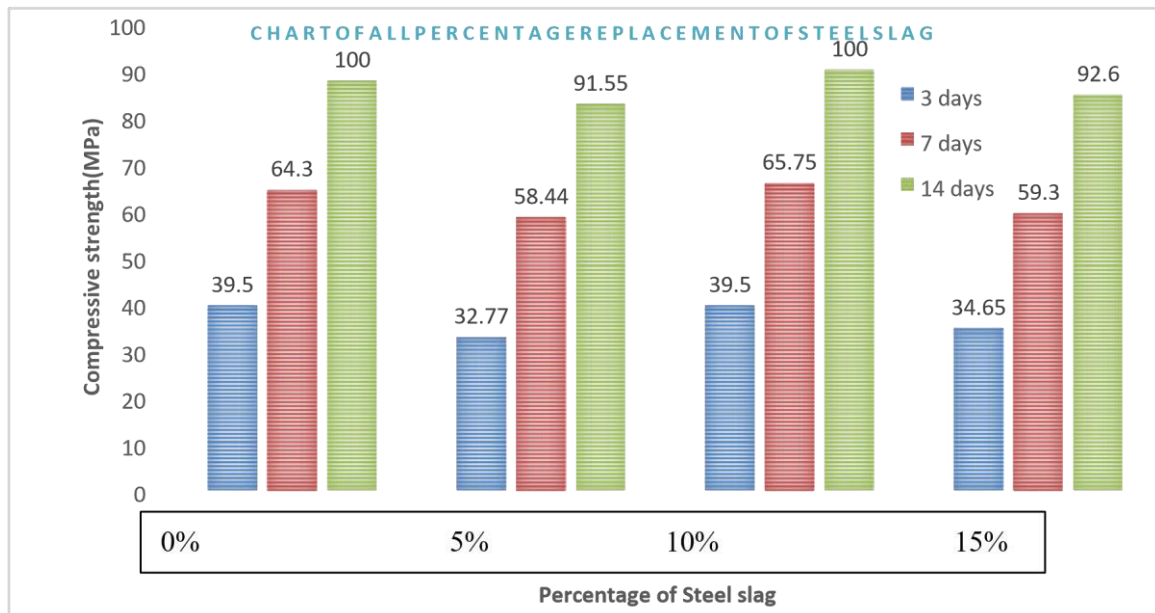
d) 10% replacement of steel slag Compression strength test



e) 15% replacement of steel slag

Fig 2 The result obtained from different test/experiments

Fig 3 Represents the analysis and Discussion of Strength and Age of cube for different Percentage of Steel slag in concrete.



a) Chart of all percentage of replacement of steel slag

Fig 3 : Chart of all percentage of replacement of steel slag

V. CONCLUSION

From the results obtained by experimentation conducted, it is observed that the strength obtained in initial days in conventional concrete is more than the concrete with replacement of 5 and 15% steel slag. However, this value holds good with concrete of 10% replacement with steel slag. Later, after the complete curing time, the strength achieved is

as same as conventional concrete for 5 and 15% replacement of steel slag. Comparatively, it is observed that for the specimen with 10% replacement of steel slag, the complete strength was achieved in 21 days. This helps in reduction of curing period, fastening of concrete work.

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