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Properties of Concrete in Rigid Pavements with GGBS Used in Part to Replace Cement

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***Abstract**: The work under review looks at properties of concrete in rigid pavements when cement is semi-replaced with ground granulated blast furnace slag (GGBs). The primary objective will be enhanced sustainability achieved by utilizing less cement and reducing associated CO2 pollution. The compressive strength, flexural strength and the durability was tested of some concrete mix that had different proportions of replacement of GGBS. The results show that GGBS can reduce the strength slightly during the young age but is much stronger and more durable over time. To have an optimal performance and environmental trade-off, the level of replacing was calculated as between 30 to 40 percent. Based on the findings of the study, GGBS can serve as an effective components of firm pavement concrete application, and can contribute to long-term sustainable environmentally friendly infrastructure.*

***Keywords**: Workability, GGBS, Flexural, Compressive, Split Tensile Quality*

I. Introduction

The epic compressive strength, durability and structure functional capacity of concrete makes its use as a building product the most applied worldwide and more in the construction of infrastructure such as stiff pavements. Nonetheless, the production of ordinary Portland cement (OPC), which is an important part of concrete, contributes a lot to global carbon dioxide (CO_2) emissions, and is an energy-intensive activity. One such industrial by-product which has become popular recently as a partial replacement of cement in concrete mixtures is the ground granulated blast furnace slag (GGBS). GGBS is a by-product of steel production process and is environmentally and performance advantageous. Use of the concrete in concrete can help reduce the environmental burden except that it heightens some of the previously hardened concrete mechanical and durability properties.

Stiff pavements require concrete to remain stable and durable over a long time exposed to heavy traffic and varying weather conditions; this makes the compressive strength the flexural strength, workability and durability of concrete key factors in a long-term performance. These characteristics might be changed with the addition of GGBS depending on the mix design and proportion of replacement. This paper aims at illuminating the possibility of utilization of GGBS as a sustainable construction material by assessing the influence of partial replacement of cement with GGBS on the performance properties of concrete applied in stiff pavements [2-].

II. Proposed Method

The proposed methodology of analysis of concrete (in rigid pavements which have used ground granulated blast furnace slag, GGBS, instead of part of cement) contains preparation of samples, mix design, selection of materials, systematic planning, and series of laboratory tests that will investigate the qualities of fresh and hardened concrete. Fine aggregate (river sand), coarse aggregate (crushed granite, maximum size of 20 mm), ordinary Portland cement (OPC) of grade 43 or 53 and potable water as per IS 12089 GGBS are used. Physical and chemical properties of all materials will be analyzed following the provisions of the relevant IS norms. During the process of creating the concrete mix design of M 40 grade that is suitable when using rigid pavement, IS 10262:2019 will be used. To be used as a reference, a control mix that does not have GGBS shall be prepared. There will be OPC replaced with GGBS by weight of cement by 10 to 50% in order to develop more mixes. Concrete batches will be mixed using pan mixer to ensure uniformity. Specimens to be used in the test will include 150 mm cube, 100 mm x 100 mm x 500 mm beams and 150 mm in diameter and 300 mm height cylinder. Demolding and curing all specimens in water (27 +/-2 o C) will be started after one day until ready to be tested. Results of the various tests will be compared at different levels of GGBS replacement. Statistical methods can be applied to find trends and ideal % of replacement of rigid pavement. Based on the findings, the analysis will be conducted in terms of the aspects of GGBS influence on durability, workability, strength development. The findings will be used to prescribe recommendations concerning optimal GGBS proportion replacement to enhance the performance of concrete and promoting the sustainability of a rigid pavement construction [5-6].

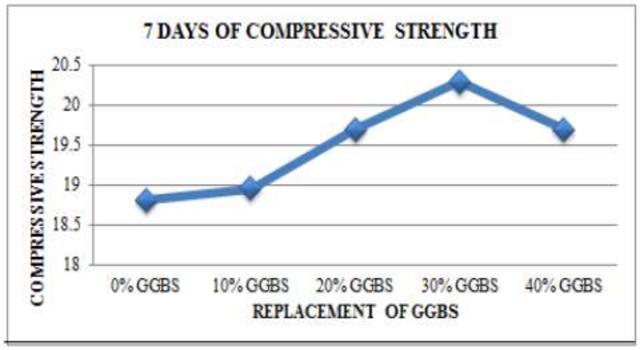

Fig 1: After 7 Days compression strength

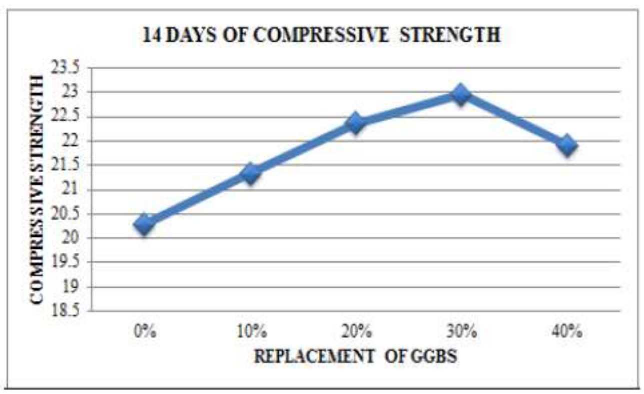

Fig 2: After 14 Days compression strength

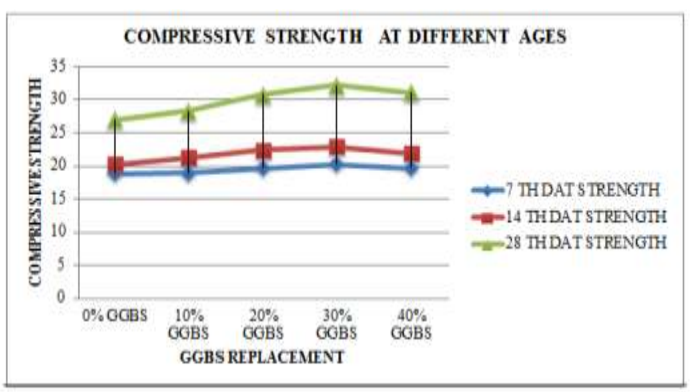

Fig 3: After 7 vs 14 Days compression strength at different ages

III. Results and Discussions

The results of the experiment indicated that GGBS made a tremendous change in the properties of concrete utilized in the rigid pavements. The slump value in mixtures containing GGBS was found to be superior with regard to the workability meaning the superior flow since the spherical shape of slag particles and the fine particles are cohesive to the mix. Compressive strength results were marginally reduced at a 7-day period in mixes that had 30% or more GGBS. Nevertheless, due to the pozzolanic reaction, leading to a long-term strength gain, the blends containing the GGBS at a level of 30-40% by the total weight of the mixture was as strong as or slightly stronger than the control mix at 28 and 90 days. Flexural and split tensile strengths also showed a marginal increase with 2030 percent of GGBS replacement hence showing bonding and microstructure refinement [1-3]. As the levels of GGBS increased, considerably positive durability results were observed especially towards the sulphate attack in addition to the penetration of chloride ions. The lowest absorption of water at 30%t GGBS was associated with denser concrete. Altogether, GGBS enhanced long-term strength and durability but a little on the expense of early strength. The optimal replacement volume in the case of rigid pavement concrete was determined to be 30 to 40%, a mid-ground between the sustainability and mechanical performance. This results in the use of GGBS as a viable partial cement substitute in the pavement-grade concrete.

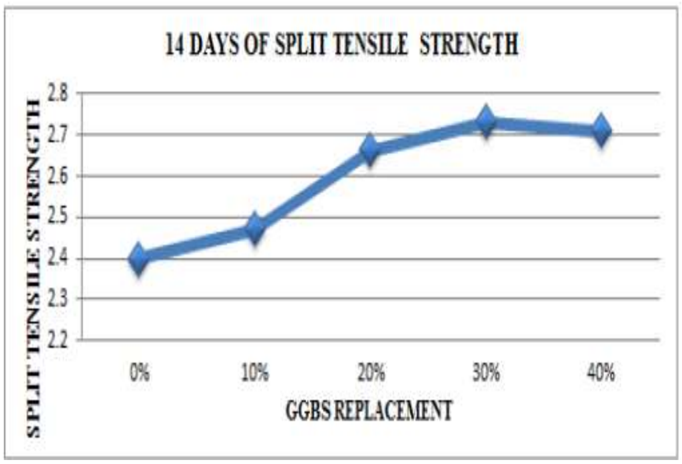

Fig 4: After 7 Days split tensile strength

Fig 5: After 28 Days split tensile strength

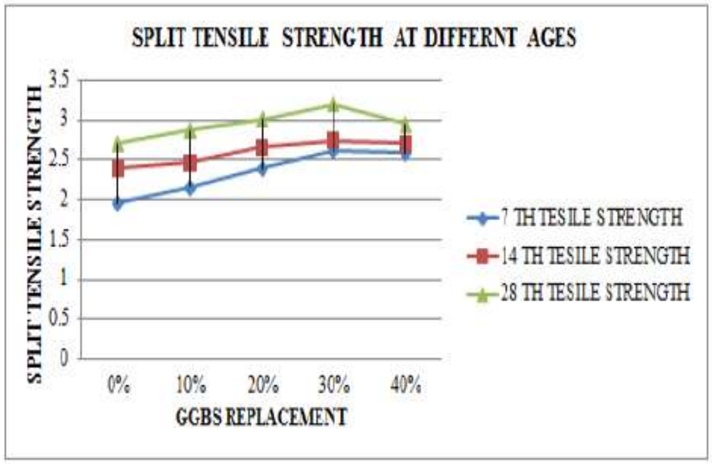

Fig 6: Split tensile strength at different ages

IV. Conclusion

The research reaches the conclusion that Ground Granulated Blast Furnace Slag (GGBS) institutes a more sustainable solution and long-term pavement performance when replacing part of the cement in concrete used on stiff pavements. The levels of long-term compressive capabilities, workability, as well as sensitivity to sulphate as well as chloride attacks are all highly advanced by GGBS. The mixtures with 30-40 percent GGBS replacement performed excellently in all aspects except a slight decrease in early strength, and should therefore be used in pavement constructions. GGBS in addition to reducing cement consumption and its adverse impact on the environment produces concrete that will last long and perform well. Consequently, GGBS is a viable environmentally friendly alternative building material in building rubber Crete stiff structure.

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