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REVIEW ON USE OF STEEL SLAG IN CEMENT CONCRETE

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ABSTRACT

As the demand for aggregate in the making of cement concrete is increasing day by day the search for alternative material has become a crying need. Stone chip is the most widely used coarse aggregate in India and the continuous spreading of the brick industries are hampering the environment to a great extent. Moreover the price of brick aggregate is also going higher as its demand gets higher. An effects on concrete by replacement of sand and coarse aggregate as steel slag on properties such as compressive strength, split tensile strength, flexural strength, are studied.

Keywords: Coarse Aggregate, Design Mix, Plastisizer, Steel Slag, Sand, Slump value, workability etc

1. INTRODUCTION

The building industry is the biggest user of natural materials and also a large amount of wastes resulted from the demolition of constructions. The construction process is responsible for 40% to 50% of the greenhouse gas generated. The bi-products from industries are slag, rice husk ash, bagasse, fly ash, cement dust, brick dusk, blast furnace slag, sludge, glass, tires, sandpaper, silica fume, etc. The above-listed waste materials represent a major problem for the environment because the dust and fine particles spread in the atmosphere which causes air pollution and leaching toxic chemicals like lead, cobalt, etc. also when they are dumped in landfills, quarries, rivers or oceans they cause a serious damage on the water in which animals and humans can consume it and lead to a health problem. As the demand for coarse aggregate in the making of cement concrete is increasing day by day the search for alternative material has become a crying need. Stone chip is the most widely used coarse aggregate in India and the continuous spreading of the brick industries are hampering the environment to a great extent. Moreover the price of brick aggregate is also going higher as its demand gets higher. Stone can be used as a replacement of brick aggregate but it has low availability and higher price. In this existing condition the waste materials such as steel slag can be considered as a possibility which can be used instead of conventional coarse aggregates. Steel slag is a byproduct obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). The molten liquid is a complex solution of silicates and oxides that solidifies on cooling and forms steel slag. Steel slag is defined by the American Society for Testing and Materials (ASTM) as ìa non-metallic product, consisting essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium that are developed simultaneously with steel in basic oxygen, electric arc, or open hearth furnacesî.

Figure 1: Steel Slag Sample

2. LITERATURE REVIEW

- Masilamani et.al. (2024) This research tests energy optimised furnace (EOF) steel slag as substitution for natural coarse aggregate in concrete. Steel slag's usefulness as a substitute for natural coarse aggregate in concrete is the primary goal of this research. According to IS:2386-1963, the characterization of EOF steel slag, as coarse, is done by examining the shape and size of a particle, mechanical properties, physical properties, soundness, and alkali-aggregate reactivity. Tests for detection of staining material in steel slag and hardness of inter-facial transition zone in hardened cement paste were also carried out. The chemical analysis of the steel slag reveals the stability of oxides present in the steel slag. Microstructural characterization by SEM (scanning electron microscope) analysis of steel slag aggregate was also employed to support the characterization and XRD analysis, and it was found that the EOF steel slag is crystalline. The digital image processing technique (DIP) is adopted to study the shape indices, circularity, sphericity, shape factor, and roundness of natural and EOF steel slag aggregate. According to the characterization and strength investigation, steel slag aggregate outperforms natural coarse aggregate.

- Abebe Demissew (2024) worked on comparative Analysis of Selected Concrete Mix Design Methods Based on Cost-Effectiveness for different industrial wastes. It was concluded that the result of the compressive strength test after 28 days showed that the specimens prepared using the mixing proportions obtained from the ACI standard met the extreme compressive strength requirement more than the other methods. On the other hand, the ACI, DOE, and EBCS methods are the most expensive to absorb an excessive quantity of cement when compared to the IS method. However, the overall result showed that the concrete designed as per the IS method is relatively easy to work with and cost-effective for developing countries such as Ethiopia for the production of normal grade concerts.
- Bang Tran (2023) Steel slag was utilized to replace natural coarse aggregates in the CEAFS mixes. CEAFS was created by blending 50% crushed stone with 50% EAF slag in coarse aggregates, with fly ash (FA) and silica fume (SF) partially replacing cement at content levels (i.e. FA: 0, 20, 30, and 40%; SF: 0, 5, and 10%). The soil compaction approach was used to evaluate the optimal moisture level for CEAFS mixes containing EAF slag aggregate fly ash and silica fume. A testing program was used to investigate the weight of CEAFS units and their mechanical qualities (compressive strength, flexural strength, and elastic modulus). As a result, the fresh and hardened unit weights in the CEAFS are comparable. Moreover, variations in the concentration of mineral additives FA and SF in adhesives, as well as the CEAFS mixed aggregate ratio, have an impact on compressive strength, flexural strength, and elastic modulus at all ages. However, combining EAF slag aggregate with (FA0% +SF10%; FA10% +SF0%; FA10% +SF10%; and FA20% +SF10%) the CEAFS mixtures have improved mechanical characteristics over time. According to this study, CEAFS pavements can be made with EAF slag aggregate fly ash and silica fume. In addition, a form-ula correlation was suggested to compute CEAFS (i.e. compressive strength with elastic modulus and compressive strength with flexural strength).
- Somnath et.al. (2023) Stated that presently, the production of solid wastes per tonne of steel is 1.2 tonne in India compared to 0.55 tonne of that practicing in abroad due to inferior quality of raw materials. Major shares of these wastes consist of blast furnace (BF) slag and basic oxygen furnace (BOF) slag. Out of total solid wastes generated in the steel plant in India, around 63% are dumped in open space which creates ecological problems because of their hazardous nature. Collection, transportation and dumping of wastes are very expensive and a large area of land needed.
- Dubey et.al. (2022) This study explores the use of GGBS and SMS slag as partial replacement to cement and coarse aggregate respectively. Further the study is extended by making a plan of residential building on AUTOCAD in which green concrete containing 55% of GGBS and 50% of SMS as partial replacement to cement and coarse aggregate respectively has been executed. The cost analysis of the building is carried out, which has helped in curtailing the cost of concrete by 22.61%.
- Wei-Ting Lin et.al. (2022) Stated that Compression strength of the mortar specimens decreased with an increase in cement replacement. Specimens that included 10% BOFS achieved the highest compressive strength at 28 days; however, even this was 5% lower than that of OPM. Increasing BOFS content beyond 50% greatly decreased compressive strength due to increased expansion and cracking. However, the inclusion of fiber in 10% BOFS composites may be used as repair mortar in emergency engineering, especially for BOFS with 6000 cm2/g due to their rapid hardening.
- M. Arivoli and R. Malathy (2021) The present paper proposes a fuzzy system for concrete mix proportioning which increases the packing density. The proposed fuzzy system have four sub fuzzy system to arrive compressive strength, water cement ratio, ideal grading curve and free water content for concrete mix proportioning. The results show, the concrete mix proportion of the given fuzzy model agrees with IS method. The comparison of results shows that both proposed fuzzy system and IS method, there is a remarkable increase in compressive strength and bulk density, with increment in the percentage replacement of steel slag.
- C. Ramganesh, P. Suresh Kannan and R. Sangeetha (2021) In this Experimental study, steel slag is used as coarse aggregate replacement Material up to 100% and Fly ash is used as Partial replacement for cement up to 30%. Class C Fly ash is used as partial cement replacement material. The steel Slag aggregate percentage replacement is 100% and fly Ash replacement percentage are 10%, 20%, 30% by weight of cement. Tests are conducted in cubes, cylinders and prisms to find out the compressive strength, split tensile strength and flexural strength for both Ordinary concrete and steel slag concrete with partial replacement of fly ash. This project report summarizes the experimental program to investigate the significance of steel slag aggregate & partial replacement of fly ash in concrete. Finally suggestions were made for the use of steel slag with partial replacement of fly ash for cement to increase the strength of concrete.

V. Subathra Devia and B. K. Gnanavel (2020) This paper aims to study experimentally, the effect of partial replacement of coarse and fine aggregates by steel slag (SS), on the various strength and durability properties of concrete, by using the mix design of M20 grade. The optimum percentage of replacement of fine and coarse aggregate by steel slag is found. Workability of concrete gradually decreases, as the percentage of replacement increases, which is found using slump test. Compressive strength, tensile strength, flexural strength and durability tests such as acid resistance, using Hcl, H2SO4, and Rapid chloride penetration, are experimentally investigated. The results indicate that for conventional concrete, the partial replacement of fine and coarse aggregates by steel slag improves the compressive, tensile and flexural strength. The mass loss in cubes after immersion in acids is found to be very low. Deflection in the RCC beams gradually increases, as the load on the beam increases, for both the replacements. The degree of chloride ion penetrability is assessed based on the limits, given in ASTM C 1202. The viability of usage of SS in concrete is found.

3. CONCLUSION

This report represents the facts that are responsible for the search of alternative materials. This chapter discusses the possibilities of using steel slag as a replacement of aggregate. Here a brief comparison is being carried out between steel slag and aggregate by doing partial replacement of these constituents in concrete and see if coarse aggregate can be replaced by steel slag based on literature review.

After the review of all properties of steel slag it can be concluded that steel slag has properties similar to Indian standard sand and coarse aggregate hence it can be used as fine aggregate and coarse aggregate in construction.

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