Comparative Study on Partial Replacement of Fine Aggregate with Steel Slag and Weld Slag in Concrete – Review Paper

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ABSTRACT:- The main objective of this paper is to find out the alternative materials for concrete to meet the demand of fine aggregate for the upcoming years, to provide adequate strength at minimum cost, to make the eco-friendly structure. Use of steel and welded slag waste industrial by-product of welded and steel production provides great opportunity to utilize it as an alternative to normally available aggregate(fine).The comparative study on partial replacement of fine aggregate by steel and welded slag on the various strength and durability properties by using the mix design of m30 grades. In this paper literature survey of fresh and mechanical properties of different mixtures are evaluated by incorporating supplementary cementitious material, i.e., and different aggregate type considering various parameters, i.e., compressive strength, flexural strength and tensile strength.

Keywords: Steel Slag, Welded Slag, Compressive Strength, Flexural Strength, Tensile Strength

1.0 INTRODUCTION

Concrete is the largest production as construction materials. The increase in demand for the ingredients of concrete is met the partial replacement if material by the waste material which is obtained by means of various industries. Due to the high cost of natural sand used as a fine aggregate and the rising emphasis on suitable construction, there is a need for the construction industry to search for alternative materials. Steel and welded slag, on of the most common industrial waste, is a by product of steel production.

One ton of steel implies the production of 130-200 kg of slag, depending on the composition the steel and steel production process. Slag often appears as granulated materials containing large cluster, coarse and very fine particles. Serious environmental problems formerly unrestrained sand and gravel taken from river, steel slag contains high content of Cao as well as mgo. It exhibits poor hydraulic property due to its lack of tri-calcium silicates and amorphous sio_2 content. Therefore, high replacement of Portland cement with the steel slag resulted in the decrease the mechanical strength development.

Submerged-arc welding produces quality welds in ferrous, stainless steels and even some non-ferrous metals. During the welding process, the flux is used to cover the weld joint and to protect welding operations from atmospheric contamination. This flux is partially melted, resulting in a liquid protective slag layer generating a waste material known as submerged-arc welding slag. In general, one kilogram of flux is consumed for every kilogram of weld metal deposited. About 2500 tonnes of slag were generated in India during which have risen to 10000 tonnes during increases. Hence the weld slag can be effective utilized.

The main objective of this paper is to investigate the effect of partial replacement of aggregates by steel slag and weld slag on the strength and durability properties of concrete and to determine the viability of slag usage in reinforced cement concrete (RCC). Use and recycling of steel and weld slag from steel manufacturing industry is an important issue. SS and WS is a by product. Not much work has been reported on the use of SS and WS in concrete related to durability. So in this work, SS and WSS used as a partial replacement material for fine aggregate and also for coarse aggregate, while manufacturing concrete, in order to investigate the effect of SS on the strength and durability properties.

2.0 LITERATURE REVIEW

Harsh Gupta et al (2017) in their studies entitled Strength properties of steel slag in concrete were investigate the management of solid waste practices has identified the reduction recycling and reuse of wastes as important for management of sustainable resources. Steel slag, a by-product obtained from steel formation during separation of the molten steel from impurities in furnance. A molten liquid melt obtained from slag is a complex silicate and oxide that solidify on cooling. A partial replacement of steel stag is referred in this study in terms of fine aggregate material. This study is carried out to understand the effects in terms of compressive, tensile and flexural strength. It will helpful for other researchers to know more about this field.

The aim of this experiment is to study the effect of steel slag as partial replacement for fine aggregate with 0%, 10%, 20%, 30%, and 40% are tested for M25& M30 grade of concrete after 7, 14, 28 and 50 days water curing. The coarse aggregate of size 20mm is selected which is retrained on 10mm sieve, fine aggregate passing through4.75mm sieve and retained on 600 microns sieve used slump cone, compressive strength test, split tensile test, flexural test, steel slag were experimentally investigated. The result shows that variation in much strength for fine aggregate replacement by steel slag for 7, 14, 28 and 50 days water curing.

Comparison and observations for the compressive strength, flexural strength and split tensile strength of normal concrete and concrete with Steel slag as partial replacements The results shows that the strength of the normal concrete is slightly lower than the Steel slag replaced concrete.

The increment in compressive strength is about 31.47% for 7 days curing 20% for 14 days curing 18% for 28 days while at 40% a slight decrement of 4.2% noted for 7 days and 3.4 % for 28 days of curing as compared to 30%.

The increment in compressive strength of M 30 grade of concrete is about 24.9% for 7 days of curing 17.5% for 14 days of curing and 15.5% for 28 days of curing while at 40% a slight decrement of 3.6% noted for 7 days and 2.5% for 28 days of curing as compared to 30%. The split tensile strength increases with increase in percentage of steel slag up to 30% by weight of fine aggregate. The increment in split tensile strength is about 16.7% for 28 days curing for M25 grade of concrete and increment about 15.6% for 28 days curing for M 30 grade of concrete. The Flexural strength increases with increase in percentage of steel slag up to 30% by weight of fine aggregate. The increment in flexural strength test is about 36.7% for 28 days curing for M 25 grade of concrete and 24.7% for 28 days curing for M 30 grade of concrete

Liwu mo et al (2017) in their studies entitled Accelerated carbonation and performance of concrete made with steel slag as binding materials and aggregates. Experimental study, 60% of steel slag powders containing high free-CaO content, 20% of Portland cement and up to 20% of reactive magnesia and lime were mixed to prepare the binding blends. The binding blends were then used to cast concrete, in which up to 100% of natural aggregates (limestone and river sands) were replaced with steel slag aggregates. The concrete was exposed to carbonation curing with a concentration of 99.9% CO2 and a pressure of 0.10 MPa for different durations (1d, 3d, and 14d). The carbonation front, carbonate products, compressive strength, microstructure, and volume stability of the concrete were investigated. The effects of CO_2 curing on the carbonation depth, compressive strength, and volume stability of the concrete made with steel slag as binding materials and aggregates were investigated. Based on the phenolphthalein indicator test, with 0.1 MPa CO_2 curing, the concrete specimens were almost carbonated within 3d, indicating it is effective to accelerate the carbonation of concrete via pressurized CO_2. Under conventional moist curing, the compressive strengths of concrete cast with the binding blends consisting of 60% steel slag powders, up to 20% of lime and magnesia, and only 20% of Portland cement were very low, being 7.9-10.7 MPa at 7 d and 9.4-11.5 MPa at 28 d. However, they were increased dramatically during the following CO_2 curing. The compressive strength of concrete subjected to CO_2 curing for 14 d were increased by 4.3-5.3 folds in comparison to those of the concrete moist cured for 28 d. This is related to the densification of concrete caused by the formation of carbonate products. Under moist curing, replacement of natural aggregates (lime stone and river sand) with steel slag caused negligible influences on the compressive strength of concrete. CO2 treatment on the steel slag concrete improved its volume stability. On the one hand, carbonation directly reduced the contents of periclase and free-CaO in the concrete. Results show that the compressive strength of the steel slag concrete after CO2 curing was significantly increased

Ramesh et al. (2017) in this investigation entitled use of furnace slag (FS) and welding slag (WS) as a replacement of fine aggregates in concrete. The aim of this study is to examine the behaviour of the WSA in HPC. For mixtures containing WS, the 7 d compressive strength of concrete cubes increased from 10 to 15% and 28 d compressive strength increased from 5 to 15%. It was concluded that 5% of WS and 10% FS replacement with fine aggregates is effective for practical purpose. On the basis of the above literature, weld slag was potentially used in the manufacture of bricks and as a replacement of fine aggregate in concrete.

Six mixture proportions were made. Control mixture (CM) without weld slag was prepared and for other five mixtures, weld slag was replaced to fine aggregates at 10, 20, 30, 40 and 50%, respectively. To recognise the mixtures, each mixture was titled as CM, WSA 10, WSA 20, WSA 30, WSA 40 and WSA 50. WSA 20 denotes that the HPC mixture made with 20% WSA replacing the fine aggregate.

Manoranjan et al. (2016) in this investigation entitled Experimental study on replacement of coarse aggregate by weld slag in concrete. The present paper is focused to investigate the mechanical property of concrete with weld slag as a replacement material for coarse aggregate. By utilizing the waste as a replacement material becomes a better contribution towards waste management, environmental safety and economically cost-less for making of coarse aggregate. The main objective of the paper includes utilization of weld slag as a partial replacement for coarse aggregate. The investigation comprises of various percentage of slag and is denoted as WS1, WS2 and WS3 respectively. The IS method has been followed for arriving the mix design for M20 grade concrete and to determined for various percentage of weld slag The weld slag is a solid form of by product and final waste product after completion of welding process. Through the slag is a waste product primilarly consists of silicates and carbonates .since the weld slag is being a solid waste it can be used in concrete making as a replacement to some extent. Conventionally small gravels have been using in coarse aggregate. The coarse aggregate is taking place 75% of concrete preparation. As an alternate effort the weld slag may be used in certain percentage along with coarse aggregate to explore the possibility of making concrete utilizing the waste product.

The weld slag is solid form of by product and final waste product after completion of welding process. Compressive test, flexural test, split tensile test, and water absorption test can be determine. Water absorption test has been carried out the 7^{th} day saturated cube specimen and oven dried specimen for specimens with and without weld slag.

The replacement of the coarse aggregate partially by weld slag with WS, WS2, and WS3 respectively to increase the strength of concrete as expected the strength is more than the conventional strength for WS1, WS2 and WS3 by replacement of weld slag. though the is a major variation in the increased strength of WS1 ,WS2 and WS3 as per the proportional mix of weld slag but the compressive strength, flexural strength, and tensile strength is gradually increased. So it is observed that the replacement of coarse aggregate by industrial weld slag is very much suitable for construction purpose.

Ismail et al (2015) in this experiment entitled Reuse of waste iron as a partial replacement of sand in concrete the test of these waste –iron concrete mixes revealed that this method performed efficiently to improve the properties of the waste iron concrete mix. In this paper waste iron were partially replaced sand at 10%, 15% and 20% in total 1730 kg concrete mixtures. This test performed to evaluate waste iron concrete quality slump.

The flexural strength of waste iron concrete mixtures at all curing periods tends to increase above the reference concrete mixes with an increasing ratio of waste–iron aggregate. The highest flexural strength was that of the concrete specimens containing 20% waste –iron aggregate at 28 days of curing, which is 27.86%higher than the reference mix at the same curing period.

The compressive strength of the concrete mixes made of 20%waste-iron aggregate increase above the reference concrete mix by 22.60% , 15.90%, and 17.40% for 3,7 and 28 days curing periods. Both the fresh and dry density values of waste–iron concrete mixes at each age tend to increase above their reference values.

The slump values of the iron concrete mixes decreases with an increases content of the waste as a fine aggregate , which is believed to be influenced by the shape of the waste grains. In spite of this decline in the slump values of the concrete mixes, they remain easy to work.

B.K Gnanavel et al (2014) in this research entitled Properties of concrete manufactured using steel slag to investigate the possibility of replacing the conventional aggregates by steel slag, the strength and durability properties were studied. Compressive, tensile, flexural strength, rapid chloride penetration, acid resistance to Hcl, H2SO4 and deflection for concrete containing steel slag in coarse aggregate and fine aggregate individually were experimentally investigated

The optimum percentage of replacement for fine aggregate is 40% and for coarse aggregate is 30%, beyond which the compressive strength decreases on further replacement. Fine aggregate replacement shows better workability compared to coarse aggregate replacement. It was observed that the partial replacement of fine aggregate by steel slag improves the compressive tensile and flexural strength of concrete. Improvement in strength property was slightly lower for CA replacement when compared with FA replacement. Compressive strength increased on large number when both CA and FA were replaced by steel slag. But the flexural strength has slightly decreased for combined replacement.

The weight loss in cubes after immersion in acids was very low. So, the concrete with partial replacement of CA and FA by steel slag shows better resistance to Hcl than to H2SO4. The penetration of chloride ion in rapid chloride penetrability is low for conventional concrete and 40% fine aggregate replacement concrete. Whereas, 30% coarse aggregate replacement comes under moderate penetrability. 40% FA replacement performs better than 30% CA replacement. Deflection in RCC beams gradually increases as the load on the beam increases for both the partial replacement. By adding steel slag to the aggregates, the resistance to deflection and vertical strain will increase. Further researches can be carried out to improve the strength and acid resistance by the addition of some admixtures.

3.0 SUMMARY AND CONCLUSION

When the industrial wastes are used in concrete for building construction, economically it is beneficial since the material cost is reduced. Comparison and observations for the compressive strength, tensile strength and flexural strength of steel slag and weld slag as partial replacements will present in the paper. Fresh and harded concrete will determine the paper. The industrial waste has lot of chemicals in it, which reacts with cement and other ingredients which reduce the life of the concrete. Hence, durability studies are very essential even if it shows better mechanical properties.

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