

A REVIEW OF LITERATURE ON PERFORMANCE BEHAVIOUR OF CONCRETE PAVEMENT WITH STEEL SLAG AS AGGREGATES

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ABSTRACT

Steel Slag is a solid waste disposed off in large quantities by the iron and steel industry in India. The recycling of steel slag, in future, will inevitably become an important measure for the environmental protection and therefore will be of great social and economical significance. For economical high performance concrete for highway, it can be used in combination with Super-plasticizer admixture. It also leads to enhanced durability and reduced cement content. Steel Slag with high basicity and being cooled exhibit cementitious property. The water absorption and volume of permeable voids displayed higher values with inclusion of steel slag 22. Reduction in number of cycles for fatigue failure was observed in geo polymer concrete mixes containing steel slag as compared to granite 23 aggregates. Overall, the performance of steel slag was found to be satisfactory for structural and pavement application and steel slag 24 can be recognised as new construction material.

KEYWORDS

Steel slag, concrete, aggregates, performance, water-cement ratio

INTRODUCTION

Steel making is a strategic requirement of the economy of developing nation like India. Many steel plants have been set up in our country. However, production of iron and steel is associated with the generation of solid waste materials like slag. Big steel plants in India generate about 29 million tonnes of waste material annually. In addition, there are several medium and small plants all over the country. Slag reduces the porosity and permeability of soil, thus increasing the water logging problem. It causes respiratory ailment among nearby residents, contaminates ground water, and adversely affects the landscape of the area. Industrial area around major cities there are several small and large scale industries wasting nearly thousands of metric tonne steel slag daily. Problem of disposing this slag is very serious which can be reduced by utilizing steel slag for concrete construction. The final properties of concrete, such as strength, durability and serviceability depend mainly on the properties and the quality of the materials used.

Locally, waste materials from the steel industry are produced in high amounts and shapes ranging from large boulders to dust. They are considered a headache for both the factories and the environment. The factories have to pay huge amounts for the disposal of these materials. The disposal of these materials will have a negative impact on the environment. Steel slag can be used in conventional concrete to improve its mechanical, physical, and chemical properties.

Steel slag is a by product from either the conversion of iron to steel in a BOF, or the melting of scrap to make steel in an EAF. In the BOF process, hot liquid metal from blast furnace, scrap, and fluxes, which consist of lime CaO and dolomitic lime, are charged to a furnace. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus, and some iron as liquid oxides, which combine with lime and dolomitic lime to form the steel slag. At the end of the refining operation, the liquid steel is tapped poured into a ladle while the steel slag is retained in the vessel and subsequently tapped into a separate slag pot. Most steel slags consist primarily of CaO, MgO, SiO₂, and FeO. In low-phosphorus steel-making practice, the total concentration of these oxides in liquid slags is in the range of 88–92%. Therefore, the steel slag can be simply represented by CaO–MgO–SiO₂–FeO quaternary system. However, the proportions of these oxides and the concentration of other minor components are highly variable and change from batch to batch even in one plant depending on raw materials, type of steel made furnace conditions, etc.

NITENDRA PALANKAR (2018)¹² in his paper investigated the possibility of replacing the natural coarse aggregates with steel aggregates in Alkali Activated Slag Concrete (AASC) mixes. The performance of AASC mixes incorporating steel slag as coarse aggregates is evaluated and is compared with conventional cement concrete wherein the natural coarse aggregates are replaced with steel slag aggregates at different replacement levels(25% , 50% , 75% , and 100%) in AASC mixes. The properties of fresh and hardened concrete mixes are studied in detail including the flexural fatigue behaviour of hardened concrete mixes by probabilistic distribution of fatigue life data of concrete mixes using Weibull Distribution.

A. RAHMAWATI (2017)⁸ in her paper replaced the natural sand with steel slag to develop an eco-friendly concrete. The properties of concrete which used 1 cement : 2 Sand : 3 Coarse aggregate ratio mixing method was examined in this paper. The ratio was in volume and then a part of natural sand was replaced with steel slag sand in six various

proportions that were 0%, 20%, 40%, 60%, 80% and 100%. The compressive strength, tensile strength and flexural strength of the concrete specimens at various proportion level were examined after curing for 28 days.

BANGWEI WU (2016)¹⁰ in his paper studied the properties of fine steel slag (0-5 mm) and slag powder produced by the roller technology in Bao Steel Group and replaced it with the minor power and finer aggregate of asphalt mixture. The mix design, volume expansion property, high temperature performance, low temperature performance, and water stability of the steel slag asphalt mixture were experimentally studied. In order to study the impact of slag powder and fine steel slag on the performance of asphalt mixture, three alternatives were designed: (a) using steel slag powder to replace the minor powder in AC13 asphalt mixture; (b) using fine steel slag to replace the fine aggregate in AC13 asphalt mixture; (c) using steel slag powder and the fine steel slag to replace the minor powder and the fine aggregate in AC13 asphalt mixture respectively. Using marshall method to design the asphalt mixture, appropriate adjustment of the proportion of materials was made in the design process to control the target void volume of 4%.

NITENDRA PALANKAR (2015)⁵ in his paper focussed on development of alternative binder materials to Ordinary Portland Cement (OPC) due to high emissions of greenhouse gases associated in the production of OPC. An innovative alternative to OPC is GGBFS-FA based geopolymer binders which can obtain high strength with being eco-friendly as its production does not involve heavy energy but also contributes to sustainability by using the industrial waste materials. In his study he evaluated the performance of weathered steel slag coarse aggregates in GGBFS-FA based geopolymer concrete.

RIYAZ KHAN (2013)⁶ in his paper studied the effect of replacement of fine aggregate with the steel slag which is locally produced in great amounts, creating problems for the environment when disposed. This paper includes in determining the different properties of locally available steel slag and utilizing the steel slag in concrete by replacing it partially and fully by fine aggregate keeping the other parameters constant. Various strengths which are considered in this study are compressive strength, flexural strength and split tensile strength on M20 grade of concrete with constant 0.5 w/c ratio.

GUO PENG (2011)¹¹ in his paper studied the performance of the pavement with steel slag pervious concrete and the study used converter slag to analyze the chemical composition, mechanical property and stability of the steel slag. A certain kind of steel slag permeable concrete by mixing the steel slag to cement concrete, different water cement ratio, volume ratio of aggregate to slurry and aggregate size influencing on strength and water permeability. Void ratio maintained is 15-20%, permeability coefficient being beyond 10mm/s, flexural strength beyond 4.0 MPa.

YUNFENG LI (2009)⁷ in his paper made a study on the application of high performance concrete when mixed with steel slag powder in the concrete pavements. In this paper various properties of steel slag cement and concrete with different types of steel slag and different dosage of admixtures which can be used has been studied. The effectiveness of using steel slag powder for suppressing Alkali Aggregate reaction has also been studied.

CAIJUN SHI (2004)⁹ This paper has reviewed the production of slag, its processing and characteristics and its use as a cementing component in different types of cementing systems. Physical and chemical properties of solidified steel slag is greatly affected by its chemical composition and cooling process.

CONCLUSION

From the review of literature, the following conclusion can be drawn:

- The replacement of traditional aggregates with steel slag in AASCs results in slight reduction of the workability whereas the density of the mix increases.
- The AASC mixes exhibit higher early and ultimate strengths as compared to OPCC. AASC mixes with steel slag aggregates exhibit lower compressive and tensile strengths as compared to AASC with normal aggregates due to the presence of a weak aggregate-paste interface.
- The AASC with steel slag aggregates display lower fatigue life as compared to AASC with normal aggregates. The modulus of elasticity of AASC with steel slag is lower than AASC with conventional aggregates.
- The AASC mixes with steel slag show satisfactory results for its use in PQC and displays economical benefits over OPCC. Production of air cured AAS concrete will result in reduction of OPC and in turn reduces carbon dioxide emissions. Utilization of steel slag in concrete creates opportunity for the conservation of natural aggregates and solves the disposal problem of slag in steel industry.
- The properties and durability of concrete is greatly improved using mineral admixtures such as steel slag powder.
- Compressive strength of steel slag concrete attained the highest compressive strength by mixture ratio 1 Pc: 1.6 Sand: 3 Coarse aggregate: 0.4 steel slag which get 1.37 of ratio of concrete steel slag sand compressive strength than concrete with natural sand.

- Tensile strengths of steel slag concrete reached the highest tensile strength by mixture ratio 1 Pc: 0.4 Sand: 3 Coarse aggregate: 1.6 steel slag which get 1.18 of ratio of concrete steel slag san tensile strength than concrete with natural sand.
- Flexural Strengths of steel slag concrete reached the highest flexural strength by mixture ratio 1 Pc: 1.6 Sand: 3 Coarse aggregate: 0.4 steel slag which get 1.13 of ratio of concrete steel slag sand flexural strength than concrete with natural sand.
- Steel slag porous concrete has high flexural strength, as porous pavement concrete, when void ratio is controlled in the range of 20%~30%, flexural strength is 3.5~ 5.0 MPa, permeability coefficient is about 20mm/s, compressive strength satisfies the drainage request of light traffic pavement.

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