Experimental Study On Durability Strengthening Of Concrete By Using Industry Metal Slag Waste Partially Replacement Of Fine Aggregate

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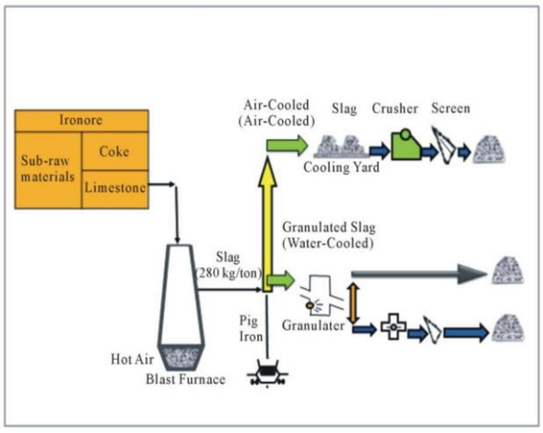
ABSTRACT

This paper present result of an experimental investigation carried out to evaluate effects of replacing aggregates (course& fine) with that of Slag (Crystallized & Granular) which is an industrial waste by product on concrete strength properties by using Taguchi's approach of optimization. Whole study was done in three phases, in the first phase natural coarse aggregate was replaced by crystallized slag coarse aggregate keeping fine aggregate (natural sand) common in all the mixes, in the second phase fine aggregate (natural sand) was replaced by granular slag keeping natural coarse aggregate common in all the mixes and in the third phase both the aggregates were replaced by crystallized & granular aggregates. The study concluded that compressive strength of concrete did not improve almost all the % replacements of normal crushed coarse aggregate with crystallized slag by 5% to 7%. In case of replacements of fine aggregate and both type of aggregates, the strength improvements were notably noticed at 30% to 50% replacement level. It could also be said that full substitution of slag aggregate with normal crushed coarse aggregate improved the flexure and split tensile strength by 6% to 8% at all replacements and in case of replacing fine aggregate & both the aggregates(Fine & coarse) with slag, the strength improvement was at 30% to 50% replacements. It is evident from the investigation that Taguchi approach for optimization helped in indentifying the factors affecting the final outcomes. Based on the overall observations, it could be recommended that Slag could be effectively utilized as coarse & fine aggregates in all concrete applications.

Keywords: Compressive; Flexure and Split Tensile Strength; Slag Aggregate;
Taguchi's Approach.

1. INTRODUCTION

The proper use of waste materials fundamentally affects our economy and environment. Over a period of time waste management has become one of the most complex and challenging problems in India affecting the environment. The rapid growth of industrialization gave birth to numerous kinds of waste byproducts which are environ- mentally hazard and create problems of storage. The construction industry has always been at forefront in consuming these waste products. The consumption of Slag which is waste generated by steel industry, in concrete not only helps in reducing green house gases but also helps in making environmentally friendly material. During the production of iron and steel, fluxes (limestone and/or dolomite) are charged into blast furnace along with coke for fuel. The coke is combusted to produce carbon monoxide, which reduces iron ore into molten iron product. Fluxing agents separate impurities and slag is produced during separation of molten steel. Slag is a nonmetallic inert byproduct primarily consists of silicates, aluminosilicates, and calcium-alumina-silicates. The molten slag which absorbs much of the sulfur from the charge comprises about 20 percent by mass of iron production. The schematic production details of Slag are shown in Figure1.1.



2. LITERATURE REVIEW

Isa Yuksel, Omer Ozkan, Turhan Bilir, (2006)

Worked on mortar made up of ground granulated blast furnace, gypsum, clinker and steel slag sand. The experimental results show the application of steel slag sand may reduce the dosage of cement clinker and increase the content of industrial waste product using steel slag sand.

Juan M. Manso, *et al.*, (2004)

Experimented use of non ground granulated blast furnace

slag as fine aggregate in concrete. The study concluded that the ratio of GGBs/sand is governing criteria for the effects on the strength and durability characteristics.

KeunHyeokYang, JinKyuSong, Jae-SamLee,(2010)

Carried out work in laboratory to produce concrete with good properties using oxidizing EAF slag as fine and coarse aggregate. The concrete was tested for durability characteristics like soundness, leaching test, accelerated ageing test etc. The durability of the EAF slag concrete was found to be acceptable, especially in the geographical region for which its use was proposed, where the winter temperature hardly ever falls below 32˚F (0˚C).

Li Yun-feng, Yao Yan, Wang Liang, (2009)

Studied alkali activated mortar sand concrete using light weight aggregates. Test results showed that the compressive strength of alkali activated mortar decreased linearly with the increase of replacement level of light weight fine aggregate regardless of the water binder ratio.

Lun Yunxia, Zhou Mingkai, Cai Xiao, Xu Fang, (2008).

Investigated effects of steel slag powder on the workability and mechanical properties of concrete. Experimental results show that mechanical properties can be improved further due to the synergistic effect and mutual activation when compound mineral admixtures with steel slag powder and blast furnace slag powder mixed in concrete.

L. Zeghichi, (2006)

Used steel slag as fine aggregate for enhancing the volume stability of mortar. Experimental results indicated that powder ratio, content of free lime and rate of linear expansion can express the improvement in volume stability of different treated methods. Autoclave treatment process is found more effective steam treatment process on enhancement of volume stability of steel slag.

Saud AlOtaibi, (2008)

Experimented on substitution of sand by GBF crystallized slag. Tests carried out on cubes of concrete showed the effect of the substituting part of sand by granulated slag (30%, 50%) and the total substitution on the development of compressive strength. Compressive strength test results at 3, 7, 28, 60 days and 5 months of hardening concluded that the total substitution of natural coarse aggregate with crystallized slag affects positively on tensile, flexural and compressive strength of concrete. The partial substitution of natural aggregate with slag aggregates permits a gain of strength at long term but entire substitution of natural aggregates affects negatively the strength (a loss in strength of 38%).

Sean Monkman, Yixin Shao, Caijun Shi, (2009)

Studied use of recycling steel mill as fine aggregate in cement mortars. The replacement of 40% steel mill scale with that of fine aggregate increased compressive strength by 40%, drying shrinkage was lower when using steel mill scale.

Tarun R Naik, Shiw S Singh, Mathew P Tharaniyil, Robert B Wendfort, (1996)

Investigated the possibility of using a carbonated LF slag as a fine aggregate in concrete. The slag was treated with CO2 to reduce the free lime content while binding gaseous CO2 into solid carbonates. The carbonated LF slag was used as a fine aggregate in zero-slump press-formed compact mortar samples and compare to similar samples containing control river sand. The 28-day strengths of the mortars made with the carbonated slag sand were comparable to the strengths of the normal river sand mortars. The carbonation of LF slag was found to be suitable for use as a fine aggregate. Significant amounts of carbon sequestration could be realized in a potentially useful form that further utilizes a waste slag material. Carbonated mortars that used LF slag sand offer the largest gains in terms ofCO2uptake.

3. METHODOLOGY

Study Scope

In this study, concrete of M20, M30 & M40 grades were considered for a W/C ratio of 0.55, 0.45 & 0.40 respectively with the targeted slump of 4 ± 1 in. (100 ± 25 mm) for the replacement of 0%, 30%, 50%, 70% & 100% of aggregates (fine & coarse) with that of slag aggregate. These concrete mixes were studied for the properties like compressive, split tensile and flexure strengths.