FERRO-CEMENT AN ECO-FRIENDLY ALTERNATIVE TO CONCRETE AND EARTHEN STRUCTURES

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Introduction:

Concrete is the composite material that consists of binding material called cement which binds fine and coarse aggregates together and hardens later. In construction industry concrete has a huge demand as it is used in various infrastructures such as bridges, buildings, highways, flyovers and etc. Cement and aggregates are manufactured using the raw materials available in the nature, in future there might be scarcity for the natural resources which brings out the demand for the alternate materials that could replace the aggregates. Cement industries are the major contributors for global warming as they produce enormous CO_2 during manufacturing process. Hence there is an urgent need to reduce the usage of cement and bring out an alternative material in place of cement.

Ground Granulated Blast Furnace Slag (GGBS) is a by product of iron and steel making industries, obtained by the process of quenching the molten iron slag. GGBS is high in calcium silicate hydrates which is a strength enhancing compound which improves the strength, durability and appearance of the concrete. GGBS being a cementitious material it can partially replace cement in concrete. GGBS can reduce thermal cracking and improves its resistance to damage from alkali-silica reaction, sulphates and chlorides. The use of GGBS in concrete isboth economical and ecofriendly.

Natural aggregates are becoming scarce and their production becomes difficult in few decades. Steel slag which is the by-product of smelting ores and used metals can be widely used in construction industry as coarse aggregates. Sand is the principal component as a construction material, where the River sand acts the major source which is formed naturally. There has been a crisis developed for natural river sand had triggered the search of alternatives for sand. The slag sand can be an ecofriendly replacement for the river sand.

Ferro-Cement Blocks:

In the present experimental study, the conventional materials used in concrete are replaced (partially or completely) by different products. The cement is partially replaced by Ground Granulated Blast Furnace Slag, Natural Coarse aggregate by Steel slag and Fine aggregate (River Sand) by Slag sand. Using these materials blocks of standard size are moulded and tested for various conditions. The blocks so produced are more ecofriendly and economical if manufactured in huge quantity.

Objectives:

Based on the detailed literature survey the present experimental study has been carried out for achieving the following objectives:

- To Prepare M5, M7.5, M10 and M15 Ferro-Cement blocks consisting of Ground Granulated Blast Furnace Slag, Cement, Steel Slag, Slag Sand following Nominal ratiosfor proportioning the mix.
- To determine the various properties of the blocks (Compressive Strength, Water absorption and Density) for 3,7,28 days of curing and to compare the characteristic strength with respect to conventional concrete blocks.
- To study the characteristic strength of concrete subjected to sustained elevated temperature.
- To analyze the experimental results with that of FEM modelling.
- To analyse the experimental results with that of Ferro-Cement cubes by XRD test results.

Methodology:

The materials used in the Experimental study were tested for their physical properties such as Specific gravity, Bulk density, Standard consistency, Initial and final setting time, Water absorption, density and Voids. The results obtained were cross verified with that of the values in the specific IS Codebooks. List of the specific tests to determine the physical properties of materials used are given below:

1. Cement and GGBS:	a) Determination of Specific gravity
	b) Determination of Consistency
	c) Determination of Initial and Final Setting time
	d) Determination of Compressive Strength
2. Steel Slag:	a) Specific gravity and water absorption
	b) Bulk density and Voids
3. Slag Sand:	a) Specific gravity and water absorption
	b) Bulk density and Voids

The Ferroform blocks are made out of the raw materials such as Ground Granulated Blast Furnace Slag, Steel slag (12.5mm), Slag sand are mixed according to the mix proportions (nominal mix for M5, M7.5, M10 and M15 grade concrete). A suitable Water Cement ratio is chosen and mixed uniformly. These Ferro-cement blocks are casted by compacting the mix- proportions in the mould of required size. The concrete is tested for compressive

strength, water absorption and density. The Ferroform blocks are made out of the raw materials such as Ground Granulated Blast Furnace Slag, Steel slag (12.5mm), Slag sand are mixed according to the mix proportions (nominal mix for M5, M7.5, M10 and M15 grade concrete). A suitable Water Cement ratio is chosen and mixed uniformly. These Ferro-cement blocks are casted by compacting the mix-proportions in the mould of required size. The concrete blocks were tested for compressive strength, water absorption and density as per Bureau of Indian Standards.

Results and Discussion:

The results obtained from the experimental study on the physical properties of materials and the compressive strength of Ferro-Cement blocks are as follows:

The Cement (OPC 43 grade) used has the specific gravity of 2.96, Standard Consistency of 31%, Initial and Final Setting Time as 145min and 235min respectively. The mortar cubes formed from the 43 grade Ordinary Portland Cement has gained the strength of 43.25N/mm^2. The GGBS used has the specific gravity of 2.96, Standard Consistency of 31%, Initial and Final Setting Time as 175min and 315min respectively. The values obtained are acceptable according to the IS codes.

The Coarse and Fine aggregate used is the study are Steel Slag and the Slag Sand respectively. The Specific Gravity of them are 2.9 and 2.59 respectively the aggregates used have the Water absorption values of 0.4% and 0.8% respectively, the bulk density of Coarse aggregates is 34.22% and 31.43% in loose and compacted condition respectively, the Bulk Density of Fine aggregates is 32.7% and 27.13% in loose and Compacted condition respectively.

The M5, M7.5, M10 and M15 Ferro-Cement cubes (150mm*150mm) that were casted using Cement, GGBS, Steel slag and Slag sand were tested for their Compressive strength, water absorption and density. The Compressive strength of M5 Blocks for 3,7 and 28 days of Curing was 6.52 N/mm^2, 7.11N/mm^2 and 8.33N/mm^2 respectively. The Compressive strength of M 7.5 Blocks for 3,7 and 28 days of curing was 6.52 N/mm^2, 7.85 N/mm^2 and 8.73 N/mm^2 respectively. The Compressive strength of M10 Blocks for 3,7 and 28 days of curing was 8.65 N/mm^2, 10.16 N/mm^2 and 12.17 N/mm^2 respectively. The Compressive strength of M15 Blocks for 3 and days of curing was 14.59 N/mm^2 and 15.78 N/m m^2 respectively. The Water Absorption of M5, M7.5 and M10 blocks are 0.4, 0.43 and 0.5 % respectively (28 days). The Density of the M 5, M7.5 and M10 Blocks are 2200kg/m^3, 2275 kg/m^3 and 2345 kg/m^3 respectively.

The strength of the Ferro-Cement blocks has increased on comparison with conventional concrete blocks by 5% as GGBS increases the binding strength when added by partially replacing the cement by (40%). The blast furnace slag by products used have similar physical properties and higher compressive strength when compared to that of conventional aggregates. The durability of the Ferro-Cement blocks increases by the usage of GGBS as a partial replacement of Cement.

Scope for the Future Work:

Cement and aggregates are manufactured using the raw materials available in the nature. In future there might be scarcity for the natural resources which brings out the demand for the alternate materials that could replace the various ingredients of concrete. Cement industries are the major contributors for global warming as they produce enormous CO2 during manufacturing process. Hence there is an urgent need to reduce the usage of cement and bring out an alternative material in place of cement. Ground Granulated Blast Furnace Slag (GGBS) is a by-product of iron and steel making industries, obtained by the process of quenching the molten iron slag. GGBS is high in calcium silicate hydrates which is a strength enhancing compound which improves the strength, durability and appearance of the concrete. GGBS being a cementitious material it can partially replace cement in concrete. GGBS can reduce thermal cracking and improves its resistance to damage from alkali-silica reaction, sulphates and chlorides. The use of GGBS in concrete is both economical and eco-friendly. Natural aggregates are becoming scarce and their production becomes difficult in few decades. Steel slag which is the by-product of smelting ores can be widely used in construction industry as coarse aggregates. Sand is the principal component as a construction material, where the River sand acts the major source which is formed naturally. There has been a crisis developed for natural river sand had triggered the search of alternatives for sand. The slag sand is the byproduct obtained in the manufacture of pig-iron in blast furnaces at high temperatures in the molten form. The slag sand can be an eco-friendly replacement for the river sand. In this experimental study the conventional materials used in concrete are being replaced (partially or completely) by eco-friendly materials. The cement is partially replaced by Ground Granulated Blast Furnace Slag, Natural Coarse aggregate by Steel slag and Fine aggregate (River Sand) by Slag sand. Using these materials blocks of standard size are moulded and tested for various conditions (compressive strength for 3, 7 and 28 days of curing and test for elevated temperature). The blocks produced are eco-friendlier and more economical if manufactured in large quantity for societal application hereby achieving United Nations Sustainable Development Goals (UNSDG).