Partial cement replacement in concrete by iron slag and silica fume

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Abstract— The most commonly used building material in civil engineering works is concrete, which is primarily due to cement, accounting for 8 to 10 percent of total CO_2 emissions. The solution to reducing these emissions is to substitute cement with iron slag and silica fumes, which contribute to reducing the use of cement, thus addressing the issue of waste management. In this article, concrete produced by cement replacement with silica fume and iron slag has been analyzed to determine these material properties. Cement was replaced by I-S (I-iron slag from steel industries and S- silica fume). For I-S, the cement substitution percentages are 5percentage, 10percentage, 15percentage and 20percentage by weight. To perform this function, the mixture of cement with I-S as a binder material in the concrete is used. The optimum percentage for cement substitution can be determined by fresh and hardened concrete test results. SEM and XRD research for the application of specimens is carried out

Key words: Industrial waste, Silica fume, Iron slag, Green concrete, cement replacement.

I. INTRODUCTION

Concrete is a versatile material for highways, residential, bridges, other structures. For every human being on average, roughly one tonne of concrete is created per year. Due to this widespread global use, it is unsafe to accurately assess the environmental effect of this content. Nowadays, the environmental influence of a product is measured, including its influence on GHG pollution and temperature variation. From this view, a great change of the so-called principle of green concrete should have been made. These principles most commonly concentrate on the partial substitution of cement, the concrete being a reason for the high carbon dioxide levels, with some products readily applied in practical implementations. The present century's aims to move to a new form that would promote the natural world. This needs a threadable rethink of ways and means to support the city with accommodation and facilities. Possibly it is important to make a deliberate attempt to produce new and substitute novel building materials. Concrete Green concrete is capable of ecological growth and is distinguished by agricultural waste application to minimize natural resource consumption and electricity and environmental emissions. 22 such waste materials are used in ijsrset.com, which saves 14-20 percent of the volume of cement. On the opposite side of the scale, to mitigate the pace of environmental alteration, the Kyoto Protocol of 1997 made a global pledge to curb GHG emissions by 8% by 2010. Developed countries are very mindful of the need, and they have adopted a climate change levy. In this regard, the UK Government has adopted the same form of tax on 1 April 2001 to meet its goal of reducing greenhouse gas emissions by 12.5 percent, which is the government's domestic objective of reducing CO_2 emissions by 20 percent by 2010. It is also clear that the concrete business paradigm has to be moved towards "sustainability" For the intent to retain its role as a key substance of the potential. For robust, safe, and long-lasting building, concrete has long been the go-to material. Everywhere you see it, roads, bridges, structures, and sidewalks- and every year about Four billion tonnes of cement made, having tremendous repercussions for our climate. But what if there was something to deal with that was better, more versatile, less costly, and carbon negative, working like a sponge to practically consuming CO_2 Well. The key mechanical properties were evaluated as compressive and break tensile power, allowing a distinction between both of them to determine which one offers the best features. Furthermore, some of the measured assets in spatial and environmental terms are used in this report.

II. METHODS AND MATERIALS

A. Experimental investigation

The experimental programs which are carried out in the partial cement replacement using the I-S materials and their discussions are presented.

B. Materials

In this experimental work, we have varied the proportion of the I-S in the cement content. I-S is used as a binder material. It is a blend of combinations of materials like iron slag and silica fume. Iron slag is the waste which is generated by the iron industry and steel industries. The silica fume is a sub-product of the ferrosilicon industry. The combination of these two is called I-S (50% iron slag and 50% silica fume). Iron slag has a specific gravity of 3.6 of size 90 microns. Generally used Portland cement with a density of 3.15 kg/m^3 was added. Locally available M-sand (passing through 2.36 mm) with fineness modulus of 2.9 having a specific gravity of 2.59 was used on IS 383(2002). Coarse aggregates of 10mm size with a density of 2.74 kg/m3 were used for cubes and cylinders. Coarse aggregates of 20 mm size with a density of 2.74 kg/m3 were used for a beam. Potable tap water was used to mix concrete and to cure it.

C. Mix proportion

The Analysis has been performed to prepare the three forms of cement forms containing iron slag and silica fume using the structure of the mixes. The iron slag and silica fume are sewn for inclusion in the cement by IS sieve 90 microns. The proportion of water-cement was 0.4. We also varied the percentages of the cement content by the replacement process in the mix proportion in this experimental analysis. The cement was replaced by cement weight content at different amounts (five percent, ten percent, fifteen percent, and twenty percent) by I-S.

D. Properties of Fresh concrete

The fresh concrete properties such as slump can be determined from the slump cone test. The results show that the slump value for the specimen is higher than the conventional mix of concrete.

E. Specimens

The mold of 10x10x10mm3 cube and the mold of 150 mm diameter with 300 mm longer cylinder for the cylinder was chosen. After the production of cubes, the molded specimens were coated with sheets of plastic at 20± 2 for 24h. Before the test time, the samples were dismantled and buried underwater. 10x10x10mm3 cubes were evaluated for each mixture to determine compression and split tensile strengths over specified days, respectively. The results obtained are a total of six samples of compression.

F. Curing

Since cutting the molds of cubes, cylinders, and beams, they are poured and placed directly for 28 days of curing.

G. Testing procedure

The strength of concrete is measured according to IS 516. (1959). The cubes are applied with the load for each 400 kN and the cylinders are loaded at each 140 to 650 kN.

III. EXPERIMENTAL RESULTS AND REVIEW

The strength results of the experimental investigations are shown in graphs. In the research program of this analysis, all the values are the mean of the three trials in each case.

TEST RESULTS FOR WORKABILITY OF CONCRETE:

The result of the fresh concrete slump test is carried out to find the workability of concrete. The table shows the slump cone results for the M 30 grade of concrete.

Slump cone test

Grade of concrete	M30				
% replacement of iron slag and silica fume	0%	5%	10%	15%	20%
Slump in mm	100	95	130	110	80

The result shows that the slump is a true slump.

COMPRESSIVE STRENGTH TEST RESULTS:

Iron Slag and Silica Fume content

	Replacement of cement (%)	Iron slag(g)	Silica Fume(g)
C_{IS1}	5%	12	12
C_{IS2}	10%	24	24
C_{IS3}	15%	36	36
C_{IS4}	20%	48	48

Compressive strength

The findings of the concrete block compressive strength test for each sample are presented. This shows that the compressive strength of 28 days for normal concrete hit the most since the formulation proportion

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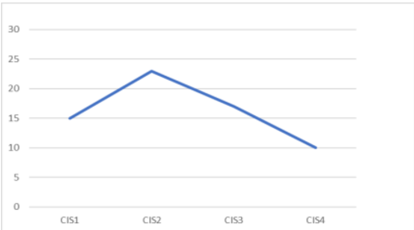
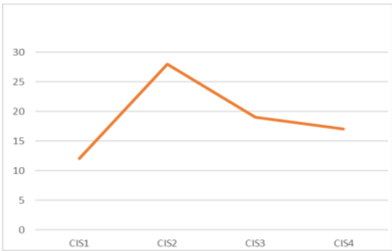
used for normal concrete mixtures was built to manufacture concrete after 28 days of curing. This indicates that the design of the mixture is as per IS 10262-2000.

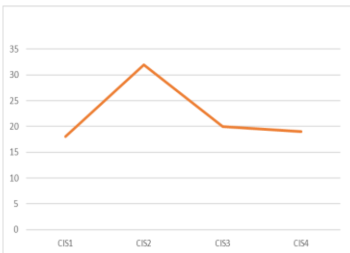
Variations of compression strength results with the usage of iron slag and silica fume with different percentages for 7, 14, 28 days for M30 grade of concrete.



Compressive Strength of specimens – 7 days



Compressive Strength of specimens – 14 days

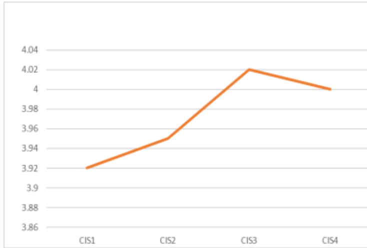


Compressive Strength of specimens – 28 days

The fig. presents the differences of the effects of the compressive strength of concrete made with cement substituted by I-S at various stages, 5%, 10%, 15%, 20% the utmost, compressive strength of 32 MPa was reached at 10% I-S replace

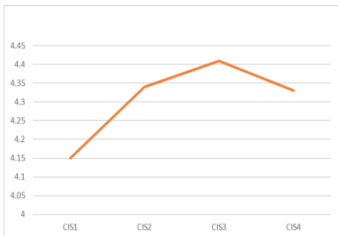
Split Tensile strength

Variations of split tensile strength results with the usage of iron slag and silica fume with different percentages for 7, 14,28 days for M 30 grade of concrete.



Split Tensile Strength of specimens – 7 days

Split Tensile Strength of specimens – 14 days



Split Tensile Strength of specimens – 28 days

The findings of the split tensile strength of hardened concrete for each batch are described. The fig. presents the differences of the effects of the split tensile strength of concrete rendered with cement substituted by I-S at various stages, 5 percent, 10 percent, 15 percent, 20 percent of the limit, 4.4 MPa split tensile strength was reached at 15 percent I-S replacement stage, which was 60 percent improvement in strength compared to that of the traditional specimen.

CONCLUSION

This research presents the hardened mechanical properties of substitute concrete made up of toxic waste. From the experimental findings, the conclusions mentioned below can be drawn.

- The slump of iron slag and silica fume replaced concrete (CIS 2) is found to be a true slump.
- The Compressive strength of iron slag and silica fume replaced Concrete (CIS 2) is found to be 20% more than the Conventional Mix.
- The break Tensile Strength of iron slag and silica fume replaced Concrete (CIS 3) is revealed out to be 60% more than the conventional Mix.
- The SEM XRD results of iron slag and silica fume replaced concrete (CIS 2) is found to be the same as the conventional mix.

Consequently, the partial replacement of cement by iron slag and silica smoke (CIS2) is not only economical but also enables the environmentally sustainable replacement of waste iron slag into a valuable commodity manufactured in vast amounts by the iron and steel industry, without losing its strength.

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