ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

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www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

EXPERIMENTAL INVESTIGATION ON SELF COMPACTING CONCRETE CONTAINING IRON SLAG AS PARTIAL REPLACEMENT FOR FINE AGGREGATE

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ABSTRACT

This study was conducted to find out the effect of partial replacement of fine aggregate by IRON SLAG and its effect on the fresh and hardened properties of self compacting concrete. The tests for the fresh properties of self compacting concrete where conducted immediately after the mixing of concrete and for the hardened properties at 7 days, 14 days & 28 days of curing. The mixture was prepared by replacing fine aggregate with Iron Slag in the ratio of 0%, 10%, 20 %, 30%, 40% & 50% by weight of fine aggregate . Iron slag is a material of low density as compared tofine aggregate but it doesn"t affect the strength properties of concrete as found in this study. From the experimental study, it is found that there is a decrease in workability (in view of fresh properties of Self compacting concrete) with the increase in replacement levels of fine aggregate with iron slag. It is also found that with the increase in replacement levels there is a significant increase in the hardened properties namely compressive, split tensile and flexural strength in the specimens at all curing ages. With 40% replacement of fine aggregate with iron slag which passed the workability criteria of Self compacting concrete, there is an increase of 19.86% in compressive strength, 16.66% in split tensile strength and 10.27% in flexural strength of the specimens after a curing period of 28 days as compared to the controlled mix (0% replacement). From the experimental findings, it is observed that iron slag is a good substitute for fineaggregate partially in SCC as it enhances the load carrying capacity of Self compacting concrete.

Keywords : Self compacting concrete (SCC),fresh properties of SCC,compressive strength, splittensile strength and flexural strength.

ISSN2454-9940

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INTRODUCTION:

General :

In this present world construction work is increasing everywhere on a huge scale and due to which our natural resources which are the essential ingredients our concrete are depleting enormously. In an attempt to save our natural recourses my dissertation work is based on partially replacing fine aggregate (sand) with iron slag in making Self Compacting Concrete. Literature survey indicates that there is only one published work relevantly related to use of iron slag in self-compacting concrete. Literature review was concentrated on use of slag in concrete as well as Self-compacting concrete.

Introduction to Experimental Investigation on Self-Compacting Concrete Containing Iron Slag asPartial Replacement for Fine Aggregate

Concrete is the most widely used construction material globally, owing to its versatility, durability, and affordability. However, the production of conventional concrete involves significant environmental impacts, including high energy consumption, carbon emissions, and depletion of natural resources. In response to these challenges, there has been growing interest in developing sustainable alternatives to traditional concrete mixes. One such approach is the utilization of industrial by-products, such as iron slag, as partial replacements for conventional aggregates in concrete production. This introduction provides an overview of the rationale, objectives, and significance of experimental investigation on self-compacting concrete (SCC) containing iron slag as a partial replacement for fine aggregate.

Background and Rationale:

The construction industry is a major consumer of natural resources, including aggregates, which are essential components of concrete. The extraction and processing of natural aggregates contribute to environmental degradation, habitat destruction, and landscape alteration. Additionally, the production of Portland cement, a key ingredient in concrete, is energy-intensive and generates significant carbon dioxide (CO_2) emissions, contributing to climate change. Therefore, there is an urgent need to explore sustainable alternatives to conventional concrete mixes that reduce reliance on virgin materials and mitigate environmental impacts.

Self-Compacting Concrete (SCC):

SCC is a specialized form of concrete that flows and compacts under its own weight, without the need for external vibration, making it particularly suitable for complex or congested structural elements. SCC mixes typically contain higher proportions of fine aggregates and viscosity- modifying admixtures (VMAs) to achieve the desired flowability and stability. The rheological properties of SCC are influenced by factors such as aggregate gradation, particle shape, binder content, and admixture dosage, which must be carefully optimized to ensure proper performance.

Objectives of the Experimental Investigation:

The primary objective of the experimental investigation is to evaluate the feasibility and performance of SCC containing iron slag as a partial replacement for fine aggregate. Specific objectives include:

Assessing the fresh and hardened properties of SCC mixes incorporating varying proportions of iron slag.

Significance and Expected Outcomes:

The experimental investigation is expected to contribute to the body of knowledge on sustainableconcrete technology and materials science. By utilizing iron slag as a partial replacement for fine aggregate in SCC mixes, the study aims to reduce the environmental footprint of concrete production while maintaining or enhancing performance characteristics. The findings of the study may have practical implications for the construction industry, offering insights into the feasibility and benefits of incorporating industrial by-products in concrete mixes. Furthermore, the study may provide guidance for optimizing SCC mix designs to meet both sustainability and performance requirements.

Iron Slag

Iron slag is an industrial waste material. It is a by-product of the iron and steel manufacturing process. Iron Slag is lighter than river sand is also brittle. Fineness modulus, unit weight specific gravity & water absorption by mass (%) of iron Slag are 2.38, 2000 kg/m^3, 2.5 & 18.54 %. Iron slag is glassy black in colour the major chemical composition and physical properties of slag arelisted in the **Table 1.**

ISSN2454-9940

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Table 1:Chemical composition of Iron Slag

Chemical proportion	Percentage (%)
Fe_2O_3	66.88
SiO_2	6.98
Al_2O_3	2.94
CaO	0.8
CO_2	22.4

LITERATURE REVIEW

Gurpeet Singh et al.,(2016) In this experimental study the durability properties of SCC with replacement of iron slag with sand in levels of (0%, 10%, 25% & 40 %) were studied. In this study it was found that SCC using iron slag gave better strength and durability than normal SCC and thus can be used in SCC. The compressive strength of SCC with substitution levels of (10%,25% & 40%) where 4%, 13% & 21% (at 28 days) more as compared to controlled mix with slight increase in compressive strengths with time. It was also found that the water absorption of was SCC with iron slag was lesser than that of controlled mix. The chloride ion penetration was found to b good for SCC with iron slag, ultra sonic pulse velocity shows an excellent condition of SCC with iron slag, SEM images showed than internal structure of SCC gets denser with IRON SLAG.

Yeong~Nain Sheen et al.,(2015) in this experimental program, SCC was made using stainless steel oxidizing slag (SSOS) as replacement for coarse and fine aggregate with (0%, 50% &100%) replacement and stainless steel reducing slag (SSRS) as partial replacement for cement in levels of (0%, 10%, 20% &30%) with a fixed water to binder ratio of 0.4.Incorporating SSOS as aggregates and SSRS as cement replacements reduces the workability of SCC. It was found that that SCC containing stainless tell slag can

ISSN2454-9940

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enhance the hardening process resulting in shortening the setting time by 25 % and 36 % corresponding to 50% & 100% replacement of SSOS aggregates. Compressive strength of SSC (100% SSOS) is10-23% better than that of **Dinakar (2015)** in this study the main objective was to design SCC with granulated blast furnaceslag as replacement for cement in levels of 20-80%.it was found that SCC with strength in range of 30-100MPa at replacement levels of 20-80% can be made. The authors gave a methodology for design of SCC using GBFS.

M.Valcuende et al.,(2014) in the experimental study the aim was to find the shrinkage of Self compacting concrete with time with replacement of sand by blast granulated furnace slag (GBFS) in levels of (0%,10%,20%,30%,40%,50% and 60%) with a water to binder ratio of 0.55.It was found that during the early days the compressive strength of SCC with replacements was almost equal as compared with the reference SCC but the strength increased with age of

.This may be due to the slag reactivity. It was also found that higher the replacement levels, higher were the shrinkage levels of SCC as compared to the reference mix. The shrinkage was in the range of 4 -44 % when replacement levels where 10 -60%.

Her-Yung Wang et al.,(2013) in this study the properties of SCC made with a fixed water to binder ratio of 0.37 and replacement of cement by slag in the ratios of 0%,15% and 30% where studied. In this study it was found that the slump flow of SCC changed with the increase in substitution levels of slag for cement. The slump flow value for 15% replacement was found to be within design limits (550-700 mm).The compressive strength of samples with 15% substitution was found to be higher than the normal mix by almost 13 %.also it was also found that the shrinkage of SCC increased as the amount of slag used was increased, with the maximum shrinkage being in 30 % replacement.

Mehmet Gesoglu et al.,(2012) in this experimental program, the main aim was to check the properties of SCC with replacement of coarse aggregates with GGBS (as artificial coarse aggregate) in the replacement levels of (0%,20%,40%,60% & 100%), fly ash was added as a binder to impart desired fluidity to SCC.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

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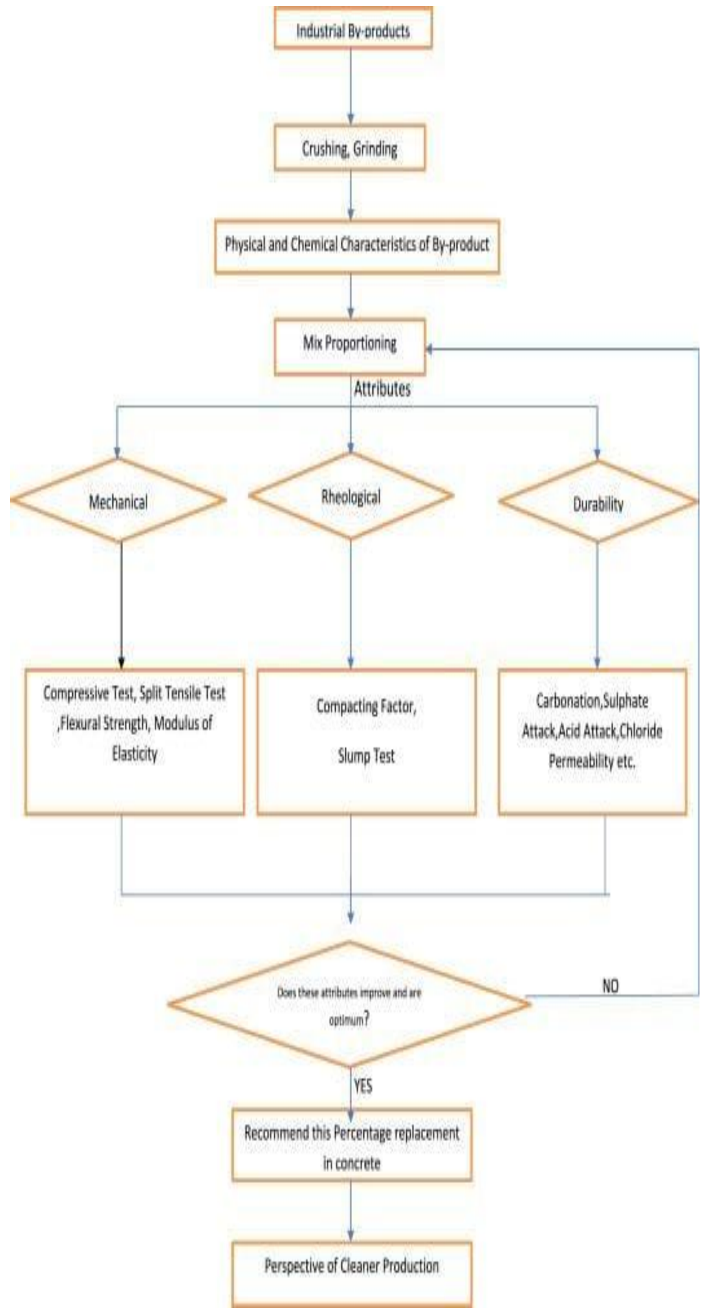
METHODOLY

Slump flow

In case of this property the SCC mixes SCC – CM, SCC – IS10, SCC – IS20, SCC – IS30, SCC IS40 exhibit slump flow in range of **764 – 670 mm** which is within the limits (650 -800 mm) given by EFNARC. These results indicate good deformability of these mixes**.** The mix SCC – IS50 exhibited a slump flow of **643 mm** which is slightly out of range as given by EFNARC.Intricate shape and sharp texture of iron slag as compared to fine aggregate (sand) plays a sound role in increasing the inter particle friction causing packing of concrete particles which thereby reduce the workability of SCC. The values of slump flow are shown in the tabular and graphical.



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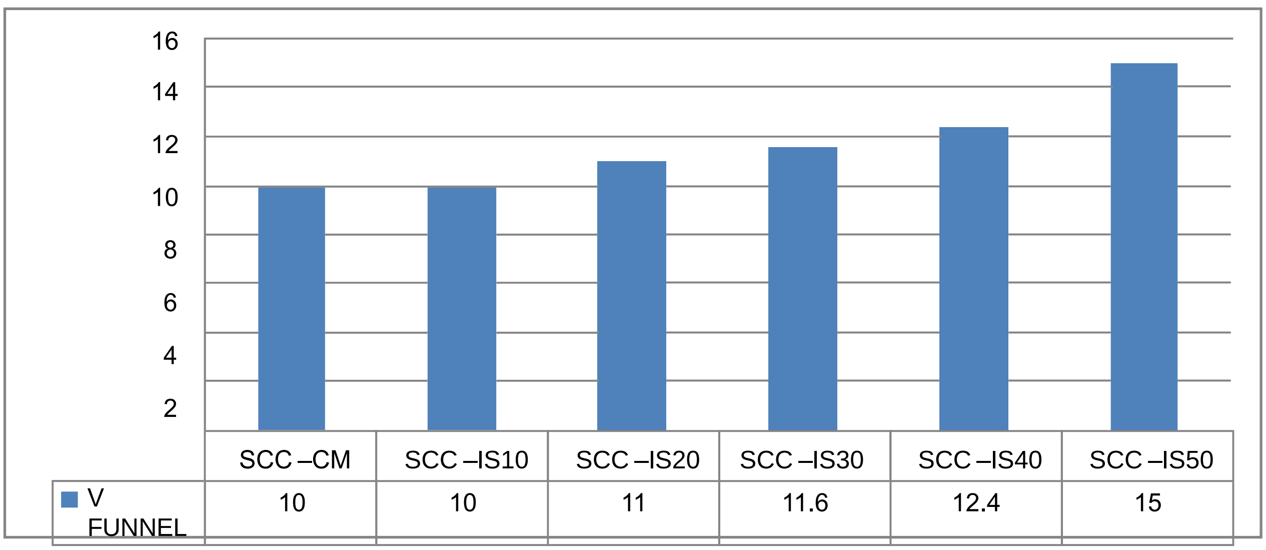
V - Funnel:

There was increase in passing time as the percentage of iron slag level was increased .The results from this test show that the mixes SCC – CM, SCC – IS10, SCC – IS20, SCC – IS30, SCC – IS40 had a FILLING ability time of (10 – 12 sec)which is within the limits by EFNARC (8 - 12 sec). The mix SCC – IS50 showed a filling ability Time of 16 s which is out of range as given by ERNARC (8 – 12 sec). The values of slump flow are shown in the tabular and graphicalin.



Experimental Work

Cubes

In this study, total numbers of 54 cubes were casted. The moulds were of size 150 mm×150 mm×150 mm. First the moulds where cleaned, lubricated and after that filled with concrete. Every specimen was tested under CTM to determine the compressive strength. These cubes were tested after 7,14 and 28 days. All the specimens were cured in the curing tank. For determining the average strength of the cubes after 7 days, 3 sample cubes were tested and their average valuewas taken and same was done for the compressive strength after 14 days and 28 days.

ISSN2454-9940
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Rectangular Beams

Total numbers of 36 rectangular beams were casted. The moulds were having cross-section of 100mm×100mm×500mm as shown in the figure 4. All these rectangular moulds where cleaned, lubricated and after that filled with concrete. Every specimen was tested under CTM to determine the Flexural strength. These beams were tested after 7 days, and 28 days. All the specimens were cured in the curing tank.

Cylinders

Total numbers of 36 cylinders were casted. The moulds were having cross-section of 150 mm × 300 mm. All these cylinders where cleaned, lubricated and after that filled with concrete. Every specimen was tested under CTM to determine the tensile strength. These cylinders were tested after 7 days, and 28 days. All the specimens were cured in the curing tank. For determining the average strength of the cylinders after 7 days, 3 samples were tested and their average value taken and same was done for the tensile strength after 28 days.

Flexural Strength

To determine the precise flexural strength an average of three samples were taken for every reading. The testing of specimens has been performed after curing period of 7 and 28 days for both controlled as well as for beams with partial replacement of Fine aggregates with iron slag. The results of flexural strength obtained in this project.

Flexural Strength of beams after 7 and 28 days.

Mixture	FLEXURAL STRENGTH (Mpa)	
	7 days	28 days
SCC - CM	2.90	4.28
SCC – IS10	3.04	4.34
SCC – IS20	3.18	4.45
SCC – IS30	3.27	4.54
SCC – IS40	3.42	4.77
SCC – IS50	3.53	4.81

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

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CONCLUSION

1. Results show that with the increase in substitution levels of fine aggregate with iron slag resulted in decrease in the fresh properties of SCC. Intricate shape and sharp texture of the iron slag particles plays a significant role in increasing the interparticle friction which thereby reduce the fresh properties of SCC.

2.From the test results it is found that with the increase in replacement levels of iron slag with fine aggregate there is a increase in the overall strength of concrete be it compressive, tensile or flexural strength.

3.Maximum increase in compressive strength is 16.75%, split tensile strength is 10.27 % and flexural strength is 16.66 % for Mix SCC – IS40 with 40 % replacement of F A with iron slag at 28 days as compared to the controlled mix.

4.With the increase in substitution level of sand with iron slag (>40 %) results in increase in the w/c ratio or increase in the admixture percentage (in view of workability) as the fresh properties of SCC decreased.

5.The optimum substitution level of replacement of fine aggregate with iron slag is 40% which results in higher strength and which also passes the criteria of limits of fresh properties of SCC given by EFNAR

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