# Performance Evaluation Of M30 Self-Compacting Concrete Utilizing Magnetically Conditioned Water And Sustainable Mineral Replacements

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***Abstract***- *This experimental study investigates the fresh and hardened properties of M30-grade self-compacting concrete (SCC) prepared using magnetic field-treated water (MFTW) at a field intensity of 0.8 Tesla. To enhance the sustainability and economic feasibility of the mix, ordinary Portland cement (OPC 53 grade) was partially replaced with silica fume at intervals of 0%, 10%, 20%, 30%, 40%, and 50%. Simultaneously, the fine aggregate component was partially replaced with industrial waste by-products, utilizing sintered fly ash aggregate (0%–50%) and foundry sand (0%–25%). The fresh-state characteristics of the concrete—specifically filling ability, passing ability, and segregation resistance—were systematically evaluated using standard slump flow, J-ring, L-box, and U-box testing methods. To determine the mechanical behavior of the modified concrete matrix in its hardened state, destructive testing was conducted to evaluate compressive and split tensile strength. All specimens were subjected to standard wet curing and tested at intervals of 7, 14, and 28 days. The primary objective of this research is to establish a comprehensive comparative analysis between the performance profiles of these multi-component, magnetically conditioned concrete mixes and conventional self-compacting concrete configurations.*

***Keywords:*** Self compacting concrete, sintered flyash aggregate, glass powder, fly ash, workability, compressive strength, split tensile strength test.

## I. INTRODUCTION

Cement used in concrete is a mixture of complex compounds. Cement is a major industrial commodity that is manufactured commercially in over 120 countries. Mixed with aggregates and water, cement forms the ubiquitous concrete which is used in the construction of buildings, roads, bridges and other structures. In countries, even where wood is in good supply, concrete also features heavily in the construction of residential buildings. Production of concrete using Portland cement is popular all over the world.

This is due to mainly low cost of materials and construction for concrete structures as well as low cost of maintenance. But high amount of energy is required for manufacturing of cement which emits carbon dioxide (CO2) which is very harmful for the environment. In order to minimize this problem, we use the concept of supplementary cementitious material. Some of agricultural and industrial waste ash which was fulfilled the criteria as supplementary cementitious materials. Self-compacting concrete (SCC) is a new kind of high-performance concrete (HPC) developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient. Fresh self-compacting concrete SCC flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking.

SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only. Self-compacting concrete has been successfully used in Japan, Denmark, France, U.K., etc. It is widely been accepted because of its enhanced properties also it reduces noise pollution, saves time, labour and energy.

To make the SCC mix economical and environment friendly, a variety of materials have been experimented and analyzed in order to replace the constituent materials. The following materials have been used as replacements in the preparation of SCC. e.

An experimental study on mechanical properties, such as compressive strength, flexural strength of self-compacting concrete (SCC) and the corresponding properties of self-compacting concrete were studied. The age at loading of the concretes for 7 and 28 days curing.

Making concrete structure without compaction has been done in the past. Like placement of concrete underwater by the use of term i.e., without compaction. Inaccessible areas were concreted using such techniques. The production of such mixes often used expensive admixtures and very large quantity of cement. But such concrete was generally of lower strength and difficult to obtain. SCC is a high performance concrete that consolidates under its self-weight, and adequately fills all the voids without segregation, excessive bleeding or any other separation of materials, without the need of mechanical consolidation.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. To design and produce mix proportions for Self Compacting Concrete (SCC).
2. To evaluate the physical and chemical properties of SCC.
3. To obtain and compare the physical and chemical properties of self-compacting concrete.
4. To evaluate the physical properties and chemical properties of fly ash, sintered flyash aggregate and glass powder.
5. To observe the literature review of self-compacting concrete using different industrial and agricultural waste materials.
6. To determine the various tests such as slump flow, L-box, U- box, V-funnel etc.

## II. REVIEW OF LITERATURE

This Self Compacting Concrete (SCC) is a new generation of concrete, which has generated tremendous interest since its initial development in Japan by Okamura in the late 1980's in order to reach durable concrete structures. SCC has gained wide use for placement in congested reinforced concrete structures with difficult casting conditions. For such applications, the fresh concrete must possess high fluidity and good cohesiveness. SCC is considered as a concrete which can be placed and compacted under its self-weight with little or no vibration effort, and which is at the same time, cohesive enough to be handled without segregation or bleeding. It is used to facilitate and ensure proper filling and good structural performance of heavily reinforced structural members. SCC development is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. SCC is not affected by the skills of workers, the shape and amount of reinforcing bars or the arrangement of a structure and, due to its high-fluidity and resistance to segregation it can be pumped longer distances.

The concept of SCC was proposed in 1986 by Professor Hajime Okamura, but the prototype was first developed in 1988 in Japan, by Professor Ozawa at the University of Tokyo. SCC was developed at that time to improve the durability of concrete structures. Since then, various investigations have been carried out and SCC has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational mix design method and Self-Compactability, testing methods have been carried out from the viewpoint of making it a standard concrete. SCC is cast so that no additional inner or outer vibration is necessary for the compaction. It flows like "honey" and has a very smooth surface level after placing. With regard to its composition, SCC consists of the same components as Conventional concrete, which are cement, aggregates, and water, with the addition of chemical and mineral admixtures in different proportions. Usually, these concretes have higher workability, superior mechanical properties and/or greater resistance to chemical attack as compared to traditional concret.

SiriratJanjaturaphan and SupapornWansom (2010):They studied on, "The Pozzolanic Activities of Industrial Sugar Cane Bagasse Ash". They find out the chemical composition of the Sugarcane Bagasse Ash and compared them with the other pozzolanic material that is, rice husk ash and concluded that the SCBA is suitable for the partial replacement of cement.

Sagar W. Dhengare, Dr.S.P.Raut, N.V.Bandwal, AnandKhangan(2015):The utilization of industrial and agricultural waste produced by industrial processes has been the focus on waste reduction. Ordinary Portland cement (OPC) is partially replaced with finely sugarcane bagasse ash. The concrete mixtures, in part, are replaced with 0%, 10%, 15%, 20%, of SCBA respectively. In addition, the compressive strength, the flexural strength, the split tensile tests were determined. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. The tests were performed at 7, 28, 56 and 90 days of age in order to evaluate the effects of the addition SCBA on the concrete. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

K Meeravali, K V G D Balaji, T. Santhosh Kumar (2014):They studied on, "Partial replacement of Cement in Concrete with Sugarcane Bagasse Ash Behaviour in Hcl Solution". In this paper concrete cubes are casted with different percentages of Sugarcane Bagasse ash replaced with cement by weight (i.e. 0%, 5%, 10%, 15%, 20%, and 25%), and this cubes are exposed to 5% HCL environment. Compressive strength of cubes for 7days, 28 days and 60days are observed.

Dinakar et al. (2008) talked about the trial consequences of durability properties of self-compacting concretes with high measure of replacements of silica fume. Eight proportions of different strength grades were designed at wanted silica fume contents of 0, 10, 30, 50, 70 and85%, in comparison with five unique proportions of traditionally vibrated concretes at identical strength grades. The durability properties were concentrated through the estimation of porous voids, water absorption, corrosive assault and chloride permeation. The outcomes demonstrated that the high sum silica fume SCC showed higher penetrable voids and water absorption than the vibrated ordinary concretes of a similar strength grades. Nonetheless, in corrosive assault and penetrability contemplates the high volume silica fume SCC had essentially lower weight misfortunes and chloride ion diffusion.

D. Mukharjee (2011):Has Study made on "Utilization of SCBA". They described the various uses of SCBA in agriculture, construction, use of bagasse as fertilizers; in horticulture etc. their chemical and other fertilizing properties etc. also gave various options for utilizing bagasse ash in various fields.

MajidGholhakiet al analyzed the effect of using silica fume,

metakaolin, rice husk ash and fly ash with different ratios of 10% and 20% by weight of cement in self-compacting concrete containing magnetic water of 0.8 Tesla and compared with a mix prepared with tap water. He concluded that the dosage of super plasticizer is reduced significantly. Also the results of hardened SSC show an improvement in mechanical and durability properties of concrete. The usage of silica fume with ratio 20% by weight of cement in self- compacting concrete containing magnetic water, increases the compressive and splitting tensile strengths by 48% and 35% respectively and decreases amount of water absorption by 55% at the age of 28days

## III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Sintered flyash
5. Foundry sand
6. Silica fume

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Sintered flyash

Sintered Fly Ash (SFA) aggregate is an artificial, lightweight aggregate produced by processing industrial fly ash—a by-product of coal-based thermal power plants. Unlike raw fly ash, which is often used as a fine powder to replace cement, SFA is processed into durable, structural-grade coarse aggregate.

5. Foundry sand

Foundry sand is a high-quality silica sand used in the metal casting industry to create molds for molten metal. Once the sand can no longer meet the thermal and physical requirements for casting, it is classified as Waste Foundry Sand (WFS). In civil engineering, this is increasingly repurposed as a partial replacement for natural fine aggregate (sand) in concrete and mortar..

6. Silica fume

Thermal plants Silica fume is a byproduct in the reduce of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine element with a surface area on the order of 20,000 $m^2/kg$ when particular by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material particle. Micro silica is added to Portland cement concrete to enhance its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of a extremely fine particle to the cement paste mix as well as from the pozzolanic reactions between the micro silica and liberated calcium hydroxide in the paste..

7. Magnetic water

The water used throughout the experiment for preparation of concrete and for curing purposes is rampachodavarawater which is found to be in accordance with IS 456:2000 and] IS3025.

## IV. MIX DESIGN

Self-compacting concrete mix does not have any standardized test methods or specified mix design procedure to follow. It shall satisfy the total performance criteria for the concrete in both the fresh and hardened state. This section describes mix design methodology by the European Federation of National Association representing for concrete (EFNARC) technique and fine-tuned by using different guidelines to get the mix with the required fresh and hardened properties. Here we are designing self-compacting concrete having minimum compressive strength of 30MPa.

## V. RESULTS AND DISCUSSIONS

In this chapter results of various tests conducted on fresh SCC mixes and hardened concrete are listed and analyzed to check if the mixes prepared met the required standards.

### 5.1 FRESH CONCRETE TESTS

As per EFNARC guidelines the following are the preferred testing methods for various characteristics of SCC:

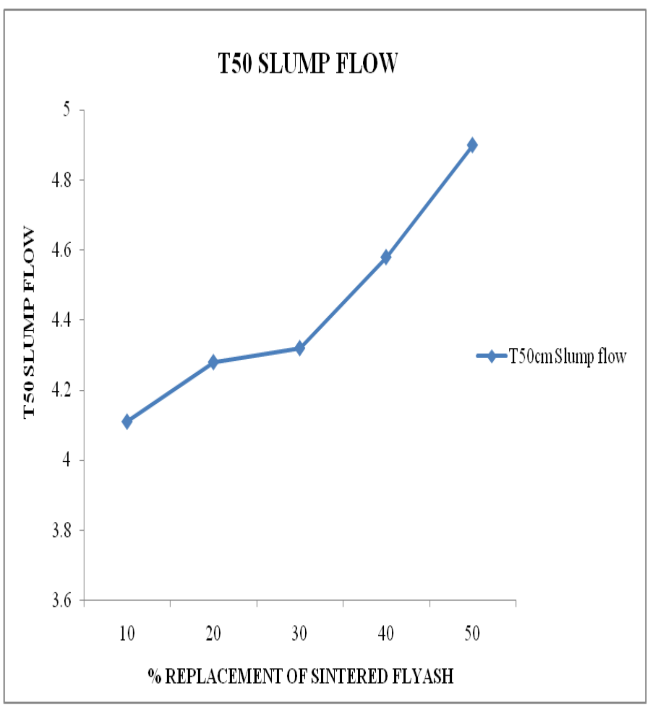


Fig 5.1 Variation in J-Ring test results with percentage replacement of sintered flyash aggregate

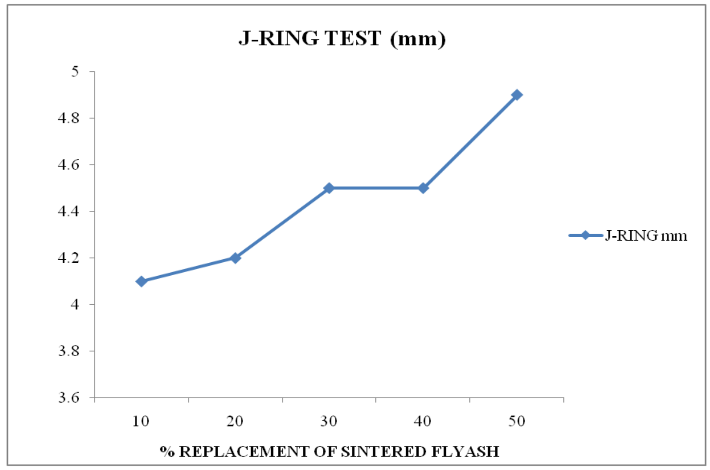


Fig 5.2 Variation in J-Ring test results with percentage replacement of sintered flyash

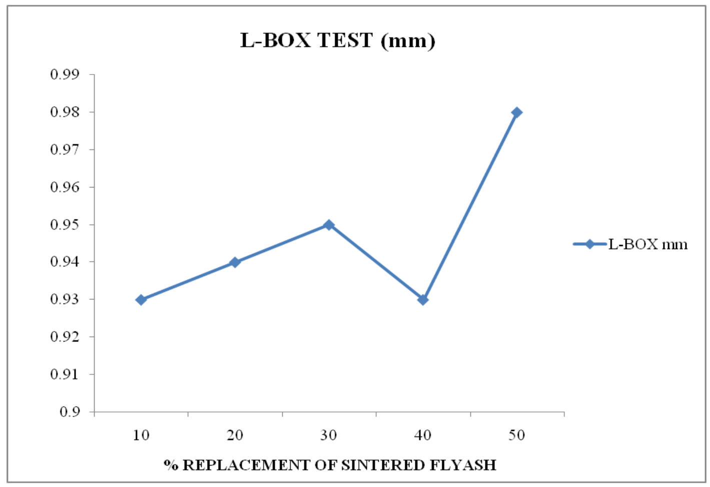


Fig 5.3 Variation in L-Box test results with percentage replacement of sintered flyash

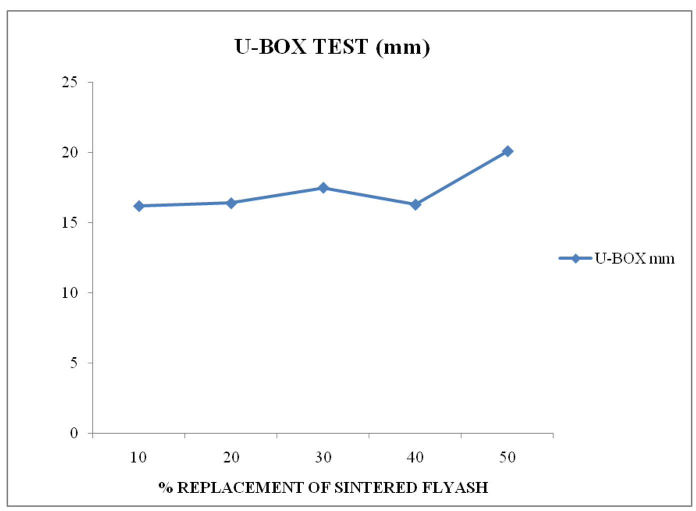


Fig 5.4 Variation in U-Box test results with percentage replacement of sintered flyash

5.2 SCC PREPARED WITH MAGNETIC WATER AND FOUNDRY SAND REPLACING FINE AGGREGATE:

This mix is prepared with magnetic water and Foundry sand replacing fine aggregates at 5, 10, 15, 20 and 25%. Various tests wereconducted on fresh concrete and following are the results obtained from the tests.

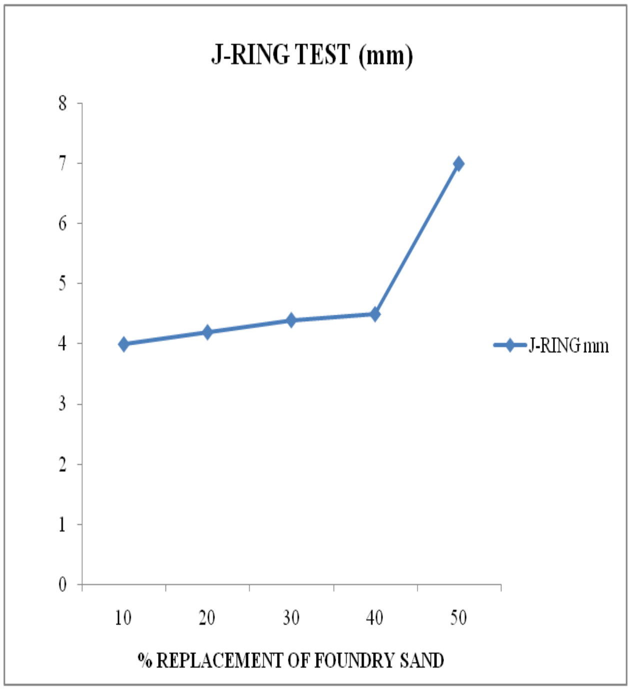


Fig 5.5 Variation in J-Ring test results percentage replacement of foundry sand

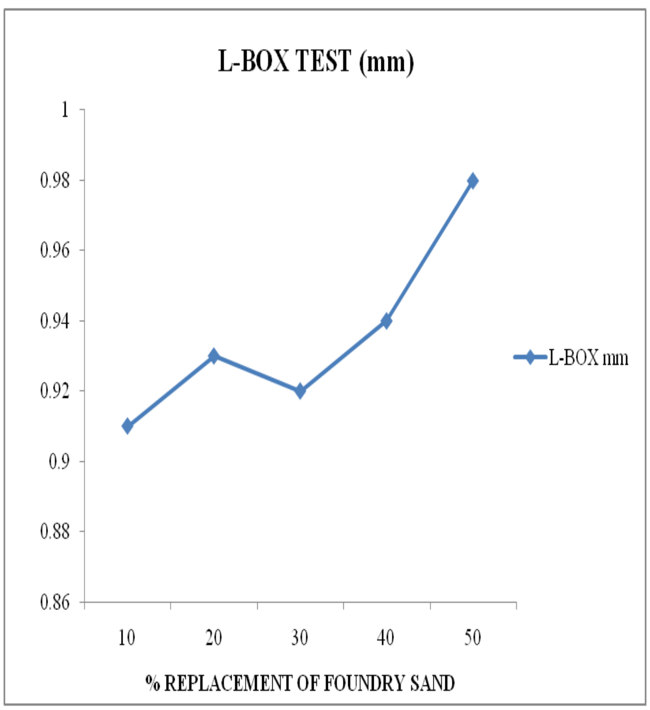


Fig 5.6 Variation in L-Box test results percentage replacement of foundry sand

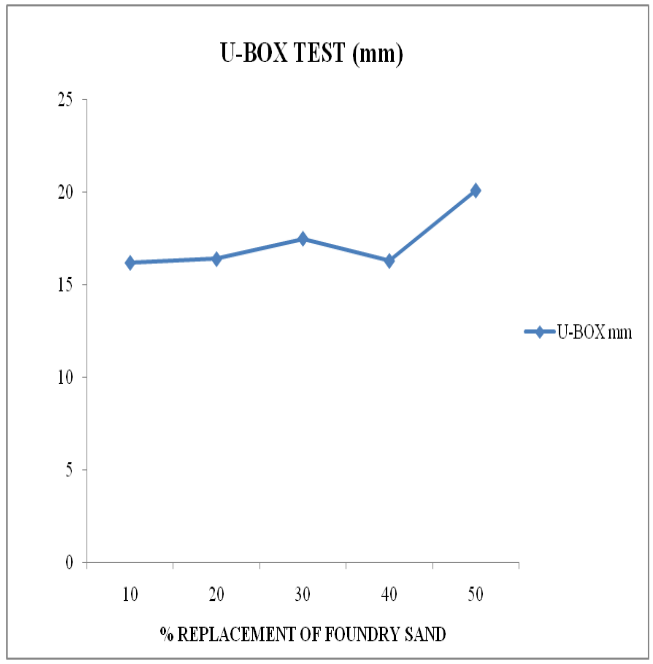


Fig 5.7 Variation in U-Box test results percentage replacement of foundry sand

5.3 SCC prepared with magnetic water and silica fume replacing cement:

This mix is prepared with magnetic water and Silica fume replacing cement at 10, 20, 30, 40 and 50%. Various tests were conducted on fresh concrete and following are the results obtained from the tests.

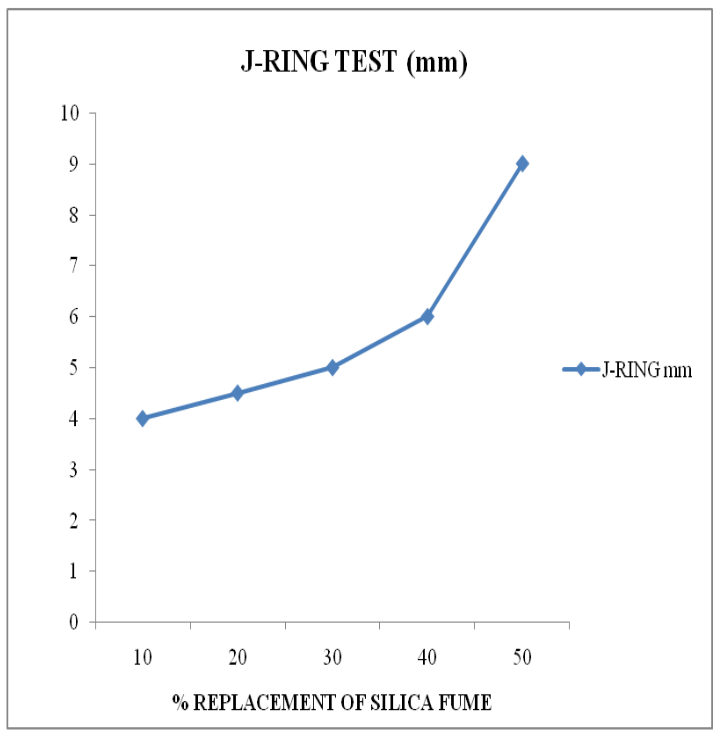


Fig 5.8 Variation in J-Ring test results percentage replacement of silica fume

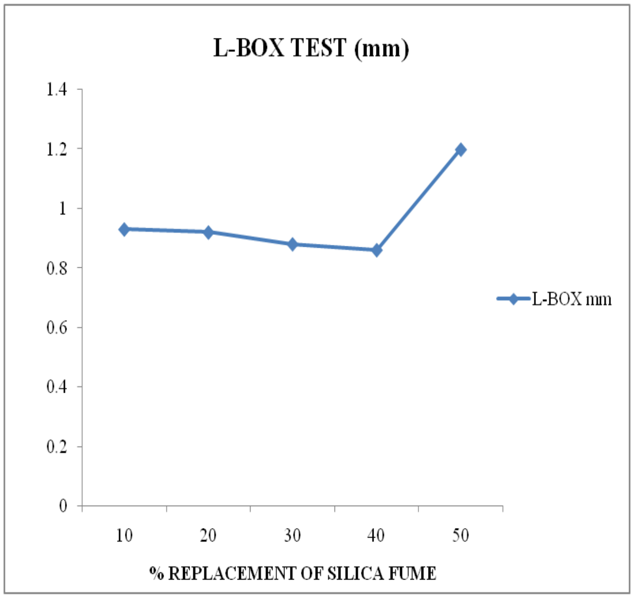


Fig 5.9 Variation in L-Box test results percentage replacement of silica fume

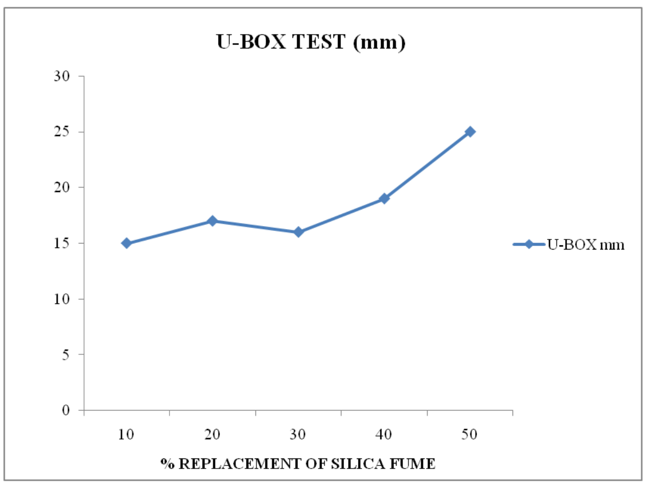


Fig 5.10 Variation in U-Box test results percentage replacement of silica fume

From Graph we can see that there is a significant increase in the flowability of SCC when prepared with Magnetic Water when compared to normal SCC. The graph also shows the effects of magnetic water on SCC mixes with varying replacement quantities.

In case of J-Ring all the replacement categories performed similar to M SCC mix except for the mix in which silica fume is partially replaced at 40% in cement.

In case of L-Box from the above graphs we can see that magnetic water improved the passing ability of SCC and had the best effect on SCC mix in which fine aggregate is partially replaced with sintered flyash.

In case of U-Box From the above graphs it is clear that magnetic water positivelyaffected all the mixes improving their filling and passing abilitiescompared to conventional SCC.

5.4 HARDENED CONCRETE TESTS:

Compressive Strength and Split Tensile Strength tests were conducted on SCC after proper curing at the ages of 7, 14 and 28 days.

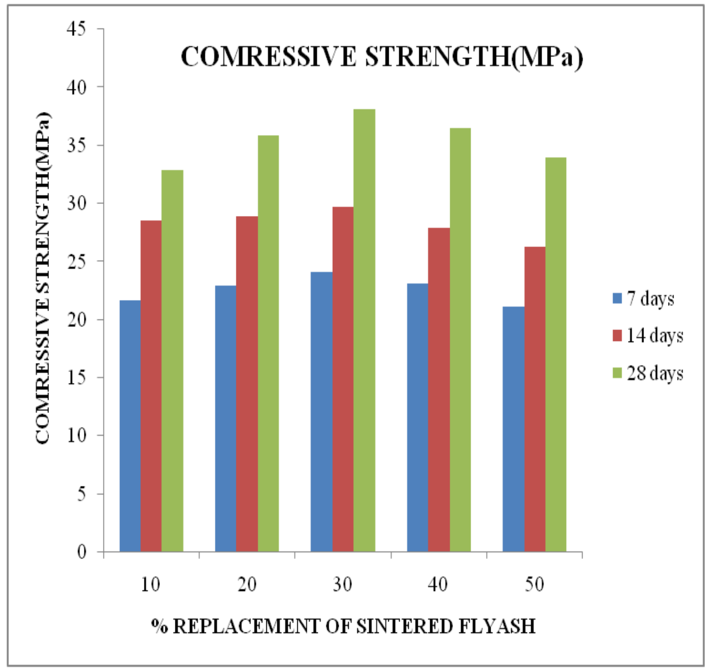


Fig 5.11 Variation in compressive strength results percentage replacement of sintered flyash

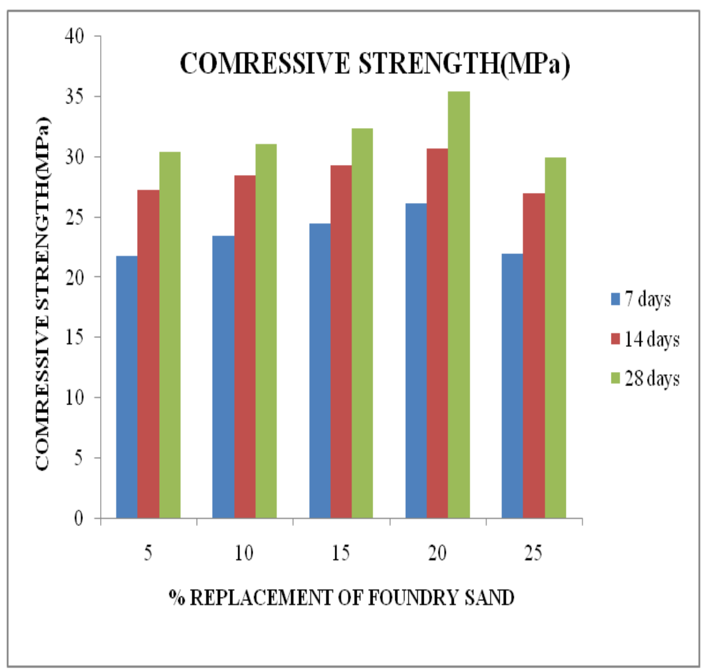


Fig 5.12 Variation in compressive strength results with replacement of foundry sand

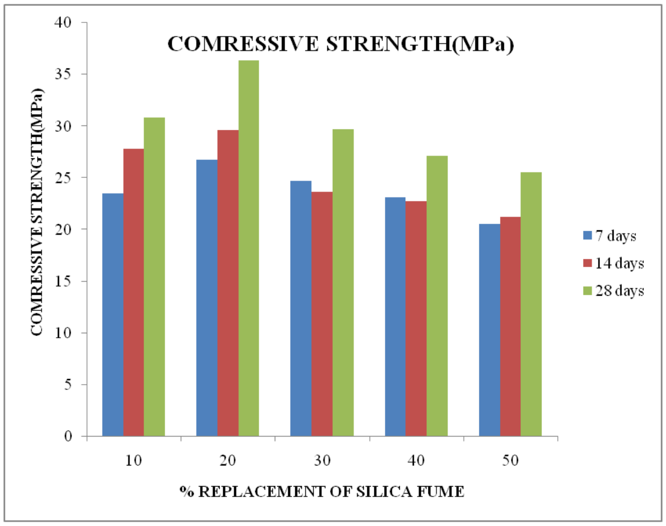


Fig5.13 Variation in compressive strength results with replacement of silica fume

## VI. CONCLUSIONS

This This study was carried out to investigate the influence of sintered flyash and foundry sand as replacing fine aggregate and silica fume replacing cement, on fresh and hardened properties of SCC. Following conclusions were inferred from the test results:

1. Effect of Magnetic Water on SCC

• Flowability: There is a significant increase in the flowability of SCC when prepared with magnetic water compared to conventional SCC.

• Passing and Filling Ability: Magnetic water positively affected all mixes, improving their filling and passing abilities. It also improved the passing ability of SCC, with the best effect observed in mixes where fine aggregate was partially replaced with sintered fly ash.

2. Sintered Fly Ash (SFA) Replacement

• Optimal Strength: When fine aggregate was replaced with sintered fly ash in magnetic water-treated SCC, the SFA30 mix (30% replacement) achieved the highest compressive strength (38.1 MPa) and split tensile strength (4.96 MPa) at 28 days.

3. Foundry Sand (FS) Replacement

• Optimal Strength: For SCC mixes with magnetic water and foundry sand, the FS20 mix (20% replacement) yielded the highest compressive strength (35.47 MPa) and split tensile strength (4.43 MPa) at 28 days.

4. Silica Fume (SF) Replacement

• Optimal Strength: Among the silica fume-replaced mixes using magnetic water, the SF20 mix (20% replacement) showed the best performance, reaching a compressive strength of 36.36 MPa and a split tensile strength of 4.54 MPa at 28 days.

• J-Ring Performance: In the J-Ring test, all replacement categories performed similarly to the M-SCC (magnetic water SCC) mix, with the exception of the 40% silica fume replacement, which behaved differently.

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