

Experimental Study on Hybrid Fibre Reinforced Concrete Property Using Silica Fume and Steel Slag

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ABSTRACT: Concrete is the most widely used everyday construction material. The advancement of concrete technology can reduce the utilization of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of silica fume and steel slag are generated in industries with an impact on environment and humans. Conventional concrete has two major defects: low tensile strength and a destructive and brittle failure. In an attempt to increase concrete ductility and energy absorption, fibre reinforced concrete has been introduced. The present investigation revealed the effect of using silica fume and steel slag as a partial replacement of cement and fine aggregate along with optimum percentage of polypropylene and steel fiber. For this study (M30) grade concrete is designed. Partial replacement of cement with silica fume will be made for varying percentages such as by weight 0%, 5 %, 10% and 15% .Along with a fixed amount of (30%) of steel slag as fine aggregate and with optimum fibre percentage as polypropylene (0.2%) and steel fiber (0. 8%) respectively. From this study the strength properties of the concrete have been investigated.

KEYWORDS: Silica Fume, Steel Slag, Hybrid Fibres, Compressive Strength, Split Tensile Strength, Flexural Strength

I. INTRODUCTION

Concrete is an important construction material consisting of ingredients which are mainly inert materials such as coarse and fine aggregate and cement as binding material. It is a composite material composed of coarse granular material enclosed in a hard matrix of material that fills the space among the aggregate particles and glues them together. It can be cast in diverse shapes. Today, concrete is the most extensively used man-made material. The concrete has high compressive strength, stiffness, low thermal conductivity, low combustibility and low resistance tensile strength, limited ductility and little resistance to cracking. Waste can be used as additive material in concrete, admixtures in cement and raw material in cement clinker, or as aggregates in concrete. Ordinary Portland cement (OPC) is acknowledged as the major construction material throughout the world. Most of the increase in cement need could be met by the use of supplementary cementing materials, in order to reduce the green gas emission. If alternative cheap cement can be produced locally, the demand for Portland cement will reduce. Industrial by-products being used as supplementary cement replacement materials and in recent times agricultural wastes are also being used as pozzolanic materials in concrete. When pozzolanic materials are fused to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms extra calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete. Therefore, for overcoming of this massive problem, the artificial manufactured aggregates viz., steel slag and silica fume generated from the industrial wastes can be utilized as an alternative. Concrete is a delicate material with low tensile strength and low strain capacity that result in low resistance to cracking. To improve such properties, fibre reinforced concrete has been developed. Fibres are intended to improve tensile strength, flexural strength, toughness and impact strength ,to modify failure mode by means of improving post-cracking ductility, and to control cracking .Tensile strength of the composite, related more to

the stress at which matrix develops a macro-crack, will not be different much for most conventional fibre reinforced cementitious materials.

II. LITERATURE REVIEW

Faseyemi Victor Ajileye (2012) in Investigations on Microsilica (Silica fume) as Partial Cement Replacement in Concrete carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete. This study investigated the strength properties of silica fume concrete as partial cement replacement in concrete. The replacement levels of cement by silica fume were selected as 5%, 10%, 15%, 20%, and 25% for M30 grade of concrete. The test results indicate that replacement up to 10% with silica fume leads to an increase in compressive strength for M30 grade of concrete. It was concluded that 10% is the optimum percentage of replacement. Ankit Sharma et al (2013) in The Structural Behaviour of Fibrous Concrete using Polypropylene Fibres investigated the effect of variation of polypropylene fibers ranging from 0.1% to 0.4% along with 0.8% steel fibers on the behaviour of fibrous concrete. The mechanical properties of the concrete such as compressive and tensile strength were investigated. The result show that the addition of polypropylene fiber on concrete had a little effect on the compressive strength. The maximum gain in compressive strength was achieved for 0.2% polypropylene fiber.

III. MATERIAL DETAILS

Cement

Ordinary Portland cement of grade 53 confirming to IS: 12269-1987 was used in this experimental study.

Table.1. Properties of cement

Sl. No	Property	Test Results
1	Normal Consistency	32%
2	Specific gravity	3.15
3	Fineness	5%

Fine Aggregate

Locally available natural sand as per IS: 383-1987 was used.

Table.2. Properties of fine aggregate

Sl. No	Property	Test Results
2	Specific gravity	2.57
3	Fineness	4.93

Coarse Aggregate

Locally available crushed stone aggregates of size 20 mm is used in this analysis.

Table.3. Properties of Coarse Aggregate

Sl. No	Property	Values
1	Specific Gravity	2.74
2	Fineness modulus	7.20

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Silica Fume

The colour of silica fume varies from light grey to dark grey. The chemical composition of silica fumes consists of silicon dioxide (96%), aluminium oxide (0.1%), iron oxide (0.6%), calcium oxide (0.1%) and magnesium oxide (0.2%).

Table.4. Properties of Silica Fume

Sl. No	Property	Values
1	Bulk Density	574 (Kg/m ³)
2	Size	0.1 Micron
3	Specific Gravity	2.1
4	Surface Area	20,000 m ² /kg

Steel Slag

It is a by-product produced during the smelting and refining process of steel. The colour of slag is like a black particle with granular material having a similar particle size range of sand.

Table.5. Properties of Steel Slag

Sl. No	Property	Values
1	Specific Gravity	2.74
2	Fineness modulus	2.96

Polypropylene Fibre

Polypropylene fibre is obtained as continuous mono – filaments with circular cross section. It is a synthetic carbon polymer .Polypropylene fibres are tough with low tensile strength and modulus of elasticity. A blend of steel with polypropylene fibre can arrest plastic cracking in fresh concrete and drying shrinkage cracking in hardened concrete. It is also to improve the post-cracking toughness.

Table.6.Properties of Polypropylene fibre

Sl. No	Property Table	Result
1	Length	50mm
2	Diameter	0.5mm

Steel Fibre

Steel fibres have equivalent diameters of 0.15mm to 2 mm and length from 7 mm to 75 mm. Generally the aspect ratio ranges from 20 to 100. It poses high tensile strength ranging from 0.5 - 2.0 GPa and with modulus of elasticity of 200 GPa.

Table .7.Properties of Steel fibre

Sl. No	Property Table	Result
1	Length	42mm
2	Diameter	1.0mm

IV. EXPERIMENTAL RESULTS

COMPRESSIVE STRENGTH RESULTS

Table.8. Average Compressive strength of M30 grade (30% Steel Slag, 0.8% Steel Fibre and 0.2% Polypropylene Fibre)

SILICA FUME%	7 DAYS (N/mm ²)	14 DAYS (N/mm ²)	28 DAYS (N/mm ²)
0%	24.18	29.76	37.20
5%	26.07	32.09	40.12
10%	28.14	34.64	43.30
15%	26.79	32.98	41.23

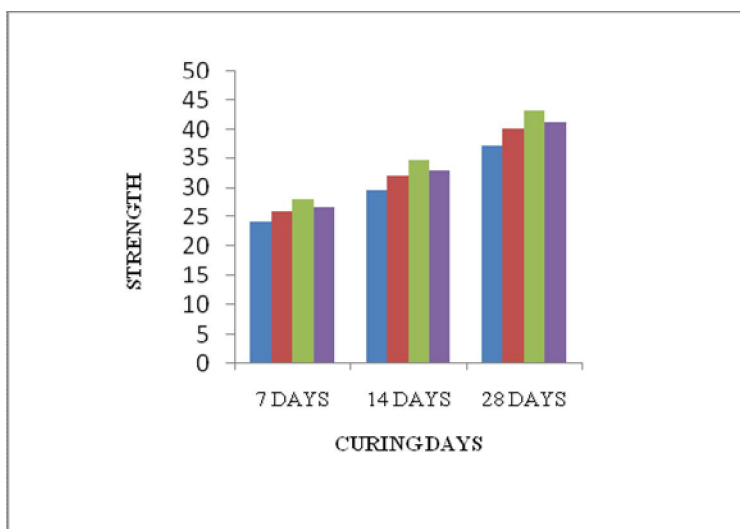


Fig.1. Compressive strength results

From the graph , it can be seen that the compressive strength of the concrete mixes with 5%,10%, and 15% cement replacement with silica fume were higher than the normal mix at all ages. From the above table, the highest compressive strength was obtained at 10% replacement of cement, which was found about 26.79 Mpa compared with 24.18 Mpa for the control mixture at 7days. This means there is an increase in the strength of almost 11.20% compared to the control mix at 7 days. Also it was found that there is an increase in strength of almost 18% compared to the control mix at 14 days. Increase in strength was from 29.76 Mpa to 34.64Mpa for the control mixture at 14 days. The increase in the strength of 28 days was almost 16.31% compared to the control mix. It was found that increase in strength was about 41.23 Mpa compared with 37.20Mpa for the control mixture at 28 days.

SPLIT TENSILE STRENGTH RESULTS

Table.9. Average Split Tensile strength of M30 grade (30% Steel Slag, 0.8% Steel Fibre and 0.2% Polypropylene Fibre)

SILICA FUME %	7 DAYS (N/mm ²)	14 DAYS (N/mm ²)	28 DAYS (N/mm ²)
0%	1.82	2.24	2.80
5%	2.18	2.68	3.36
10%	2.53	3.12	3.90
15%	2.32	2.86	3.59

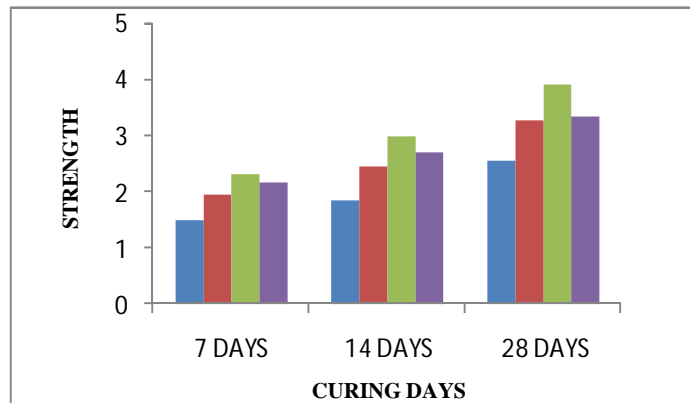


Fig.2. Split tensile strength results

From the above graph , it can be seen that the split tensile strength of the concrete mixes with 5%,10%, and 15% cement replacement with silica fume were higher than the normal mix at all ages. From the above table ,the highest compressive strength was obtained at 10% replacement of cement, which was found about 2.53 Mpa compared with 1.82Mpa for the control mixture at 7days. This means there is an increase in the strength of almost 20% compared to the control mix at 7 days. Also it was found that there is an increase in strength of almost 32% compared to the control mix at 14 days. Increase in strength was from 3.12 Mpa to 2.24Mpa for the control mixture at 14 days. The increase in the strength of 28 days was almost 44% compared to the control mix. It was found that increase in strength was about 3.59 Mpa compared with 2.80Mpa for the control mixture at 28 days.

FLEXURAL STRENGTH RESULTS

Table.10. Flexural strength of M30 grade (30% Steel Slag, 0.8% Steel Fibre and 0.2% Polypropylene Fibre)

SILICA FUME %	FLEXURAL STRENGTH (N/mm ²)
0%	4.10
5%	5.47
10%	6.06

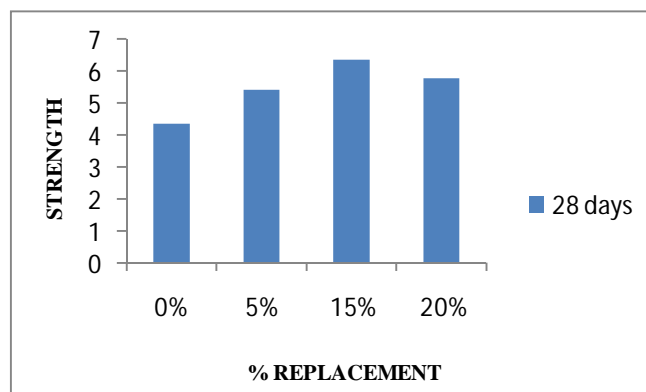


Fig.3. Flexural strength results

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

From graph, it has been observed that there is increase in flexural strength with replacement of cement by 10% silica fume and then decreases beyond 10%. From table, it has been observed that the 28 days highest tensile strength was obtained at 10% replacement, which was found about 6.06Mpa compared with 4.10Mpa for the control mixture at 28days.

IV. CONCLUSION

The following conclusions can be drawn from the present investigation .Due to the addition of silica fume in concrete, compressive strength, split tensile strength and flexural strength of replaced concrete were higher than the plain concrete specimens at all the stages. The maximum compressive strength, split tensile strength, flexural strength value occurs at 10% replacement ratio of silica fume and then it declines beyond 10% replacement ratio. The results of this research were encouraging, they show that using of steel slag as fine aggregate in concrete has no negative effects on the short term properties of hardened concrete. So steel slag meets the requirements to be used in concrete mixes. The optimum percentage of hybrid fiber addition is 1.0%. Addition of fibers up to 1.0% gives best results in all strength parameters compare to other mix proportion.

REFERENCES

- [1] Gambhir M. L., 1986, Concrete technology, Tata McGraw Hill publishing company Ltd., New Delhi.
- [2] Faseyemi Victor Ajileye, "Investigations on micro silica (silica fume) as partial cement replacement in concrete", Global Journal of researches in engineering Civil And Structural engineering, Volume 12, Issue 1, Version 1.0, January 2012.
- [3] P.S.Kothai, Dr.R.Malathy, "Utilization of Steel Slag in Concrete as a Partial Replacement Material for Fine Aggregates", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 4, April 2014.
- [4] M.Soundar Rajan, "Study on strength properties of concrete by partially replacement of sand by steel slag", International Journal on Engineering Technology and Sciences, Volume 1, Issue 6, October 2014.
- [5] Er. Darole J. S., Prof. Kulkarni V.P, "Effect of hybrid fiber on mechanical properties of concrete", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 4, Jul-Aug 2013.
- [6] Sumeet Thakur, "Strength modification of steel slag concrete due to silica fume", International Journal of Civil Engineering (SSRG-IJCE) – EFES April 2015.
- [7] Sudheer Jirobe, Brijbhushan.S, "Experimental investigation on strength and durability properties of hybrid fiber reinforced concrete", International research journal of engineering and technology (IRJET)", Volume 2, Issue 5, Aug-2015.
- [8] Devaraj P Kumbar, V. D Gundakalle, "A study on effect of silica fume on the mechanical properties of steel slag aggregate concrete", International journal of structural and civil engineering research , Vol. 2, No. 1, February 2013.