Experimental Investigation on the Effect of Steel fiber and Silica Fume based High Strength Concrete with M- Sand

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Abstract:-A huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced using natural sand from river beds as fine aggregates. Decreasing natural resources poses the environmental problem and hence the government on sand quarrying resulted in scarcity and increase in its cost. In recent trends, manufactured sand is used as an alternative to natural river sand. This paper presents the effect of steel fiber in concrete under full replacement of natural sand with manufactured sand by reducing the consumption of natural sand. The addition of steel fiber is done at an aspect ratio of 30. The steel fibers are added at 1%, 1.5% and 2%. The addition of steel fiber and silica fume shows an increase in compressive strength, splitting strength and flexural strength.

Key words: ***Steel Fiber, Silica Fume, M-Sand, compressive strength, split tensile strength***.

I. INTRODUCTION

1.1 General

Concrete technology has developed at a fast pace indeed during the last two decades and material performance has been significantly improved. Normal concrete is widely used because of the advantages it possesses such as low cost and ubiquitous availability [2].Also, it is widely used construction material for various types of structures due to its structural stability and strength. The materialswhich are required for producing huge quantities of concrete comes from the earth's crust. Therefore, the resources are depleted every year and creates ecological strain. The human activities on the Earth produces solid waste in large quantities of over 2500/MT per year, that includs industrial wastes, agricultural wastes and wastes from rural and urban societies. The fly ash, blast furnace slag, rice husk, silica fume and demolished construction materials are the most prominent solid waste materials used. Portland cement is commonly utilized in the construction sector, the concrete hat is manufactured from this cement has some features. It is strong in compression; however, it is brittle in tension [12]. To meet the growing demand for cement and concrete, the partial cement replacement method is done. When the industrial byproducts are used as partial replacement for the energy intense Portland cement, which results in saving substantial energy and cost.In India, the conventional concrete is produced using natural sand from river beds as fine aggregates. Decreasing natural resources poses the environmental problem and hence the government on sand quarrying resulted in scarcity and increase in its cost. In recent trends, manufactured sand is used as an alternative to natural river sand. It is generally accepted that the ductility of highstrength concrete can be improved by introducing various types of fibres, especially steel fibre, into the mixtures [13]. The scope of the authors was specifically mention that the evaluation of concrete shear strength will get enhance by the addition of fibers [11]. Construction of high rise buildings, long span bridges and off-shore structures has made steel fibres important in improving the properties of concrete such as strength, toughness and energy absorption capacity [14]. Also, steel fiber addition was found to improve the durability performance of ordinary reinforced concrete [5]. By adding silica fume, more space-frame and high strength concretes can be obtained because the interfacial transition zone of the aggregate paste is reduced [4]. Silica fume consists of ultra fine($< 1\mu m$) particles and increases the bond strength between cement paste and aggregate by making the interfacial zone more dense [3]. The optimal silica fume content is in between 20% and 30% by the experimental program [15]. This paper presents the effect of steel fiber in concrete under full replacement of natural sand with manufactured sand. The steel fibers are added at 1%, 1.5% and 2%. The addition of steel fiber shows an increase in compressive strength, splitting strength and flexural strength.

II. MATERIALS AND METHODOLOGY

This chapter briefly explains the methodology adopted in this project. It has been already discussed in the previous chapter about the manufactured sand, the introduction of micro silica and steel fiber in concrete and their advantages in construction industry. The following methodology has been adopted to achieve the objective of this project.

2.1 Cement

Ordinary Portland cement will be used throughout this investigation. As we know the most widely used cementations ingredient in present day is concrete. The function of cement is first, to find the fine aggregate together and second to fill the voids in between fine aggregate and coarse particles to form a compact mass. The constitutesof cement is only about 10% of the volume of the concrete mix which is the active portion of the binding medium and is scientifically controlled ingredient of concrete. Ordinary Portland Cement (OPC) 53 Grade conforming to Indian Standard IS 12269-2013[8] was used. The physical properties of cement are shown in the Table:1

2.2 Coarse aggregate

Coarse aggregate is used mainly for providing bulk to the concrete to the strength of concrete depends also on the strength of the coarse aggregate and hence selection of suitable aggregate is very essential. It should be hard, strong, dense, durable, rough and free from salt and organic matters. Well graded aggregate provided denser concrete with less voids. The physical properties of coarse aggregate are shown in the Table:1

2.3 M sand

M Sand is used instead of river sand for concrete construction. Manufactured sand are produced by crushing hard granite stones. These crushed sand is of cubical shape with grounded edges, washed and graded to as construction material. The size of manufactured sand is in between 4.75mm to 150 micron.The physical properties of M sand are shown in the Table:1

2.4 Silica fume

Silica fume is a byproduct of producing silicon metal or Ferro Silicon alloys. The silica fume used as concrete is one of the most beneficial method. It is the very reactive pozzolanebecause of its chemical and physical properties. To get high strength and durable concrete by the addition of silica fume in them. Silica is 100 to 150 times smaller than a cement particle it can fill the voids created by free water in the matrix this friction is called as particle packing. Silica fume reduces the number and size of capillaries that would normally enable contaminates to infiltrate the concrete. The physical properties of silica fume are shown in the Table:1

2.5 Steel fibres

Steel fibersthat are used in reinforcing concrete are describedwith short, discrete length of the steel which has an aspect ratio in the range of 20-100, with any cross section and which are sufficiently small to be randomly dispersed in an unhardened concrete mixture using usual mixing procedures. Steel fiber reinforced concrete （SFRC） has the ability of excellent tensile strength, flexural strength, shock resistance, fatigue resistance, ductility and crack arrest.

Table:1 Physical properties of materials

Material	**Property**	**Value**
Silica Fume	Specific gravity	2.2
	Fineness	13%
M-Sand	Specific gravity	2.615
	Fineness modulus	3.52
	Water absorption	1.5%
Coarse aggregate	Specific gravity	2.57
	Fineness modulus	4.08
	Water absorption	0.5%
	Impact value	4.8%
Cement	Specific gravity	3.13
	Fineness modulus	6%
	Consistency	34%

III. RESULTS AND DISCUSSIONS

3.1 Compression Test:

Determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm. the results obtained from this test will be helpful in increasing the bearing capacity of foundations, Decreasing the undesirable settlement of structures, Control undesirable volume changes, Reduction in hydraulic conductivity, Increasing the stability of slopes and so on.Compressive strength on cubes for 7 days,14 days and 28 days are given in the table 3.1,3.2 and 3.3. The compression testing machine was shown in the fig.3.1.

The compressive strength was calculated based on the formula,

$$\text{Compressive strength} = P/A \quad N/mm^2$$

where, P - load in N, A - Area of cube in mm^2

Fig.3.1 Compression testing machine

Table : 3.1 Compressive strength on cubes 7 days

S .no.	**Specimen type**	**%Replacement of silica fume**	**Average strength (N/mm^2)**
1.	Cube	0	30.5
2.	Cube	10	32.1
3.	Cube	20	35.5
4.	Cube	30	32.4

Table : 3.2 Compressive strength on cubes 14 days

Sl.no.	Specimen type	% Replacement of silica fume	Average strength (N/mm^2)
1.	Cube	0	41.1
2.	Cube	10	43.7
3.	Cube	20	45.9
4.	Cube	30	43.6

Table : 3.3 Compressive strength on cubes 28 days

Sl.no.	Specimen type	% Replacement of silica fume	Average strength (N/mm^2)
1.	Cube	0	50
2.	Cube	10	53.5
3.	Cube	20	55.1
4.	Cube	30	53.2

The Table:3.1, 3.2 & 3.3 shows about average strength of concrete at 7,14 and 28 days with the replacement of silica fume at various percentages. In this study, it is observed that about 20% replacement of silica fume provides maximum compressive strength with the addition of steel fibres.

3.1.1 Comparative study

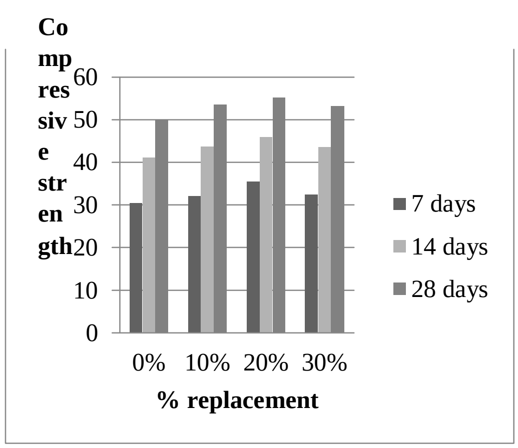

Fig.3.2 Variation of compressive strength with the replacement of cement by silica fume

3.2 split tensile strength test

Split tensile strength was carried out by using Compression testing machine by casting cylinders of 15cm x 30cm size mix for M40 grade of concrete. To evaluate the splitting strength initially, Clean the bearing surface of the testing machine.Then, thecylindrical specimen is placed in a manner that the longitudinal axis is perpendicular to the load. Apply the load gradually till the specimen fails. Finally, Record the maximum load. Tensile strength on cylinders for 7 days,14 days and 28 days are given in the table 3.4,3.5 and 3.6. The Calculation of Splitting Tensile Strength of the specimen is made by using the formula,

Split tensile strength, $f_t = (2P/\pi DL)$

Where,

P - Compressive load at failure in N
D - Diameter of cylinder in mm
L - Length of cylinder in mm

Table : 3.4 Split Tensile Strength for 7 Days

Sl.no.	Specimen type	% Replacement of silica fume	Average strength (N/mm^2)
1.	Cylinder	0	2.15
2.	Cylinder	10	1.89
3.	Cylinder	20	2.15
4.	Cylinder	30	1.83

Table : 3.5 Split Tensile Strength for 14 Days

Sl.no.	Specimen type	% Replacement of silica fume	Average strength (N/mm^2)
1.	Cylinder	0	2.8
2.	Cylinder	10	3.1
3.	Cylinder	20	3.38
4.	Cylinder	30	3.03

Table : 3.6 Split Tensile Strength for 28 Days

Sl.no.	Specimen type	% Replacement of silica fume	Average strength (N/mm^2)
1.	Cylinder	0	3.15
2.	Cylinder	10	3.5
3.	Cylinder	20	3.9
4.	Cylinder	30	3.56

The Table:3.4, 3.5 & 3.6 shows about average strength of concrete at 7,14 and 28 days with the replacement of silica fume at various percentages. In this study, it is observed that about 20% replacement of silica fume provides maximum tensile strength with the addition of steel fibres.

3.2.1 Comparative study

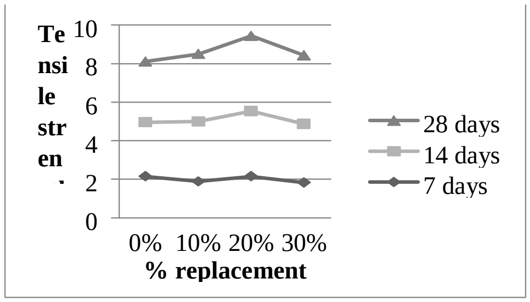

Fig.3.3 Variation of tensile strength with the partial replacement of cement by silica fume

IV. CONCLUSION

Initially the literature survey has been made regarding various materials used such as steel fiber and silica fume. After the completion of literature survey the flow chart for methodology has been prepared. The physical properties of materials are also determined. ***** Increase in compressive strength is noticed. ***** Split tensile strength also increased with the addition of steel fiber and silica fume.

*Formation of cracks and crack width has been reduced than normal concrete. *Air voids gets removed by adding silica fume.

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