An Experimental Study on Mechanical Properties of Concrete With Steel And Glass Fibre, Silica & Fly Ash

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Abstract- *Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space and because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns.*

A review of literature regarding the requirements of ingredient-materials for producing high strength concrete along with the results of an experimental study on achieving HSC has been reported in this paper. Use of quality materials, smaller water-cement ratio, larger ratio of coarse aggregate (CA) to fine aggregate (FA), smaller size of coarse aggregate, and suitable admixtures with their optimum dosages are found. In the experimental study, the targeted strengths of concretes were from 30 MPa to 50 MPa. A larger ratio of CA to FA (1.81 except one mix of 1.60) was considered in the study.

Additional to this fibre inclusion, about 1% & 2% silica fume, glass fibre and steel fibre 5% & 10% of mineral admixture such as Fly ash is used. Slump test was carried out for each mix in the fresh state. 28-day compressive strength and tensile strength were performed in the hardened state. Various numerical analyses were carried out to quantify the determined mechanical properties and to describe the effects of fibre inclusion on these mechanical properties.

Keywords- Glass fibre, Steel fibre, silica fume, Fly ash, Mechanical Properties

I. INTRODUCTION

Concrete is the most widely used man-made construction materials in the world. Slightly more than a ton of concrete is produced each year for every human being on the planet Fundamentally, concrete is economical, strong, and durable. Although concrete technology across the industry continues to rise to the demands of a changing market place. The construction industry recognizes that considerable improvements are essential in productivity, product performance, energy efficiency and environmental performance. The industry will need to face and overcome a number of institutional competitive and technical challenges. One of the major challenges with the environmental awareness and scarcity of space for land-filling is the wastes/byproducts utilization as an alternative to disposal. Throughout the industrial sector, including the concrete industry, the cost of environmental compliance is high. Use of industrial by-products such as foundry sand, fly ash, bottom ash and slag can result in significant improvements in overall industry energy efficiency and environmental performance.

The consumption of all type of aggregates has been increasing in recent years in most countries at a rate far exceeding that suggested by the growth rate of their economy or of their construction industries. Artificially manufactured aggregates are more expensive to produce, and the available source of natural aggregates may be at a considerable distance from the point of use, in which case, the cost of transporting is a disadvantage. The other factors to be considered are the continued and expanding extraction of natural aggregates accompanied by serious environmental problems. Often it leads to irremediable deterioration of the country side. Quarrying of aggregates leads to disturbed surface area etc., but the aggregates from industrial wastes are not only adding extra aggregate sources to the natural and artificial aggregate but also prevent environmental pollution.

Over 70% of the total by-product material consists of sand because moulds usually consist of molding sand, which is easily available, inexpensive, resistance to heat damage, easily bonded with binder, and other organic material in moulds.

Cement which is one of the ingredients of concrete plays a great role, but it is most expensive. Therefore requirements for economical and more environmental-friendly cementing materials have extended interest in other cementing material that can be used as a partial replacement of the normal Portland cement. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry..When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties..

II. LITERATURE RIEVIEW

Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space, because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical but also helps in reducing disposal concerns. Natural sand is getting depleted due to large scale construction. So it is important to find out an alternative of natural sand, which can be used as partial replacement of natural sand (fine aggregate). There are several types of waste material/byproducts, which have been explored for possible use in concrete as a partial replacement of fine aggregate. Such types of materials are coal bottom ash, recycled fine aggregate, sewage sludge ash, stone dust and glass cullet, and waste foundry sand, etc.

Ezeldin A. S. and Balaguru, P.N."BOND BEHAVIOR OF NORMAL AND HIGH STRENGTH FIBER REINFORCED CONCRETE" Sep-Oct 1989 Experimental results on the bond behavior of normal and high-strength concrete made with and without fibers are reported. A total of 18 mix proportions were investigated. The fiber lengths and reinforcement bar sizes were 30, 50, and 60 mm and 3, 5. 6, and 8 (9, 16, 19 and 25 mm) respectively. The bond tests were conducted using a modified pullout test in which the concrete surrounding the bar was in uniform tension. Addition of silica fume results in higher bond strength but causes brittle bond failure. Fibers can be used to improve the ductility to a considerable extent. The slip (relative movement between the bar and the concrete) at maximum bond load increases with increase in fiber content. Post peak behavior is improved substantially by the fibers.

"Toughened Behavior and Mechanisms of Synthetic Fiber Reinforced Normal Strength And High Strength Concrete" in Fiber Reinforced Cements and Concretes: Recent Developments, Papers presented at the International Conference held September 18-20 1989 at the School of Engineering, University of Wales College of Cardiff, UK; Ed. by R. N. Swami and B. Barr; Elsevier Applied Science, London, 1989, pp 420-433

Celik et al. (1996), Sahu et al. (2003), Tripathy and Barai (2006) and Shi -cong et al (2009) have reported the use of stone dust (SD) as partial replacement of fine aggregate. Celik et al. (1996) reported that increasing the dust content up to 10% improve the compressive strength and flexure strength of concrete. Sahu et al. (2003) concluded that there is significant increase in compressive strength, modulus of rupture and split tensile strength of concrete when sand was partially replaced by stone dust up to 40 percent. Tripathy and Barai (2006) investigated the compressive strength of mortar made with crusher stone dust (CSD) under normal, hot water curing and autoclaving curing. They concluded that up to 40% cement replacement by crusher stone dust and autoclave curing of mortar mix, gave same or better compressive strength than the control mortar mix (without CSD and normal curing).

Khatib (2005), Rakshvir and Barai (2006), Evangelista et al. (2007), Rao et al. (2007) and Soutsos et al. (2011) studied the properties of concrete incorporating recycled aggregate. Khatib (2005) used recycled fine aggregate to study mechanical properties. The fine aggregate in concrete was replaced with 0, 25, 50 and 100% recycled aggregate. Beyond 28 days of curing, the rate of strength development in concrete containing recycled aggregate was higher than that of the control mix indicating cementing action in the presence of fine recycled aggregate.

Mohammed Nadeem & Arun D.Pofale (2012) in their paper “Utilization of industrial waste slag as aggregate in concrete applications by adopting Taguchi’s approach for optimization” represented the experimental results of replacing fine and coarse aggregate with crystalline and granular waste slag.

III. EXPERIMENTAL PROGRAM

The chapter describes the details of experimental programs for the measurements of fresh properties, strength properties (compressive strength, splitting tensile strength and modulus of elasticity) with varying percentages of waste foundry sand as partial replacement of fine aggregates.

MATERIALS USED

Cement

Portland pozzolana (fly ash based) cement was used. It was tested as per Indian standard specification (BIS-1489 part 1:1991). Test results are given in Table 3.1.

Table 3.1: Physical Properties of Portland Pozzolana Cement

Physical Properties	**BIS-**	**Test Result**
Soundness	10.0 Max	1.6
Setting time (mm)		
Initial	30 Min	32
Final	600 Max	572
Compressive Strength (Mpa)		
3 days	16	18
7 days	22	36
28 days	33	47.8
Specific gravity	-	3.05
Standard Consistency (%)	-	35 %
Drying Shrinkage	0.15 Max	0.024

Fine aggregates

Locally available natural sand with 4.75mm maximum size was used as fine aggregate. Its physical properties and sieve analysis are given in Tables 3.2 and Table 3.3 respectively.

Table 3.2: Physical Properties of Fine Aggregate

S.No	**Properties**	**Observed**
1	Bulk Density (Loose), Kg/m^3	1690
2	Bulk Density (Compacted),	1890
3	Specific Gravity	2.68
4	Water Absorption (%)	1.2
5	Moisture content (%)	0.16
6	Material finer than 75μ (%)	0.5

Coarse aggregates

Crushed stone with maximum 12.5mm graded aggregates (nominal size) were used. Physical properties and sieve analysis results are given in Tables 3.4 and Table 3.5 respectively.

Table 3.3: Physical Properties of Coarse Aggregates

Properties	Observed Values
Maximum size (mm)	12.5
Bulk Density (kg/m^3)	1650
Specific Gravity	2.7
Total Water Absorption (%)	1.14
Moisture content (%)	Nil

Steel Fibers

Steel fibers are used for crack control, to replace secondary reinforcement, which is also used for this purpose. The increase in toughness can prevent or minimize cracking due to temperature changes, relative humidity etc. Steel fiber inclusion also increases the resistance to dynamic loading.

Glass fibers

Glass fiber reinforced concrete consists of 4-4.5 per cent by volume of glass fibers. Basically concrete material utilizes glass fibers for the reinforcement, as a substitute of steel. The glass fibers are normally resistant to alkali. Alkali resistant glass fiber is used extensively since it has a greater resistant to the environmental effects. GFRC is a combination of cement, glass fibers, and polymers. It is normally cast in thin sections. As the fibers are not rusted like steel, protecting concrete coat is not necessary for the prevention of rust.

Fly ash as Admixture

Fly ash is normally produced from burning anthracite or bituminous coal, usually less than 5% of Calcium oxide by thermal plants. It finely divided residue resulting from the combustion of pulverized coal and transported by the flue gases of boilers fired by pulverized coal. Fly ash particles can be spherical and rounded, sub-rounded, irregular and angular. Fineness is probably a single important physical characteristic which influences the activity of fly ash more than any other physical factor. The surface area is found to range between 3627 and 6091 Cm2/gram showing India's fly ashes to be quite fine. The quality of Fly ash is governed by IS 3812-part I-2003. The fly ash particles are in amorphous state which greatly contributes to the pozzolanic reaction between cement and Fly ash.

Silica fume as admixture

Silica Fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and Physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete Production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

IV. RESULTS AND DISCUSSION

COMPRESSIVE AND SPLIT TENSILE STRENGTH RESULTS FOR M30

Table 4.1: Compressive & Split tensile strength results for M30.

S.N	Type of Mix	Compressive Strength (N/mm^2)	Split Tensile Strength (N/mm^2)
1	Ordinary	35.33	2.65
2	1% Glass Fiber	36.5	2.75

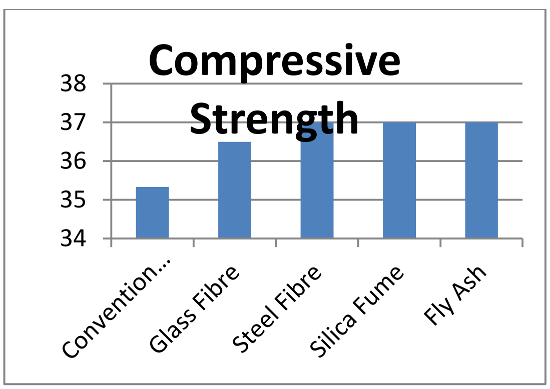
	2 % Glass Fiber	37	2.8
3	1 % Steel Fiber	37	2.7
	2 % Steel Fiber	37.5	2.75
4	1% Silica Fume	37	2.7
	2% Silica Fume	38	2.79
5	5% Fly ash	37	2.7
	10% Fly Ash	38	2.71

Compressive Strength results for 1% glass fibers, steel fibers, silica fume and 5% fly ash

Effect of Fibers & Flyash on compressive strength of M30 Grade concrete mixes at the age of 28 days are below table and graphs

Table 4.2: Compressive Strength results for 1% glass fibers, steel fibers, silica fume and 5% fly ash

% of Fibers and admixtures	Compressive Strength (N/mm^2)
Conventional	35.33
1% Glass Fiber	36.5
1% Steel Fiber	37
1% Silica Fume	37
5% Fly Ash	37



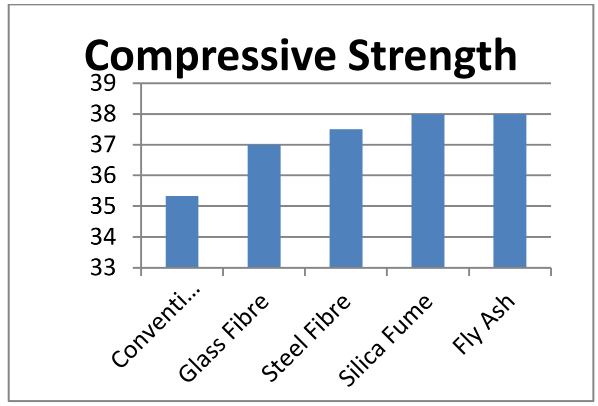
Graph 4.1: Showing the variation of compressive strength when 1% of fibers and admixtures and 5% of Flyash added to concrete

Compressive Strength results for 2% glass fibers, steel fibers, silica fume and 10% fly ash

Effect of Fibers & Flyash on compressive strength of M30 Grade concrete mixes at the age of 28 days are below table and graphs

Table 4.3: Compressive Strength results for 2% glass fibers, steel fibers, silica fume and 10% fly ash

% of Fibers and admixtures	Compressive Strength (N/mm^2)
Conventional	35.33
2% Glass Fiber	37
2% Steel Fiber	37.5
2% Silica Fume	38
10% Fly Ash	38



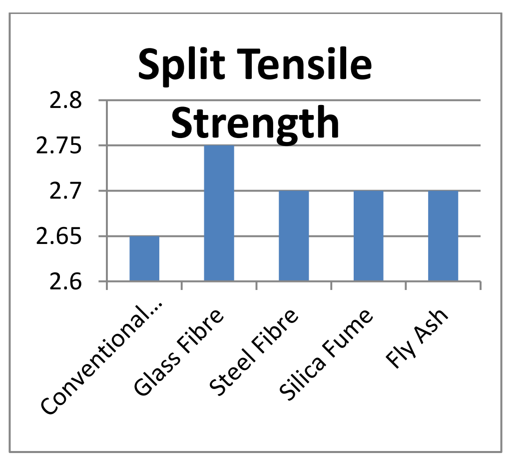
Graph 4.2: Showing the variation of compressive strength when 2% of fibers and admixtures and 10% of Flyash added to concrete

Split Tensile Strength results for 1% glass fibers, steel fibers, silica fume and 5% fly ash

Effect of Fibers & Flyash on Split Tensile strength of M30 concrete mixes at the age of 28 days are below table and graphs

Table 4.4: Split Tensile Strength results for 1% glass fibers, steel fibers, silica fume and 5% fly ash

% of Fibers and admixtures	Split Tensile Strength (N/mm^2)
Conventional	2.65
1% Glass Fiber	2.75
1% Steel Fiber	2.7
1% Silica Fume	2.7
5% Fly Ash	2.7



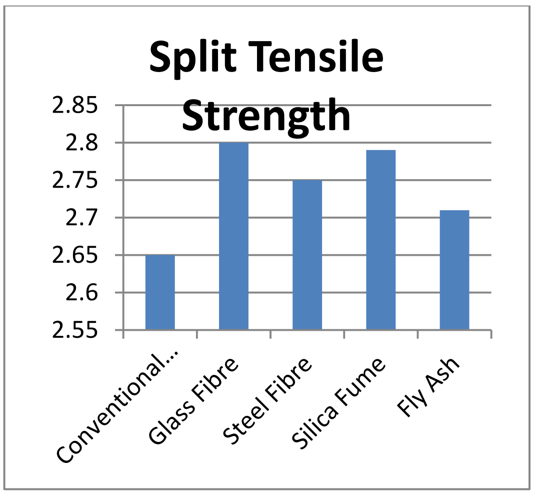
Graph 4.3: Showing the variation of Split Tensile strength when 1% of fibers and admixtures and 5% of Flyash added to concrete

Split Tensile Strength results for 2% glass fibers, steel fibers, silica fume and 10% fly ash

Effect of Fibers & Flyash on Split Tensile strength of M30 concrete mixes at the age of 28 days are below table and graphs

Table 4.5: Split Tensile Strength results for 2% glass fibers, steel fibers, silica fume and 10% fly ash

% of Fibers and admixtures	Split Tensile Strength (N/mm^2)
Conventional	2.65
2% Glass Fiber	2.8
2% Steel Fiber	2.75
2% Silica Fume	2.79
10% Fly Ash	2.71



Graph 4.4: Showing the variation of compressive strength when 2% of fibers and admixtures and 10% of Flyash added to concrete

V. CONCLUSIONS

On observing the experimental investigations conducted on the carted cubes and cylinders, the usage of fibers and admixtures with conventional concrete have given predominant outputs in physical and mechanical properties of concrete. Since the steel fibers and glass fibers are of high elastic modulii. The following conclusions were drawn as follows,

- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M30 showed a maximum increase in compressive strength to 5.78%

- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M30 showed a maximum increase in compressive strength to 4.5%.
- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M35 showed a maximum increase in compressive strength to 3.85
- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M35 showed a maximum increase in compressive strength to 5.59%.
- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M40 showed a maximum increase in compressive strength to 5.05%.
- Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M40 showed a maximum increase in compressive strength to 4.27%.

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