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EXPERIMENTAL INVESTIGATION ON PROPERTIES OF CONCRETE USING HYBRID FIBRES WITH GGBS AND BAGASSE

[1]P.Selvarasan , [2]G.Akshaya,

[1]Professor, Department of Civil Engineering, SKP Engineering College, Tiruvannamalai, India,

[2]PG Student of Structural Engineering, Department of Civil Engineering, SKP Engineering College, Tiruvannamalai, India

ABSTRACT

The aim of the study is to improve the understanding of the influence of steel and polypropylene fibres on the behavior of high strength concrete. Concrete mixes were studied by adding steel fibres and polypropylene fibres. Steel fibre (75%) and polypropylene fibre (25%) are used as hybrid fibres. They were utilized in four different proportions as 0, 0.5%,1%,1.5% in this study. Experiments were conducted to study the effect of steel fibre and polypropylene fibre in different proportions in hardened concrete. The combining of fibres often called as hybridization, is investigated for M40 grade concrete at a proportions of steel and polypropylene and Cement was partially replaced by Baggase ash and Ground Granulated Blast furnace Slag (GGBS) varied up to 30% by weight of cement. To study the compressive strength of specimen 150x150x150mm size, tensile strength of specimen 75x100mm size and flexural strength of specimen 100x100x500mm size hardened concrete. . To study the durability characteristics and water absorption of specimen 100x200mm size. Finally compare the results with conventional concrete. The results showed the effect of hybrid fibres with GGBS and Baggase ash on concrete elements has a considerable amount of increase in the compressive and flexural strength characteristics.

Keywords: Experimental, Investigation, Hybrid fibre Partial Replacement, GGBS and Baggase

1. INTRODUCTION

Concrete is the most often used material by the community. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Concrete is conventionally produced by using the ordinary Portland cement (OPC) as the primary binder. OPC is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Also, now a day's one of the great applications in various structural fields is fibre reinforced concrete, which is getting popularity because of its positive effect on various properties of concrete. Addition of randomly distributed fibres improves concrete structural characteristics viz. The major advantages of fibre reinforced concrete are resistance to micro cracking, impact resistance, resistance to fatigue, reduced permeability, and improved strength in shear, tension, flexure and compression. Also, Concrete is much stronger in compression than it is in tension. Concrete less brittle and prone to cracking is to add fibres. Because fibres are strong in tension, they help prevent crack growth and stabilize the concrete against shrinkage. They also increase the impact and abrasion resistance of the concrete. A variety of different types of fibres can be used in concrete, including steel, glass, plastic, and cellulose. Steel fibre offers good tensile strength, ultimate strength, flexural strength, ductility and crack arrest. Polypropylene fibre when added to concrete reduces the compressive strength, but increase both spilt tensile strength and flexural strength. They are more porous compared to the plain concrete.

2. MATERIAL COLLECTION

2.1 Cement

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. Cement and water form a paste that binds the other materials together as the concrete hardens. Portland Pozzolana cement (PPC) is manufactured by the inter-grinding of OPC clinker with 10 to 25 per cent of pozzolanic material. The pozzolanic materials generally used for manufacture of PPC are calcined clay or baggase ash. PPC produces less heat of hydration and offers greater resistance to the attack of aggressive waters than Ordinary Portland Cement. The reaction of cement when mixed with water is called hydration. Both C_3s and C_2s make up nearly 75% of cement.

2.2 Fine Aggregate

Sand used for the experimental program was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was first sieved through BIS 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. Fine aggregate was tested as per IS 2386-1963. Fine aggregate is an accumulation of grains of mineral matter derived from thedisintegration of rocks. It is distinguished from gravel only by the size of the grains orparticles, but is distinct from clays which contain organic materials. Sands that have beensorted out and separated from the organic material by the action of currents of water or bywinds across arid lands are generally quite uniform in size of grains. making molds in foundries. Clear sands areemployed for filtering water. Sand is sold by the cubic yard (0.76 m^3) or ton (0.91 metricton) but is always shipped by weight. The weightvaries from 1,538 to 1,842 kg/m^3,depending on the composition and size of grain. Construction sand is not shipped greatdistances, and the quality of sands used for this purpose varies according to local supply.Standard sand is a silica sand used in making concrete and cement tests. The fine aggregateobtained from river bed of Koel, clear from all sorts of organic impurities was used in this experimental program.

2.3 Coarse Aggregate

The material which was retained on test sieve 4.75mm was termed as coarse aggregate. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20 mm was used in the work. The aggregate was washed to remove dust and dirt and was dried to surface dry condition. The aggregate was tested as per Indian Standard Specifications IS: 2386-1963. Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone,and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark-colored, fine-grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although larger sizes may be used for massive concrete aggregate. Machine crushed granitebroken stone angular in shape was used as coarse aggregate. Coarse aggregates are usually those particles which are retained on I.S. 4.75mm sieve.The aggregates should be absolutely clean, free from organic matter and other impurities. The aggregate should be capable to resist weather.

2.4 Steel fibre

Since 1900, steel fibres are using in constructions. Only straight and round cross sectional steel fibres were used in the beginning. Though remarkable improvements in toughness and ductility were obtained, problems in mixing and workability were encountered. These problems were overcome with the

Table 1 Properties Steel Fibre

Fibre type	Steel fibres
Shape	Hooked end
Length	50mm
Diameter	1mm
Aspect ratio	50

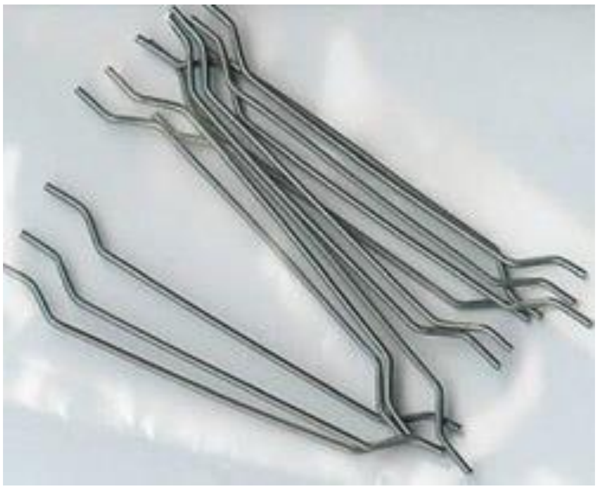

Fig 2.1 Hooked End Steel Fibres

It is possible to produce steel fibres in many ways. Round fibres are produced by cutting or chopping wires. Flat fibres may be produced either by shearing sheets or flattening wires. Crimped and deformed steel fibres of various shapes are also produced, in which deformations may extend through the length of the fibre or maybe limited to the end portions. Some fibres are collated into bundles using water soluble glue dissolving during the mixing process, in order to ease handling and mixing. Depending on the type of steel and the type of production technique, steel fibres may have tensile strengths of about 280-2800 MPa, and ultimate elongations of about 0.5% to 3.5%.

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2.5 Polypropylene fibres

Synthetic fibres have attracted more attention for reinforcing cementitious materials in the recent years. In this part emphasis is given on polypropylene fibres, as they were used throughout the experimental program. Polypropylene fibres were suggested as an admixture to concrete in 1965 for construction of blast-resistant buildings for the U.S Corps of Engineers. Results of this research work showed that polypropylene fibres could be practical for reinforcing concrete, since polypropylene is cheap, abundantly available, and possess a consistent quality. Considerable improvements in strain capacity, toughness, impact resistance, and crack control of concrete can be obtained through the use of polypropylene fibres.

Fig 2.2 Polypropylene Fibres

Polypropylene fibres are manufactured in various shapes and different properties. The polypropylene fibres are made of high molecular weight isotactic, a type of polymer chain configuration where in all side groups are positioned on the same side of the molecule, polypropylene. The macromolecule has a sterically regular atomic arrangement, thus polypropylene fibres can be produced in a crystalline form, and then processed by stretching to achieve a high degree of orientation, which is necessary to obtain good fibre properties. The polypropylene fibres can be produced in three different geometries, monofilaments, film, or extruded tape. The polypropylene film consists of amorphous material and crystalline micro fibrils. However these films are weak in the lateral direction. monofilament and the fibrillated polypropylene is usually about 3.5GPa, and the tensile strength is about 560 to 770 MPa. The geometry of fibrillated polypropylene is difficult to quantify. It can be described in terms of film thickness and the width of the individual filaments, or alternatively by measuring the specific surface area by adsorption techniques. Fibre denier, a term commonly used in textile industry

Table 2 Properties Of Polypropylene Fibres

Fibre type	Polypropylene
Length	12mm
Diameter	0.1mm
Aspect ratio	120
Specific gravity	0.91
Color	Natural

2.6 Water

Casting and curing of specimens were done with the potable water that is available in the college premises.

2.7 Ground Granular Blast furnace Slag (GGBS)

The blast furnace slag is a by-product of the iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500ºC to 1600ºC. The molten slag has a composition of about 30% to 40% $SiO_2$and about 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then water-quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as Ground Granulated Blast furnace Slag (GGBS).

FIG 2.3 GGBS (GROUND GRANULAR BLAST FURNACE SLAG)

The production of GGBS requires little additional energy as compared with the energy needed for the production of Portland cement. The replacement of Portland cement with GGBS will lead to significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

2.8 Bagasse ash

Sugar-cane **bagasse** is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste product (Sugar-cane **Bagasse ash**) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse baggase ash, a waste produced in sugar industries, has been converted into an inexpensive and effective adsorbent. The product was characterised by different chemical and physical methods and has been used for the removal of copper and zinc from wastewater. Various parameters such as pH, adsorbent dose, initial metal ions concentrations, temperature, particle size, etc. were optimised. Copper and zinc are adsorbed by the developed adsorbent up to 90/95% in batch and column experiments. The adsorption was found to be endothermic in nature and follows both the Langmuir and Freundlich models. Isotherms have been used to evaluate thermodynamic parameters for the adsorption process.

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3. MATERIAL PROPERTIY

Physical Properties

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FIG 2.4 BAGASSE ASH

Investigation On Cement

a. Specific Gravity of cement:

This is done using standard le-chatelier flask apparatus. Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml. Put a weighted quantity of cement (about 50 gm) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and to see that cement does not adhere to the sides of the above the liquid. After putting all the cement to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rises to the surface of the liquid.

b. Consistency test for cement :

Consistency test is used to find out the consistency of cement. There should not be nay air bubbles. Place the paste into the mould. Attach the plunger with a needle having diameter of 1mm. Release the needle quickly without any jerk. This should be done within 3-5 mints after adding water to cement. . Take 400 grams of cement and form a paste by mixing 35% of normal consistency of water, note the time when the water is added to the cement with the help of the stop watch. Fill the vicat mould completely with the paste prepared as for normal consistency. Fix the specified needle with the rod. Place the mould with the test specimen. Then release rod quickly. Note the depth to which the needle, penetrate the paste. Repeat the experiment till the penetration is 37mm. (the mould is 37mm depth) when it happens note the once again for every 5 minutes. The needle has a steep decrease in height. The reading is maintained up to 5 minutes. The depth has been penetrated found out

The initial setting time of cement = 30 minutes

The final setting time of cement = 600 minutes

Investigation On Fine Aggregate

a. Specific Gravity of Fine Aggregate:

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Specific gravity test is important test of fine aggregate. This test is conducted by pyconometer. Take the empty weight of the pyconometer. Fine Aggregate is taken upto2/3 level of the pyconometer and takes weight. Add the water up to cap of the pyconometer and also take weight. Take weight of pyconometer with water only. Calculate the average specific value of the fine aggregate.

Specific gravity of fine aggregate $\frac{(W_2-W_1)}{(W_4-W_1)-(W_3-W_2)}$

b. Sieve analysis of Fine Aggregate:

Assemble IS determined as described in IS: 2386 (Part I)-1963 shall be within the limits given in Table 4 of IS 383 – 1970. Place the aggregates in the top of the sieves and cover with lid properly secure the sieves in the mechanical shaker for five minutes. Weigh the materials that are retained on each sieve and in the pan. Then cumulative percent retained and the percent passing each sieve.

Fineness modulus = 401/100 = 4.01 (For Zone II aggregate According to IS 383 - 1970)

c. Bulk density of Fine Aggregate:

Take representative of fine aggregate as required for the test. Determine the empty weight (A) and the volume V of the container at 27ºC. Fill the container in three layers, each layer being subjected to 25 strokes with the rounded end of the tamping rod. Strike off the surplus aggregate using tamping rod as a straight edge and weigh (B).

d.Water absorption of Fine Aggregate

Take 600gm of sample and place it in tray covered with distilled water at a temperature 22ºC to 32ºC and sample shall be kept immersed for about 24 hours. The water shall be carefully drained and decanted through a filter paper and uniform drying shall be ensured until no free surface moisture can be seen. The saturated and surface dry samples shall be weighed (A).Dry specimen in a ventilated oven at a temperature of 100ºC to110ºC for a period of 24 ½ hours. Cool; the specimen to room temperature and obtain its weight (B).

Investigation On Coarse Aggregate

a.Specific gravity of coarse aggregate

Specific gravity test is important test of coarse aggregate. This test is conducted by pyconometer. Take the empty weight of the pyconometer. Aggregate is taken upto2/3 level of the pyconometer and take weight. Add the water up to cap of the pyconometer and also take weight. Take weight of pyconometer with water only. Calculate the average specific value of the aggregate.

For 20mm coarse aggregate :

Specific gravity of coarse aggregate

$$= \frac{(W_2-W_1)}{(W_4-W_1)-(W_3-W_2)}$$

b.Bulk density of Coarse Aggregate:

Take representative of coarse aggregate as required for the test. Determine the empty weight (A) and the volume V of the container at 27ºc. Fill the container in three layers, each layer being subjected to 25 strokes with the rounded end of the tamping rod. Strike off the surplus aggregate using tamping rod as a straight edge and weigh (B).

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c.Water absorption of Coarse Aggregate:

Take 600g of coarse aggregate and place it in tray covered with distilled water at a temperature 22ºC to 32ºC and sample shall be kept immersed for about 24 hours. The water shall be carefully drained and decanted through a filter paper and uniform drying shall be ensured until no free surface moisture can be seen. The saturated and surface dry samples shall be weighed (A).Dry specimen in a ventilated oven at a temperature of 100ºc to110ºc for a period of 24 ½ hours. Cool; the specimen to room temperature and obtain its weight (B).

d. Sieve analysis of Coarse Aggregate:

The sample shall be brought to an air dry condition by either drying at room temperature or heating at a temperature of 100ºC to 110ºC. Sample for sieving shall be prepared by either quartering or by means of sample divider. Take proper weight of dries coarse aggregate of 2000gm. assemble IS sieves in following order 40mm, 20mm, 10mm, 4.75mm and pan place the aggregates in the top of the sieves and cover with the lid properly secure the sieves in the mechanical shaker and turn on the shaker or shake manually for five minutes.

Investigation On GGBS

This is done using standard le-chatelier flask apparatus. Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml. Put a weighted quantity of GGBS (about 50 gm) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and to see that GGBS does not adhere to the sides of the above the liquid. After putting all the GGBS to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rises to the surface of the liquid. Note down the new liquid level as final reading.

a. Specific Gravity of GGBS:

$$\text{Specific gravity} = \frac{(W_2 - W_1)}{(W_2 - W_1) + (W_4 - W_3) \times \text{Sp.gr.of kerosene}}$$

Specific gravity of GGBS = 2.95

Investigation On Bagasse ash: This is done using standard le-chatelier flask apparatus. Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml. Put a weighted quantity of baggase ash (about 45 gm) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and to see that baggase ash does not adhere to the sides of the above the liquid. After putting

all the baggase ash to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rises to the surface of the liquid. Note down the new liquid level as final reading.

Th Specific Gravity of Baggase ash:

$$\text{Specific gravity of bagasse ash} = \frac{(W_2 - W_1)}{(W_2 - W_1) + (W_4 - W_3) \times \text{Sp.gr.of kerosene}}$$

Specific gravity of bagasse ash = 2.14 (According to IS 3812-1981, range fm 1.9 to 2.55)

3.3 MIX DESIGN

3.3.1 *General*

The constituents used were divided into different fractions to determine the mix proportions that would yield the targeted compressive strength at a test age of 28 days. The optimum proportion included the coarse aggregate, sand, cement, ceramic waste, copper slag and
water to yield a cubic meter of concrete. In this method M40 grade concrete was used.

MIX DESIGN DETAILS PER m3

(As per IS 10262:2009)

CONCRETE GRADE : **M40**
Type of cement : **opc 53 grade**
w/c ratio : **0.36**
Weight of cement : **330 kg**
weight of water : **165.6 lit**
Weight of fine aggregate : **684 kg**
Weight of coarse aggregate**(20mm)** : **649.39 kg**
Weight of coarse aggregate**(12 mm)** : **428.95 kg**
Super plasticizer**(gelinium)** : **3.0 lits**

Mix proportion

Water : cement : F.A : C.A : admixture

0.4:1:1.68:2.67:0.007

5. TESTING PROCEDURE

COMPRESSIVE STRENGTH

This tests were carried out in accordance with IS 516-1999 standards conducted on concrete specimen size 150mm x 150mm x 150mm and the test results are tabulated .The compressive strength calculated using formula

Fck = P/A.

COMPRESSIVE STRENGTH FOR 7 DAYS

TABLE 8 COMPRESSIVE STRENGTH - (7th DAY)

MIX DESIGNATION	Compressive strength (N/mm^2)			AVG COMPRESSIVE STRENGTH(N/mm^2)
	TRIAL 1	TRIAL 2	TRIAL 3	
conventional concrete	30.4	31.6	32.0	**31.3**
MIX-1	30.23	32.02	30.47	30.9
MIX-2	25	25	24.6	24.6
MIX-3	28.3	30	26.4	28.2
MIX-4	31.6	28.3	27.4	**29.1**
MIX-5	25.1	23.3	22.6	23.6
MIX-6	25.9	29.3	29.7	28.3

TABLE 10 COMPRESSIVE STRENGTH - (28th DAY)

MIX DESIGNATION	Compressive strength (N/mm^2)			AVG COMPRESSIVE STRENGTH (N/mm2)
	TRIAL 1	TRIAL 2	TRIAL 3	
conventional concrete	36.9	37.4	32.9	**37**
MIX-1	30.7	43.9	36.3	37
MIX-2	38.1	39.8	48.1	42
MIX-3	38.9	38.9	29.7	35.8
MIX-4	53.9	45.6	46.7	**48.7**
MIX-5	35.3	43.8	44.3	41.1
MIX-6	49.4	45.7	48.1	47.7

MIX DESIGNATION	Compressive strength (N/mm^2)			AVG COMPRESSIVE STRENGTH(N/mm2)
	TRIAL 1	TRIAL 2	TRIAL 3	
Conventional Concrete	7.4	8.4	8.9	**8.23**
MIX-1	6.4	7.4	7.1	7
MIX-2	8.2	7.3	9.1	8.2
MIX-3	7.2	7.2	6.8	7.06
MIX-4	7.9	8.4	9.6	**8.63**
MIX-5	6.2	6.3	6.6	6.4
MIX-6	8.2	5	5.3	6.2

MIX DESIGNATION	Compressive strength (N/mm^2)			AVG COMPRESSIVE STRENGTH (N/mm2)
	TRIAL 1	TRIAL 2	TRIAL 3	
conventional concrete	4	4.3	3.6	**4**
MIX-1	3.23	2.7	4.14	3.36
MIX-2	2.32	1.83	2.16	2.1
MIX-3	4.2	4	3.54	4
MIX-4	4	5.4	4	**4.5**
MIX-5	2.4	3	2.7	2.7
MIX-6	2.3	2.62	1.22	2.01

l is the length of cylind

FLEXURAL STRENGTH OF CONCRETE

Determination of flexural strength is essential to estimate the loads at which concrete members may crack. The bearing surface of the supporting and loading rollers were wiped clean, and any loose sand or other material were removed from the surface of the specimen where they are to make contact with the rollers. The specimen was then placed in the machine in such a manner that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 13.3 cm apart.

CONCLUSION

GGBS and baggase ash can be effectively used as a partial replacement of cement in small percentages varying between 10-20 %.

1. Addition of the above has both positive and negative impacts on the mechanical properties of concrete.
2. Fortunately, the addition of fibres minimizes the ill effects of GGBS and baggase ash to a certain extent.
3. Addition of Steel fibres to concrete increases its ductility and offers impact resistance.
4. Incorporation of polypropylene fibres to concrete reduces in minimizing micro and macro cracks and works in arresting it further.
5. The addition of hybrid fibres has improved the compressive strength, flexural strength and split tensile strength of concrete.
6. The results also revealed that addition of the hybrid fibre in concrete increases the density of about 10 to 20% thereby the self–weight of the concrete.

7. The workability of the concrete is increased considerably compared to normal concrete.
8. The workability of concrete decreases with increase in volume fraction of fibres. Water absorption value of hybrid fibres concrete is reducing upto 40%. After that the surface water absorption is increased rapidly.
9. The combination of hybrid fibres in concrete imparts good effects in compressive strength, spilt tensile strength, flexural strength compared to control mix.

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