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Experimental Study on Strength of Concrete Using Glass Powder and Recron Fiber

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Abstract: *Non-degradable wastes has been a major issue now in the 21st century as more and more of these wastes are piling up in our world today and being disposed of in landfill areas without being recycled. These wastes take up a very long period of time to decompose. Because of this problem, researches have been done to fully utilize these wastes as the final products for construction materials such as concrete and mortar. The fundamental binder in concrete is cement, a significant contributor to green house gas emissions that are implicated in global warming and climate change. Utilization of waste glass produced by the community is a partial solution to environmental and ecological problems. Replacing cement by glass powder not only increases the strength but also reduces the unit weight. From the studies when the concrete contains waste glass powder gives higher percentage of C_2S, low C_3A,C_4AF,C_3S content which results in produce less heat of hydration and offers greater resistance to attack and the concrete with glass powder at 20% replacement has a greater compressive and flexural strength value at 28 days compared with the control specimen. In order to get higher strength for further replacement by glass powder recron polyester fibers are added to the concrete for 30% and 40% replacement.*

Key words: *compressive strength, flexural strength, recron fiber, waste glass powder, workability.*

1. Introduction

Concrete is the most widely used building material in the world because of its beauty, strength and durability, among other benefits. And in an era of increased attention on the environmental impact of construction, concrete performs well when compared to other building materials. As with any building product, production of concrete and its ingredients does require energy that in turn results in the generation of carbon dioxide (CO_2).

Carbon dioxide is one of several greenhouse gases that can cause global warming by trapping the Sun's radiant energy in our atmosphere. This process is called the greenhouse effect. Greenhouse gases include water vapor (36-70%), carbon dioxide (9-26%), methane (4-9%) and ozone (3-7%).Many scientists believe global warming will cause a rise in sea level, increase the intensity of extreme weather, and change the amount and pattern of precipitation. Other effects could include changes in agricultural yields, glacier retreat, species extinctions and increases in disease. These effects could severely impact the Earth's ability to support life.

Reuse of post-consumer wastes and industrial byproducts in concrete is necessary to produce even "greener" concrete. The use of solid waste materials or industrial by-products as partial replacement for cement in concrete is a viable strategy for reducing the use of Portland cement and hence making concrete production environmentally friendly and energy efficient. Glass, which is rich in amorphous silica, has the proper chemistry and reactivity to enter pozzolanic reactions with the lime released during hydration of cement these reactions can yield highly stable end products with desired binding qualities.

Past efforts to recycle waste glass in concrete have focused on the use of crushed glass as replacement for aggregate in concrete. These efforts neglected the reactive nature of glass in concrete, which was slowed down due to the relatively large (millimeter-scale) size of glass particles. Such long-term reactions proved to be detrimental to the long-term stability of concrete incorporating relatively large (crushed) glass particles. Milling of glass to micrometer- scale particle size, for accelerating the reactions between glass and cement hydrates, can bring about major energy, environmental and cost benefits when cement is partially replaced with milled waste glass for production of concrete. It has been reported that recycling of each ton of glass saves over one ton of natural resources, and recycling of every six tons of container glass results in the reduction of one tone of carbon dioxide emission.

Most of existing studies recommend that waste glass can be used only as fine powders. Fine particles of glass usually present pozzolanic activity beneficial to the concrete while coarse particles are usually deleterious to concrete due to Alkali-Silica Reaction(ASR). Fine glass powder has been used effectively in blended cement binders and cementitious concrete.

The volume expansion produces large tensile stresses in the concrete, which initiates cracks and results in concrete spalling from the surface. More recently micro fibers, such as those used in traditional composite materials have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth FRC is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions.

Reinforcing the concrete structures with fibers such as polyester (commercial name of recron) is one of the possible ways to provide low shrinkage, good thermal expansion, substantial modulus of elasticity, high tensile strength, improved fatigue and impact resistance. Recron 3s is meant for improving the quality of construction, savings on wastage and for speeding up the work place. Recron is meant for secondary reinforcement only.

Objective of the work

The main endeavor of this project is to strengthen the capacity of concrete by using glass powder and recron polyester fiber.

Therefore, the aim of this study is

To experimentally ascertain the compressive and flexural strength of concrete by using GP and recron.

To examine experimentally the benefits of internal bonding of concrete with fiber.

Scope of the work

To minimize the greenhouse gas effect by partially replacing cement by glass powder.

To increase the strength by adding fibers to the glass powder concrete, when cement is replaced with GP beyond its replacement limit.

II. Experimental program

Design of specimen: The experimental program includes 6 number of specimens designed as per IS 456-2000. The overall dimension and details of the reinforcement of beam is given in figure . The beam of 700 x 150 x 150mm is reinforced with 2#10mmdia bars at bottom of the beam and 2#8mm dia of bars at top of the beams. 6mm stirrups are provided with 100 mm spacing to take care of shear.

Reinforcement details:

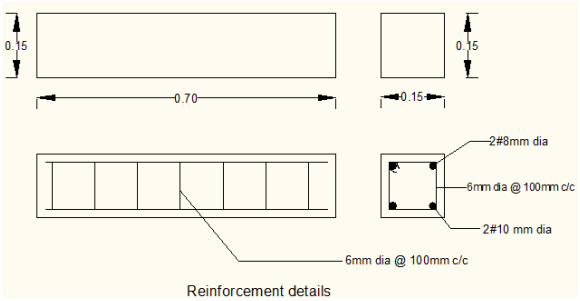

Figure 1. Reinforcement details

TABLE I. SPECIMEN DETAILS

Specimen details	Cubes(7+28days strength)	Beams(28days strength)
Control specimen(CS)	3+3	3
20% GP + 80% cement	3+3	3
20% GP + 80% cement + .2% fiber	3 +3	3
30% GP + 70% cement + .3% fiber	3+3	3
40% GP + 60% cement + .4% fiber	3+3	3

III. PREPARATION OF SPECIMENS

Material properties and Mix design:

TABLE II. MATERIAL DETAILS

Material	Properties
Cement	Ordinary Portland cement of 53 grade
Sand	Locally available river sand having a fineness modulus of 3.73, specific gravity 2.64
Coarse aggregate	Coarse aggregate of 20mm maximum size having specific gravity 2.7

Water	Water confirming to the requirement of water for concreting and curing as per IS 10262.

Admixture:

To import workability to the mix, a superplasticiser from a reputed company was used with the dosage of 2% by weight of cement.

Glass powder:

Glass is non-biodegradable material which is going to be obtained by crushing waste glass pieces in a crusher mill.Early forms of glass were probably rife with impurities and subject to cracking and other instability.When manufactured by humans, glass is a mixture of silica, soda, and lime. GP is highly pozzolanic material suitable for use in lime-pozzolanicmixes and for Portland cement replacement.

GP of particle size smaller than 75μm, or less than #200 mesh, is to be used to act as a pozzolanic material. In my project #150 mesh is used.

Mesh material is often used in determining the particle size distribution of a granular material.

Figure 2. Glass powder

TABLE III.COMPARISON OF CEMENTWITHGLASS POWDER(GP):

Composition	Cement	Glass powder
Silica	20.2	72.5
Alumina	4.7	0.4
Iron oxide	3.0	0.2
Calcium oxide	61.9	9.7
Magnesium oxide	2.6	3.3
Sodium oxide	0.19	13.7
Potassium oxide	0.82	0.1
Sulphur trioxide	3.9	-
Lossof ignition	1.9	0.36

Properties of recron 3s polyester fiber:

Shape - Triangular

provide higher surface bonding and results in three dimensional crack controls. It improves bonding by 40% over circular fiber.Circular fiber tends to slip out from cement matrix when load is applied.

Aspect ratio:

$$\text{Aspect ratio} = \frac{\text{Length}}{\text{Diameter}}$$

$$= \frac{6\text{mm}}{35\mu\text{m}} = 175$$

Figure 3. Recron 3s fiber

TABLE IV. PROPERTIES OF RECRON 3S POLYESTER FIBER:

Material	100% virgin polyester fiber
Length	6mm
Diameter	35µ
Tensile strength	1000Mpa
Specific gravity	1.36
Modulus of elasticity	17250MPa
Dispersion	Excellent
Acid resistance	Good
Thermal conductivity	Low

Mix design:

The grade of concrete used is M30 and mix design was made as per IS 10262 with the above material properties.

Mix ratio:

Water : Cement : Fine aggregate : Coarse aggregate
0.38 : 1 : 1.03 : 2.39

The work progresses are shown in figure.

Figure 4. Mixing, Compacting, Finishing of the specimen.

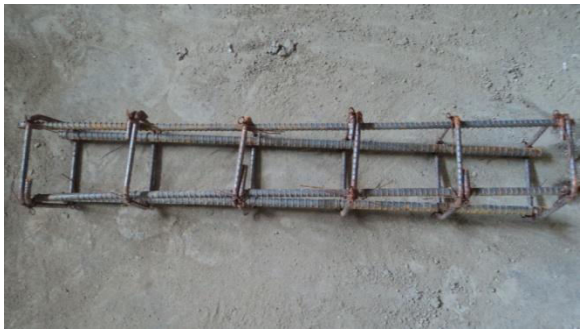

Figure 5. Reinforcement cage.

Figure6.Reinforcement cage in the mould

Figure 7. Finishing of the specimen

Casting: Steel moulds are used for casting the specimens. Reinforcement cages are fabricated and placed inside the moulds shown in figure 5. Required quantities of cement, sand, coarse aggregate , Glass powder, Recron polyester fiber are mixed along with water in the mixer machine. Mixing is done till a uniform mix is obtained. The mould is compacted by means of hand, after 24 hours specimens are demoulded and cured for 7 & 28days.

Strength tests:

Following are the tests conducted for evaluating the strength properties of hardened concrete.

1.Compressive strength test
2.Flexural strength test

1.Compressive strength test:

150mmx150mmx150mm concrete cubes were cast using 1:1.03:2.39 mix with w/c ratio of 0.38. Specimens with OPC and OPC replaced by glass powder at 20%, 30% ,40% and addition of 0.2%, 0.3%, 0.4% of recron fiber respectively.

After 24 hours the specimens were removed from the mould and subjected to water curing for 7, 28 days. After specified period of curing the specimens are to be tested using compressive testing machine of 2000KN capacities. The tests are carried out on triplicate specimens and average compressive strength values are to be recorded.

The cube compressive strength (f_{ck}) was computed from the fundamental principle as

$$F_{ck}= \frac{\text{Load at failiure}}{\text{Cross sectional area}} (N/mm^2)$$

Figure 7.Compression test

2.Flexure strength test:

It is the resistance of concrete to tension under flexure loading. The tensile strength of concrete is primarily made to estimate the load under which cracking develops.

Test set up: The specimens are to be tested for flexure under two point loading. The testing are to be done by using the test set up shown in figure .The size of the specimen is 700mmx150mmx150mm.

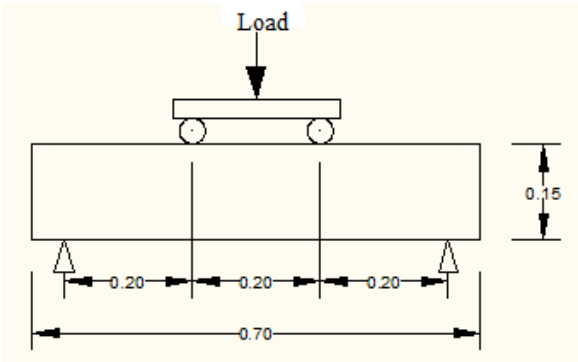

Figure 8. Test set up diagram

TEST RESULTS:

TABLE V. COMPRESSION TEST RESULTS:

S.No	Specimen	Compressive strength (N/mm^2)	
		7days	28days
1	CS	25.5	44
2	20% GP + 80% cement	26.7	45.5
3	30% GP + 70% cement + .3% fiber	26.1	46.2
4	40% GP + 60% cement + .4% fiber	26	44.9

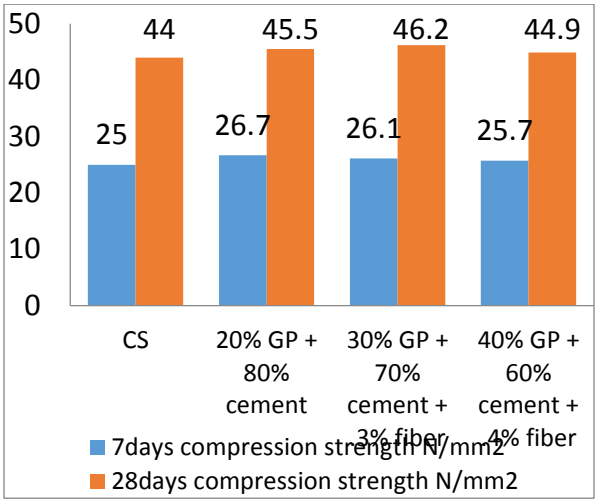

Chart 1. Compressive strength test results

TABLE VI. FLEXURAL TEST RESULTS:

S.No	Specimen	Load carrying capacity of beam(kN)
1	CS	62.93
2	20% GP + 80% cement	74.8
3	30% GP + 70% cement + .3% fiber	95.4
4	40% GP + 60% cement + .4% fiber	60

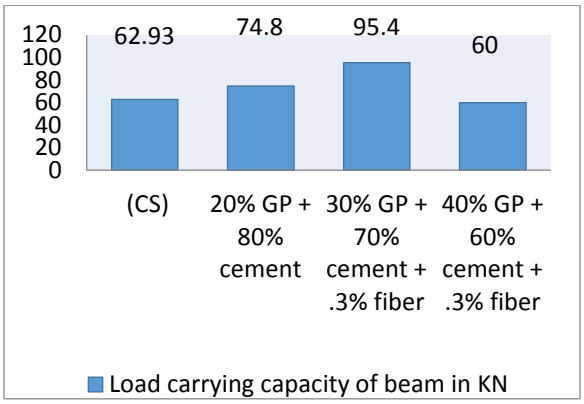

Chart 2. Flexural strength test results

IV.CONCLUSIONS

Based on experimental observations the following results are drawn:

Concrete containing 20% glass powder showed higher compressive strength as compared with control concrete.

Compressive strength resultsfor specimens replaced cement with glass powder are shown better results when compared with control specimen.

Similar results are obtained for flexural strength test also.

Considering the strength criteria, by the addition of recron fiber cement can be successfully replaced by glass powder up to 40%.

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