

Combined Effect of Glass powder & Coconut fiber on strength of Concrete

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Abstract - Glass products are widely available across the globe as a waste product and so are the natural fibers like coconut shells. Glass materials are not environmental friendly because of their non-biodegradable nature. Production of cement leads to emission of greenhouse gases like CO₂. Glass materials when grounded to powder behaves like pozzolanic materials. An economic and substantial concrete can be developed by the replacement of OPC with glass powder. And as it was reported that fibers in concrete can improve its flexural strength. An experiment is carried out to check the possibility of using Glass powder & coconut fiber as a partial replacement of Ordinary Portland Cement & Coarse aggregate respectively. In the first stage of test, only Coarse aggregate was replaced with coconut fiber with varying percentage as 3%, 5% & 7%. The percentage corresponding to maximum compressive strength was noted as 3%. In the second stage, keeping 3% fiber constant, Ordinary Portland Cement was replaced with Glass powder with varying percentage as 5%, 10%, 15% & 20%. The strength obtained from test results for 7 days and 28 days were compared with that of standard concrete (without any replacement).

Key Words: Glass powder, coconut fiber, substantial, compressive strength, flexural strength, curing, economic concrete, etc.

1. INTRODUCTION

Rapid urbanization has led to increase in demand of production of concrete which is indirectly the increasing demand of cement. Manufacturing process of cement releases greenhouse gases to the atmosphere, and one of the prominent gases is CO₂. Among the green house gases CO₂ contributes about 65% of global warming. The Global cement industry contributes about 7% of the greenhouse gas emission to the earth atmosphere [5]. The consumption of cement can be reduced by replacing it with glass powder. Waste glass contain high silica (SiO₂) i.e. 72%. When glass is grounded to very fine powder (600 micron) reacts with alkalis in cement (pozzolanic reaction) and produces cementitious products that contributes to the strength development [1]. The main problem in using crushed glass as aggregate in Portland cement concrete are expansion and cracking caused by glass aggregate due to alkali silica reaction.

The use of natural fibres in concrete is suggested since there are ample of fibres available in nature. They are used to enhance the strength and durability of concrete which is brittle in nature [8]. It basically improves the tensile strength of concrete. India has a vast coastline with coconut producing more than 2/3rd of the world production of coir and its products [10]. Using of fibres are also an initiative towards healthy environment. Coir fibre is the opportunity to promote the coir usage as an admixture in building materials [8]. In this experiment, the combined effect of glass powder and coconut fibre has been studied and found that there is no significant increase nor decrease in strength of concrete as compared to that of standard concrete, instead they are identical. The aim being focused on environmental issues due to production of cement and disposal of waste glass, using of glass powder and natural fibre are recommendable.

2. OBJECTIVE

The main objective of this experiment was to study the combined effect of Glass powder and Natural fibre on the strength of concrete and to check the possibility to make use of waste materials without compromising its strength. The following were also considered:

- To substitute OPC with glass powder
- To introduce coconut fiber for improving strength and durability.
- To compare the strengths with strength of nominal concrete.
- To determine the percentage at which compressive and tensile strength of concrete are maximum.

3. MATERIAL USED

1. Ordinary Portland Cement of Grade 53.
2. Fine aggregate of size 4.75 mm and lesser.
3. Coarse aggregate of size 40 mm and lesser
4. Glass Powder of 600 micron and lesser.
5. Coconut fibre (Coir).

3.1 PROPERTIES OF MATERIALS

The properties of material are given below:

- | | |
|---|--------|
| 1) Specific gravity of cement | = 3.15 |
| 2) Specific gravity of Fine aggregate | = 2.73 |
| 3) Specific gravity of Coarse aggregate | = 2.64 |

- 4) Specific gravity of Glass powder = 2.45
- 5) Fineness modulus of Fine aggregate = 3.99
- 6) Fineness modulus of coarse aggregate = 7.17

4. MIX DESIGN

The mix design for M20 grade concrete was made using IS 456:2000, IS 10262:2009. The material required as per design are given in the table:

Table -1: Materials required as per mix design

W/C ratio	Cement kg/m ³	Fine aggregate kg/m ³	Coarse aggregate kg/m ³
0.5	340	575	1397.5

5. METHODOLOGY

The methodology / steps adopted for accomplishment of the experiment are described below:

- 1) Waste glasses & Coconut shells were collected from dumping areas in neighbors.
- 2) Impurities on the waste materials were cleaned properly.
- 3) Glass material is then grounded to powder and coir of coconut were prepared manually from coconut shell.
- 4) Quantity of cement, fine aggregate, coarse aggregate and water were measured and taken according to calculated mix design for M20.
- 5) Initially, 8 cubes of dimension 150 x 150x 150 mm were casted and cured with just coir replacement as 0%, 3%, 5% & 7% for strength of 7 & 28 days. The fiber was replaced with Coarse aggregate.
- 6) Compressive strength test was conducted and results were compared and found compressive strength to be maximum when coir replacement was 3%, but lesser than strength of standard concrete.
- 7) Then, as 3% fiber constant, 8 more cubes of same dimensions with varying glass powder percentage as 5%, 10%, 15% & 20% were casted and cured for 7 & 28 days.
- 8) Again, compressive strength test was conducted and results were compared.

9) Then for flexural test, 10 beam specimens of dimension 150 x 150 x 500 mm were prepared with same 3% fiber content and varying glass powder content as 0%, 5%, 10%, 15% & 20%.

10) The beam specimens were casted and cured for 7 & 28 days.

11) Flexural strength test was conducted, and results were compared with that of standard concrete.

6. RESULTS & DISCUSSION

Cubes & beams were cured for 7 & 28 days and compression & flexural test were conducted respectively. The test result is plotted on graph for better presentation.

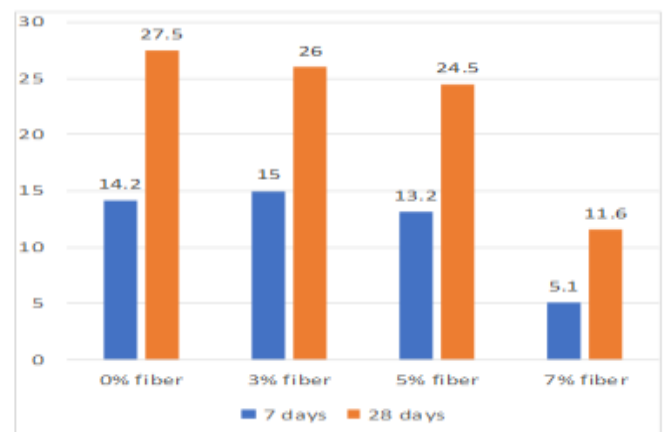
6.1 Compressive strength

Compressive strength test was conducted on cube specimens. Cubes were tested at 7 & 28 days of curing. The results of compressive strength test conducted on various specimens are discussed in this section with graphs.

6.1.1 Coconut fiber replacement

Table 1: Compressive Test Result with Various Fiber Replacements %

Replacement % of CF	7 days(N/mm ²)	28 days(N/mm ²)
0%	14.2	28.37
3%	15	26
5%	13.2	24.5
7%	5.1	11.6



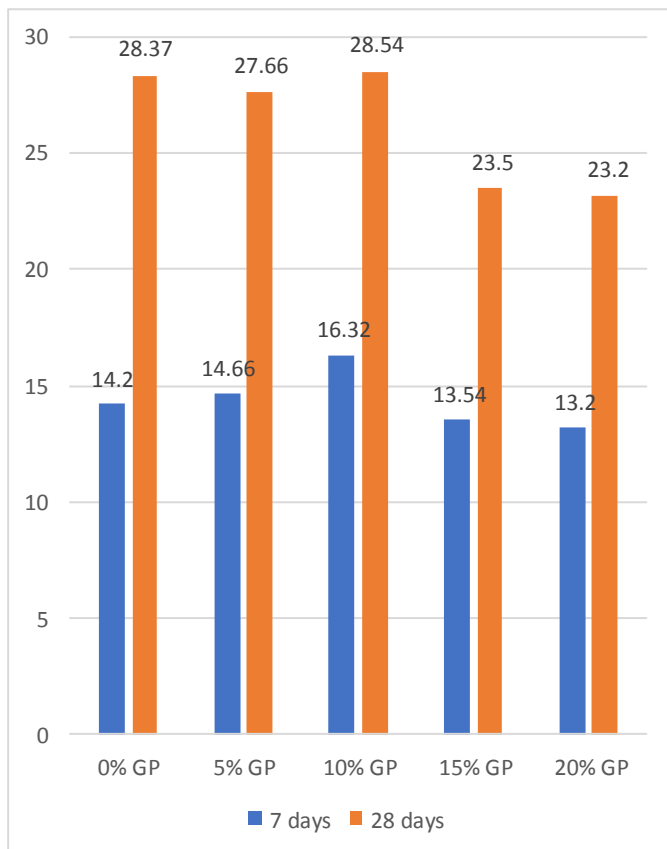
Graph 1: Compressive strength of concrete cubes at various coconut fiber content.

The compressive strength of cube is found to be maximum when the fiber content was 3%. On further test, 3% fiber will be maintained constant but with varying glass powder content.

6.1.2 Glass powder replacement (3% CF constant)

Table 2: Compressive test result with various Glass powder replacement

Replacement % of GP	7 days(N/mm ²)	28 days(N/mm ²)
0%	14.2	28.37
5%	14.66	27.66
10%	16.32	28.54
15%	13.45	23.5
20%	13.2	23.2



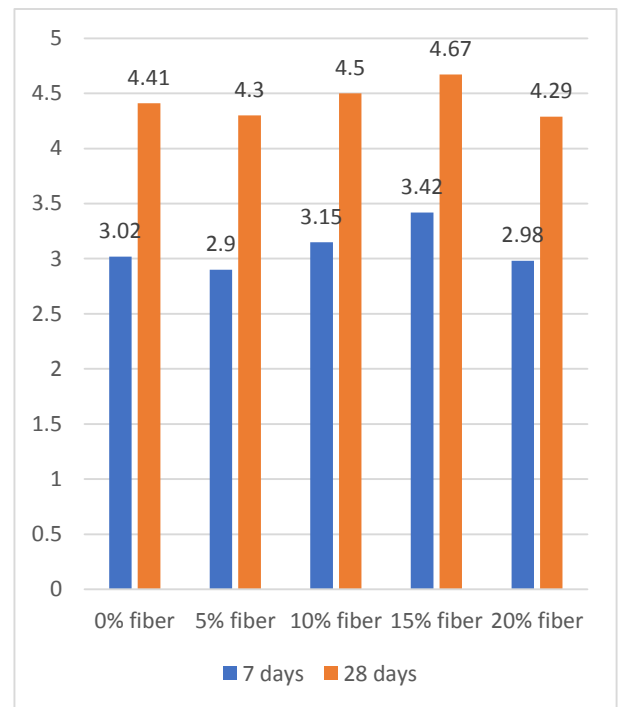
Graph 2: Compressive strength of concrete cubes at various Glass Powder content (3% fiber)

6.2 Flexural Strength

Flexural strength test was conducted on beam specimens. Cubes were tested at 7 & 28 days of curing. The results of flexural strength test conducted on various specimens are discussed in this section with graphs.

Table 3: Flexural Test Result with Various GP Replacements (3% CF constant)

Replacement % of GP	7 days (N/mm ²)	28 days(N/mm ²)
0%	3.02	4.41
5%	2.9	4.3
10%	3.15	4.5
15%	3.42	4.67
20%	2.98	4.29



Graph 3: Flexural strength of concrete beams at various Glass Powder content (3% fiber)

7. CONSLUSIONS

From the results of tests conducted on various specimens, the following conclusion can be noted:

- 1) Glass Powder is a good alternative for cement.

- 2) Glass powder increases the compressive strength of concrete.
- 3) Coconut fiber has significantly lowered the compressive strength of concrete.
- 4) Concrete cubes without coconut fiber behaves like crystal material which cause sudden failure on loading.
- 5) Concrete cubes with coconut fiber undergo cracking rather than sudden failure like crystal on compression.
- 6) Flexural strength of concrete was more or less same as that of Standard concrete without replacement, for various Glass Powder and coconut fiber content.
- 7) The combined effect of glass powder and coconut fiber has some uncertainty and requires more detailed research.

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Fig 1: Failure in concrete without coconut fiber.



Fig 2: Failure in concrete cube with coconut fiber