Experimental Investigation of Strength and Durability of Concrete by Partial Replacement of Cement with Glass Powder and Fine Aggregate with Copper Slag

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Abstract— This experimental study is to investigate the effect of using glass powder as replacement of cement and copper slag as a replacement of fine aggregate on the strength and durability properties of concrete. The importance of this alternatively glass powder and copper slag replacement is to reduce wastage of the locally available waste products and to reuse it in construction industry. In the present study experimental investigation has been carried out on M30 grade concrete is used and tests were conducted for various percentage replacement of cement with glass powder and fine aggregate with copper slag in concrete. The results obtained were compared with those of conventional concrete made with ordinary Portland cement (53 Grade) and fine aggregate. The use of glass powder and copper slag in concrete provides potential atmosphere likewise as economic advantages for all connected industries, notably in areas where ever a substantial quantity of glass powder and copper slag is created. This study reviews the characteristics of glass powder and copper slag and its effect on the engineering properties of M30 grade concrete. Now a day's use of glass powder and copper slag as substitute for cement and fine aggregate is to increase the strength of cement concrete. The Glass Powder and copper slag was replaced by 0%, 10%, 15% & 20% for 7 & 28 days for Cubes for Compressive strength and beams are casting for flexural Strength and other properties like compacting factor and slump were also determined for four mixes of concrete. There are two trial mixes to be made i.e. 1) Ordinary Concrete, 2) Concrete with addition of glass powder and copper slag for M-30 grade of concrete.

Keywords: Cement; Glass Powder, Copper Slag

I. INTRODUCTION

Due The study, various investigations have been found the solution on concrete composite materials. Natural resources are decreasing from the world and increasing waste from industries generated simultaneously. The eco-friendly and reliable development for construction consists of the use of non-conventional and different waste materials. Concrete is a blend with cement, sand, coarse aggregate and water. The key issue adds price to concrete that it is can be designed to resist harshest atmosphere vital role. Sand is an important material for the making of concrete. Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste. At present, across the world around 33 tonnes of slag is generated while in India three copper producers Sterlite, Birla Copper and Hindustan Copper produce around 6-6.5 tonnes of slag at different sites. Slag's containing <0.8% copper are either discarded as waste or sold cheaply the potential use of granulated copper slag, a relatively heavy material, as a replacement for sand in concrete mixes is explored..

Cement industry emits 8% of greenhouse gases to the environment. 1 ton of co2 is released to the environment for the production of one ton cement in industry. To reduce the emissions of greenhouse gasses alternative materials is used in concrete. There are many alternatives like rice husk ash, fly ash, egg shell, glass powder. When we are going for an alternative in construction it should be economical and easily available. In India 5200 tons per day of glass is produced. Glass is an amorphous material produced by melting a mixture of silica, soda ash, caco3 at high temperature followed by cooling where the solidification occurs without crystallization. Glass is non-biodegradable material so it is not suitable for landfill. It is an inert material which could be recycled and used many times without changing their chemical properties. In glass powder the main concern is alkali silica reaction, the chemical reaction takes place between silica rich glass particle and the alkali in pore solution of concrete. The finely grounded glass does not contribute to the alkali silica reaction. The waste glass contains high silica sio2-72%. The amorphous silica in glass would dissolve in alkaline environment due to OH- ions in pore solution of cement paste. Then it reacts with calcium hydroxide (CH) to form secondary calcium silicate hydrate (C-S-H) this process is known as pozzolanic reaction. It leads to studies on partial use of waste glass as raw material in concrete batching. The finely ground glass powder reacts with alkali and cementatious product for increase the development in strength.

A. Objectives of the Project

- To study the properties of concrete like workability, compressive strength, and Flexural strength with partial replacement of cement with glass powder and fine aggregate with copper slag in concrete.
- Study the influence of partial replacement to fine aggregate with copper slag by using V.S.I. sand.
- Find the percentage of copper slag replaced to fine aggregate that makes the strength of concrete maximum using V.S.I. sand.
- Determine the suitability of glass powder as partial replacement with cement and copper slag with of fine aggregate in concrete.
- Find the alternative of basic materials which are used in construction from past many years.
- To manage the industrial waste and to determine the suitability of cooper slag and glass powder as partial replacement with fine aggregate and cement.

– Compare the mechanical properties of glass powder and copper slag in concrete with control concrete.
– Develop suitable mix design.

B. Significant of the Study:

– To reduce the space required for landfill of glass powder and copper slag.
– To diminish the pressure of exploiting the natural resources.
– To introduce the potential of cement as glass powder and fine aggregate as copper slag.

II. MATERIAL USED

1) Cement: Locally available OPC 53Grade cement is used.
2) Fine Aggregate: Locally available VSI sand is used, with specific gravity 2.63, water absorption 2%
3) Coarse Aggregate: Locally available coarse aggregate from quarry is used, maximum size 20 mm, with specific gravity 2.68, water absorption of 0.705%
4) Water: Portable water was used for the experimentation.
5) Glass powder: Glass powder obtained from Store. Glass powder is an ideal material for recycling. The use of glass powder as partial replacement with cement is the best alternative.
6) Copper slag: Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on molten metal. Copper slag is mixed in the concrete as replacement material of fine aggregate. It is the waste product of copper produces from iron or steel plant.

III. PHYSICAL PROPERTIES OF MATERIAL USED

A. Cement:

Physical properties of cement are as follows;

S. No	Property	Test results
1	Normal consistency	31.5%
2	Specific gravity	3.15
3	Initial setting time	130-160 minutes
4	Final setting time	230-260 minutes

Table 1: Physical properties of Cement

B. Fine Aggregate:

Physical properties of Fine Aggregate are as follows;

S. No	Property	Test results
1	Specific gravity	2.60
2	Fineness Modulus	3.75
3	Grading Zone	II

Table 2: Physical properties of Fine Aggregate

C. Coarse Aggregate:

Physical properties of Fine Aggregate are as follows;

S. No	Property	Test results
1	Size	20mm
2	Specific gravity	2.68
3	Fineness modulus	7.20
4	Total water absorption	0.705%
5	Shape	Angular

Table 3: Physical properties of Coarse Aggregate

D. Glass powder:

Physical properties of Glass powder are as follows;

Sr. no	Physical property	Test result of cement	Test result of glass powder
1	Specific Gravity	3.15	2.68
2	Fineness passing 90µm	<90µm	<75µm
3	Colour	Grey	White

Table 4: Physical properties of Glass powder

E. Copper slag:

Physical properties of copper slag are as follows;

S. No	Property	Test results
1	Moisture content	0.1%
2	Specific gravity	3.35
3	Fineness modulus	3.18
4	Total water absorption	0.40%
5	Shape	irregular
6	Appearance	Black and Glassy
7	Type	Air cooled

Table 5: Physical properties of Glass powder

IV. EXPERIMENTAL PROGRAM AND SETUP

The main aim of this experimentation is to study the effect of partial replacement of cement with glass powder and fine aggregate with copper slag on the properties of concrete and check its compressive strength, flexural strength and workability of concrete. The experimental programme is divided in four phases.

1) Concrete mix design is done as per IS 10262-2009 for M30.
2) Casting of cubes and beams.
3) Curing of cubes and beams for 7 days and 28 days.
4) Testing of cube in compression testing machine and Beam are tested in flexural testing machine.

Each test result plotted in the Figures or given in the Tables is the mean value of results obtained from at least three specimens.

V. MIX DESIGN

Concrete mix design is done as per IS 10262-2009 for M30 grade of concrete. Material quantity required for 1m^3 volume of work are tabulated in table no.5

S. No	Item	For 1 m^3Concrete	Mix Ratio
1	Cement	350.00 Kg	1
2	Fine aggregate	664.00 Kg	1.897
3	Coarse Aggregate	1271.00 Kg	3.631
4	Water	140.00 Lit.	0.42

Table 5: Material Quantity for 1 m3

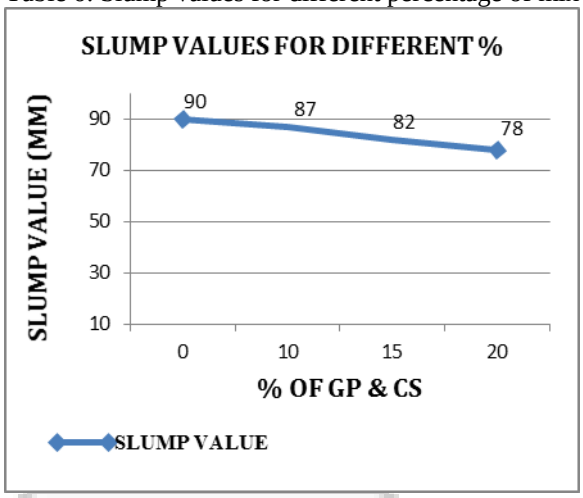
VI. WORKABILITY

The workability of M30 grade of concrete is measured by widely used empirical test i.e. slump test with w/c ratio 0.40 for addition of different percentage glass powder and copper slag.

Values obtain for different percentage mix is as show in following Table 6

% of cement replaced with glass powder and fine aggregate with copper slag	Slump value (mm)
0	90
10	87
15	82
20	78

Table 6: Slump values for different percentage of mix



Graph 1: Slump Value

VII. Experimental Methodology

A. *Compressive Strength Test:*

Compressive strength is measured at 7 days and 28 days. The result indicate that as we increase the percentage of glass powder and copper slag from 0% to 15% its compressive strength increases after the further increments in percentage of glass powder and copper slag there is loss in strength. That mean we replace up to 15%.

B. *Flexural Strength Test:*

Testing of all beam specimens with two point loading is carried out to measure its flexural strength. The load was applied by using a hydraulic jack via a load cell. The load was transferred from the jack to the main specimen by using a loading beam Two roller supports carried the reactions; therefore, the loading states were two incremental bending points loads. The deflection at the Centre of web is measured by using dial gauge.

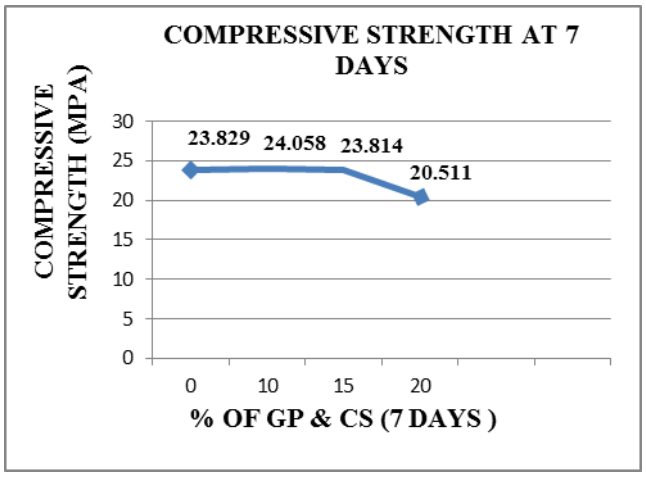
$$F_r = \frac{P \times L}{b \times d^2}$$

VIII. Experimental Results

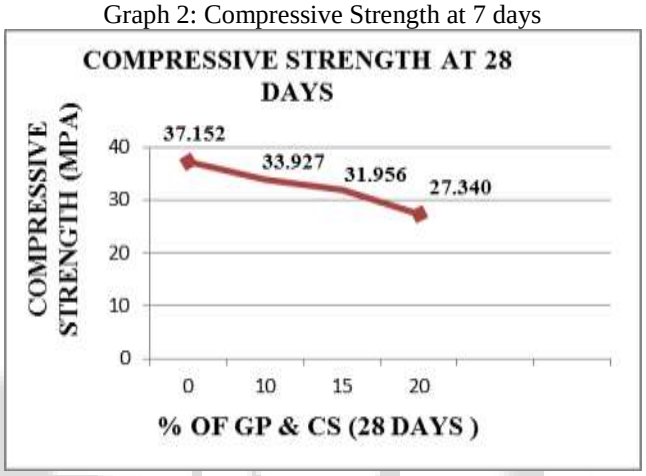
A. *Compressive Strength Test:*

% of Crushed Plastic Bottle Caps	Compressive Strength (N/mm^2)	
	7-Days	28-Days
0	23.829	37.152
10	24.058	33.928
15	23.814	31.956
20	20.814	27.340

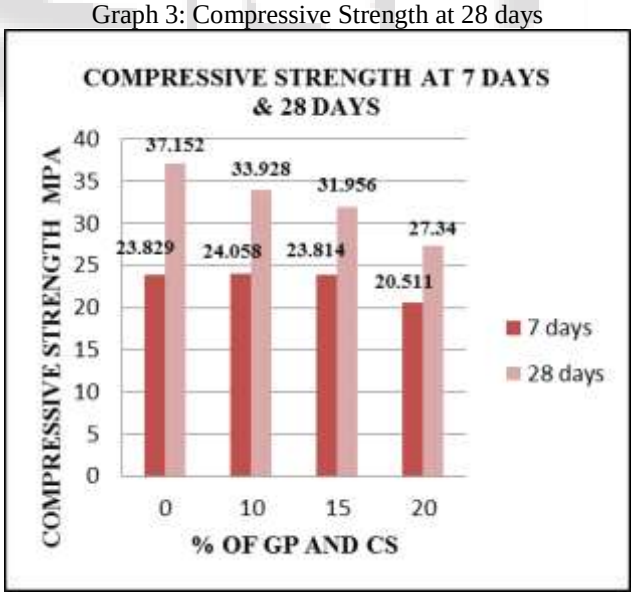
Table 7: Results of Compressive Strength



Graph 2: Compressive Strength at 7 days



Graph 3: Compressive Strength at 28 days

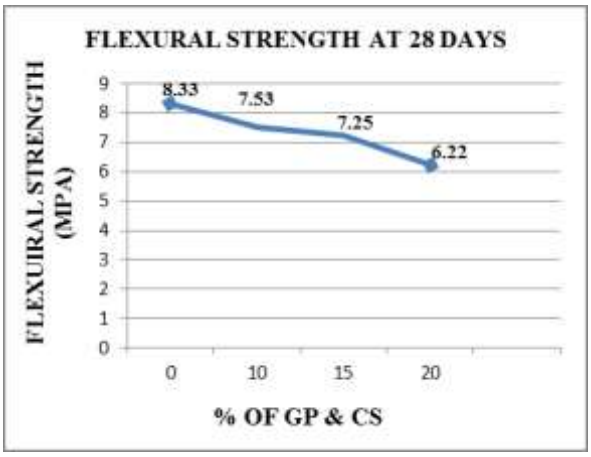


Graph 4: Compressive Strength 7 days at 28 days

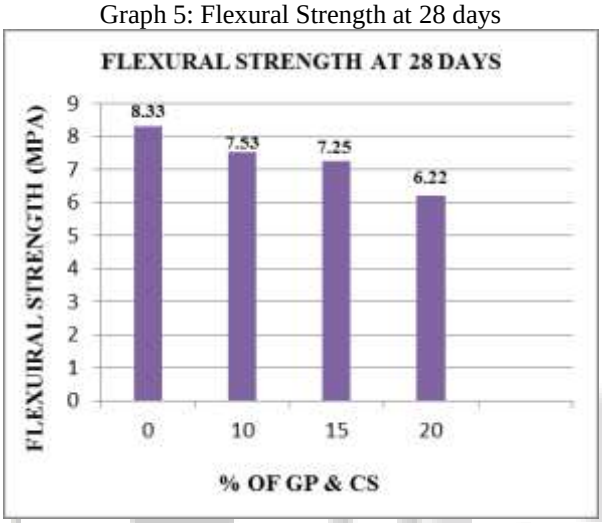
B. *Flexural Strength Test:*

% of Crushed Plastic Bottle Caps	Flexural Strength (N/mm^2) 28 days
0	8.33
10	7.53
15	7.25
20	6.22

Table 8: Results of Flexural Strength



Graph 5: Flexural Strength at 28 days



Graph 6: Flexural Strength at 28 days

IX. CONCLUSION

Based on results and observation made in experimental research study. The following conclusions are drawn.

1) It is observe that with increase in percentage of waste glass powder and copper slag workability decreases.
2) Concrete made by partial replacement of cement with glass powder and fine aggregate with copper slag is cheaper than conventional concrete.
3) Current study concluded that strength of concrete is achieved up to 15% replacement and strength of concrete decreases at 20%.
4) The use of waste glass powder and copper slag in concrete is possible to improve its compressive strength, and flexural strength.
5) Glass powder with 75micron size shows pozzolanic properties as per ASTM.
6) The results of the slump tests of waste glass powder as cement and fine aggregate as copper slag in concrete mixtures, these results indicate that the slump value of fresh concrete is prone to decrease with increasing copper slag aggregate ratio.
7) The slump was about 90 mm for concrete without any plastic aggregate and the slump was about 82 mm for replacement of 10% copper slag aggregate in concrete. The reasons for the lower slump value of the concrete mix containing plastic aggregate are the sharp edges and angular particle size of plastic aggregate.
8) Flexural strength of concrete increase up to 15% and at 20% flexural strength of concrete decreases.

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