An Experimental Study on Strength Properties of Concrete with Partial Replacement of Cement by Pozzolanic Glass Powder

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***Abstract*- Waste glasses were finely grind to use as ordinary Portland cement (OPC) replacement in concrete. Its pozzolanic reactivity was evaluated at different replacement levels, including 5%, 10%, 15% by mass. The particle size distribution for glass powder is almost the same as that of OPC. It was found that the total hydration heat was greatly reduced due to the dilution effect of OPC, which results in a lower strength at early age. However, the pozzolanic reaction of glass powder became obvious with longer curing period, supported by the much improved strength for concrete with 15% glass powder. Calcium hydroxide content was determined at different ages for paste with various amount of glass powder and the results revealed that the calcium hydroxide drastically dropped with age, consumed by the pozzolanic reaction of glass powder. At 28 days, almost no calcium hydroxide was found in the paste with glass powder, implying that the optimum replacement level should be less than 45%.**

***Index terms*- calcium hydroxide, glass powder, pozzolanic reaction, replacement, waste glass**

I.INTRODUCTION

Concrete is the most widely used construction material in civil engineering industry because of its high strength and stability. Concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem ie, waste glass powder. Lime stone is short supply in India thus; an increased demand for cement and concrete can be met by partially replacing cement with waste glass powder. Glass is an inert material which could be recycled and used many times without changing its chemical property.

II. OBJECTIVES

- The main objectives of the present work is to systematically study the effect of percentage of replacement of glass powder by cement
- To study the influence of manufactured cement on the compressive strength development of concrete and compare the result with that of concrete produced using selected glass powder.
- The study is carried out by partially replacing manufactured glass powder in 5,10,15 %.

GLASS POWDER

- Glass is an amorphous (non-crystalline) that in essence, a super cooled liquid and not a solid.
- Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibers to meter -sizes pieces.
- Primarily glass is made up of sand, soda ash, limestone and other additives (Iron, Chromium, Alumina, Lead and Cobalt).
- Glass has been used as aggregates in construction of road, building and masonry materials.

Fig .1 crushing process of waste glass

Sources of waste glass

- Glass food and beverages container
- Window repair shops
- Glass decorative items
- Old tube lights, electric bulbs
- Glass polishing and glass window and door manufacturing shop.

PHYSICAL PROPERTIES OF GLASS POWDER

Table.I- physical properties of glass powder

Sl. No	Physical Properties of Glass powder	
1	Specific Gravity	2.6
2	Ph	10.25
3	Colour	Grayish White

CHEMICAL COMPOSITION OF GLASS POWDER

Table.II- chemical properties of glass powder

S.No	Chemical Properties of Glass Powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420
4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8	K_2O	0.638
9	ZrO_2	0.019
10	ZnO	0.008
11	SrO	0.016
12	P_2O_5	0.051
13	NiO	0.014
14	CuO	0.009
15	Cr_2O_3	0.022

III. METHODOLOGY

The methodology clearly shows the process which have been carried out in this work. The step by step process of this project is explained in the fig. This is discussed below.

- Collecting the material like cement, coarse aggregate, and fine aggregate. And to collect the replacing material glass powder.
- Material properties like specific gravity, setting time will be studied for fine aggregate, coarse aggregate, cement, glass powder.
- IS method of Mix design will be made for concrete as per IS 10262- 2009.
- The M40 grade concrete is used for the casting of specimen.
- Totally 24 cubes, 24 cylinders and 8 prisms are casted.
- The glass powder is replaced at 5% ,10%,15%.
- The cubes are tested under compressive testing machine, the cylinders are tested under ultimate testing machine and prisms are tested under ultimate testing machine.
- The values are noted from the testing of cubes, cylinders and prisms.
- The calculations are made on the test results.
- Experimental investigations are made on strengthening the conventional concrete by replacing glass powder in different percentages.

IV. CONCRETE MIX DESIGN

In any mix proportioning, the quantities to be determined are those of the four materials i.e. Water, Cement, Fine aggregates and Coarse aggregates.

In this investigation, M40 mix concrete is considered to perform, the test by weight basis by replacement of 0%, 5%, 10%,15% of glass powder in the concrete. Different mix proportions used are shown in the table.

Table.III- mix proportion

Water	Cement	Fine aggregate	Coarse aggregate
186L	465kg	538.02kg	1172.11kg
0.40	1	1.15	2.52

V.TESTS ON HARDENED CONCRETE:

Test on hardened concrete is carried out to determine the strength of the concrete such as:

A.Compressive strength

B.Flexural strength

C.Split tensile strength

A.COMPRESSIVE STRENGTH TEST

The compression test is conducted to determine the internal resistance of a material towards the load acting onto it. The compressive strength of thirty cubes of 150mm x150mm x 150mm was tested for 7, 14 & 28 days. 2000 KN capacity compression testing machine (CTM) was used to measure the compressive strength of concrete. As per IS: 516-1959, loading rate of 2.5 KN/S was applied. Compressive strength was measured for 7, 14 & 28 days. The table below shows the compression strength for various mix trails.

Ultimate compressive strength = Ultimate compressive load / Area of the specimen

Fig.5 Test for Compressive Strength

B.FLEXURAL STRENGTH TEST

Flexural strength of fifteen concrete prisms of 100mm x100mm x 500mm were tested for 7, 14 & 28 days was tested based on IS: 516-1959. The specimen is casted and cured as per standards prescribed for such tests. After the period of curing the specimen is allowed to dry for about four hours.

The axis of the specimen is carefully aligned with the axis of the loading device of the flexural strength testing machine. No bearing is used between the bearing surfaces of the specimen.

Flexural strength = pl/bd2 (for a < 13.3 cm)

=3pa/bd2 (for a > 13.3 cm)

Where, P = Applied load,

L = Length of the specimen,

b& d = C/S dimension

C.SPLIT TENSILE STRENGTH TEST

The Split tensile strength of 30 cylinders of 150mm diameter and 300mm long was carried out for 7, 14 & 28 days as per IS 5816-1976. As per IS456, split tensile strength of concrete.= 0.7Fck.The split tensile strength of concrete using formula

TSP = 2P/ΠDL

Where, P = Applied load,

D = Diameter of the specimen,

L = Length of the specimen

Fig.6 Test for Split Tensile Strength

VI. RESULTS AND DISCUSSION

The following results were obtained from the tests conducted on the proposed specimens.

a)COMPRESSIVE STRENGTH TEST

Table.IV-Compression Strength Test Results

S. No	Glass powder (%)	Compressive strength(N/mm^2)		
		7 DAYS	14 DAYS	28 DAYS
1.	0%	24.80	28.60	33.65
2.	5%	26.80	29.33	35.60
3.	10%	27.11	31.14	36.72
4.	15%	28.72	35.50	38.20

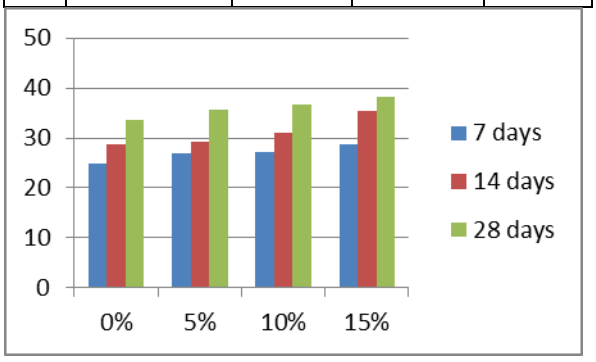

Fig.7 Comparison of compressive strength for 7, 14 & 28 days

b)SPLIT TENSILE TEST RESULTS

Table.V- Split tensile strength test results of 7, 14 & 28 days

Sl. No	GLASS POWDER %	Split Tensile Strength (N/Mm^2)		
		7 Days	14 Days	28 Days
1	0%	2.43	2.85	3.41
2	5%	2.68	3.18	3.56
3	10%	2.71	3.38	3.60
4.	15%	2.97	3.46	3.71

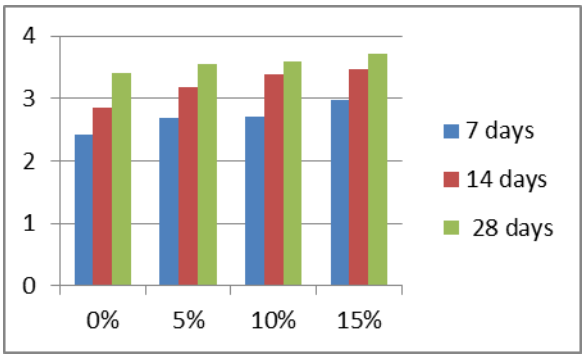

Fig .8 Comparison of split tensile strength for 7, 14, 28 days

c)FLEXURAL TEST RESULTS

Table VI - Flexural strength test results

Sl. No	GLASS POWDER %	Flexural Strength (N/Mm^2) 28 Days
1	0%	2.71
2	5%	3.43
3	10%	3.90
4	15%	4.16

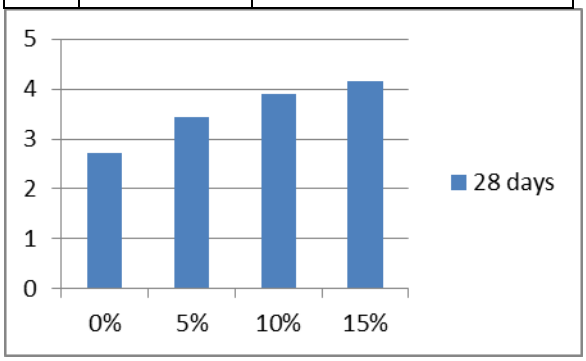

Fig. 9 Comparison of flexure strength for 28 – days

VII. CONCLUSION

The following conclusion can be from the results obtained from the experimental investigations:

- The test carried out at 7 days, 14 days,28 days the comparison is made between the conventional concrete with three proportion of glass powder (5%,10% &15%).
- The result obtained is there is an increase in the strength of compressive, split tensile, flexural strength of concrete at the combination of 15% glass powder.

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