ANALYSIS OF STRENGTH AND DURABILITY OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH GLASS SILICA POWDER

Mayank Tyagi[1], B.S. Tyagi[2]

[1]M.Tech Student, Department of Civil Engineering, Radha Govind Group of Institution Meerut. E-mail:
[2]Assistant Professor, Department of Civil Engineering, Radha Govind Group of Institution Meerut. E-mail:

Abstract - *Now a days, in a developing country like India usage of a large quantity of industrial waste are becoming hazardous to the environment. By keeping this in the mind the study has been performed to make use of such type of industrial waste which can be utilized which self-contribute to the developing infrastructure in such countries. Apart from reducing environmental hazard this type of materials will also help in improving the construction materials properties like its strength, workability, durability, flexural strength etc.*

***Key Words*: Glass powder, Compressive strength, Split tensile strength, Flexural strength……**

1. INTRODUCTION

Tons of tons of waste glass material is getting generated every year throughout the globe. This waste glass material generated it is generally used for land filling which is definitely not a sustainable solution since it will not decompose in the nature. Glass predominantly consists of silica. Using this waste glass material in the preparation of concrete mix to construct any structure as a partial replacement to cement could definitely be very crucial step to save the environment be it in reducing the carbon dioxide emission, reduction of raw materials, and unlawful way of discarding the glass which is used mainly as land filling material. Hence this can be considered as an environmentally friendly, economical or cost saving, and energy effective in infrastructure system. When we grind the waste glass material down to micro size particles it will undergo pozzolanic chemical reactions with the cement and it hydrates to form secondary calcium silicate hydrate.

The analysis of chemical properties of the glass as well as the cement samples was determined by using x-ray fluorescent technique and it was found there are minor differences with reference to chemical composition of clear and coloured glass samples.

2. EXPERIMENTAL STUDY

The various properties of concrete depend upon the many factors like water-cement ratio, shape and size of aggregate and type of aggregate etc. In the present experimental study cement, sand, coarse aggregate, water, glass silica powder has been used. The properties of all ingredients of concrete i.e., cement, fine aggregate, natural coarse aggregate, and glass silica powder, determined as per Indian standard specifications.

2.1 Cement

In this project, locally available Ordinary Portland cement of 43 grade is taken in to account which conforms to Indian Standard code 8112-2013 as shown in Table-1.

Table -1: Physical properties of Cement

Properties	Result
Normal consistency	29.50%
Fineness	2%
Soundness	1mm
Setting time. a) Initial setting time b) Final setting time	150 minutes. 215 minutes.
Specific gravity	3.15

2.2 Fine Aggregate

The fine aggregates which is considered for this project work is having maximum size of 4.75 mm in diameter are shown in Table-2.

Table -2: Properties of Fine Aggregate

Properties	Result.
Zone	II
Fineness modulus	2.923
Specific gravity	2.65
Bulk density (Loose)	1818.18 Kg/cum
Bulk density (Compacted)	1909.09 Kg/cum

2.3 Coarse Aggregate

Natural coarse aggregate to be used as shown in Table-3.

Table -3: Properties of Coarse Aggregate

Properties	Result
Specific gravity	2.66
Impact value	10%
Crushing value	20.91%
Bulk density (Loose)	1454.55 Kg/cum
Bulk density (Compacted)	1636.36 Kg/cum

2.4 Water

The water which is considered is potable, fresh, odourless, colourless, tasteless confirming to Indian Standard code 10500. The water considered will be free from any organic matter. This water has can be used for both concrete as a binder and for curing of concrete as well.

2.5 Chemical Composition of Cement and Powdered Glass

In present experimental work different property are defined as shown in Table–4.

Table -4: Properties of Cement and Powder Glasses

Composition (% by mass) /Property	Cement	Wate Glass Powder
Silica (Sio_2)	20.2	72.3
Alumina (Al_2O_3)	4.7	0.4
Iron Oxide (Fe_2O_3)	3.0	0.2
Calcium Oxide (Cao)	61.9	9.7
Magnesium Oxide (MgO)	2.6	3.3
Sodium Oxide (Na2O)	0.19	13.7
Potassium Oxide (K2O)	0.82	0.1
Sulphur trioxide (SO3)	3.9	-
Loss of ignition	1.9	0.36
Fineness % passing (sieve size)	97.4 (45 µm)	80 (45 µm)

2.6 Concrete Mix Design

In present experimental work different property are defined as shown in Table–5.

Table -5: Final Mix Proportion

Material	Weight (kg/cum)
Cement	405
Fine aggregate.	674.96
Coarse aggregate.	1158
Powdered Glass	1132
Water.	182

3. EXPERIMENTAL METHODOLOGY

3.1 Compressive Strength Test

Compressive strength test for the cement concrete specimen is a mechanical test which is performed to measure the maximum value of compressive load that the concrete specimen takes before it cracks. The specimen used for the test was a cube of standard size 150 mm X150 mm after 24 hours these cubes were de moulded and immersed in the curing tank. The curing of specimen at 7days and 28 days has been done. The testing of specimen has been carried out at 7days and 28 days as per- IS-516-1959.The test value with different proportion of fibre reinforced concrete are given in Table–7 and graphically represented in Fig.- 2.

Fig. No-1 Compressive Strength Test.

Table-7. Compressive Strength at 7&28 Days.

S. No	% Replacement of glass Powder	Compressive strength (N/mm²)	
		7Days.	28 Days.
1	0.0%	20.02	32.36
2	10%	22.50	33.49
3	20%	24.84	34.78
4	30%	20.65	33.70
5	40%	20.01	33.05

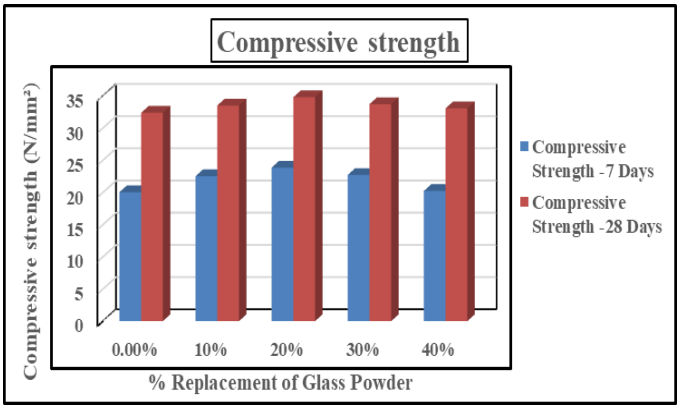

Fig- 2 Compressive Strength of Concrete.

3.2 Split Tensile Strength Test

To find out split tensile strength, 150mm diameter and 300mm height cylinder were casted. After 24 hours all specimen were de moulded and immersed in curing tank.

The curing of specimen at 7 days and 28 days has been done. The testing has been carried out at 7days and 28 days. The test result value of fibre reinforced concrete is given in Table- 8 and graphically represented in Fig-4.

Fig.No-3 Split Tensile Strength Test.

Table-8. Split Tensile Strength at 7&28 Days

S. No	% Replacement of Glass Powder	Split tensile strength (N/mm²)	
		7days.	28days
1	0.0%	2.203	3.82
2	10%	2.338	4.14
3	20%	2.477	4.52
4	30%	2.403	4.38
5	40%	2.023	3.87

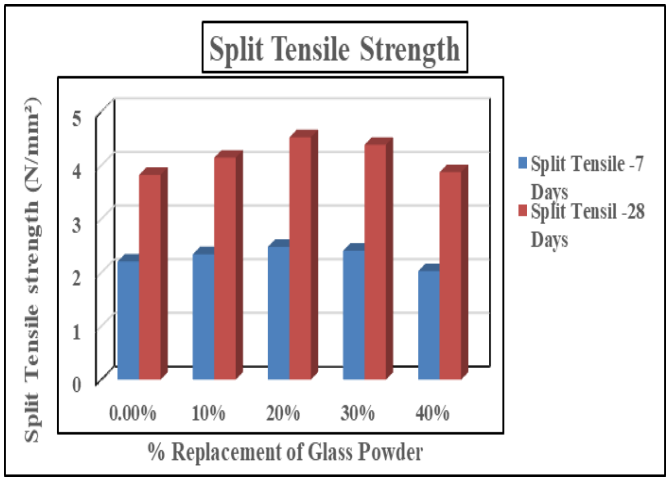

Fig- 4 Split Tensile Strength of Concrete.

3.3 Flexural Strength Test

For calculating flexural strength, 150x150x700 mm, size beam was casted. After 24 hours the beam specimen was de moulded and immersed in the curing tank. The curing of specimen at 7days and 28 days has been done. The testing has been carried out at 7days and 28 days as per - IS-516-1959.

The experimental test result of fibre reinforced concrete beam are given in Table-9 and graphically represented in Fig-6.

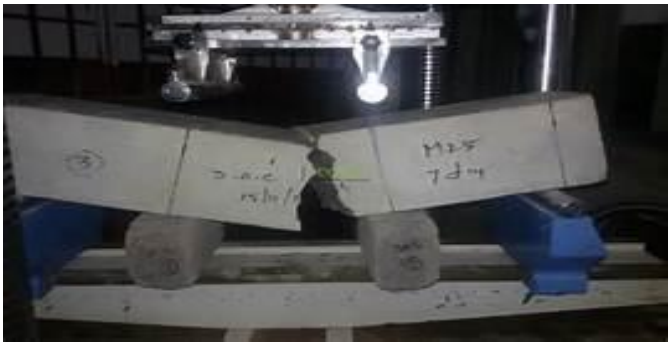

Fig. No-5 Flexural Strength Test.

Table-9. Flexural Strength at 7&28 Days.

S. No	% Replacement of Glass Powder	Flexural strength (N/mm^2)	
		7Days.	28days.
1	0.0%	2.20	3.11
2	10%	2.34	3.28
3	20%	2.49	3.96
4	30%	2.35	3.39
5	40%	2.10	3.01

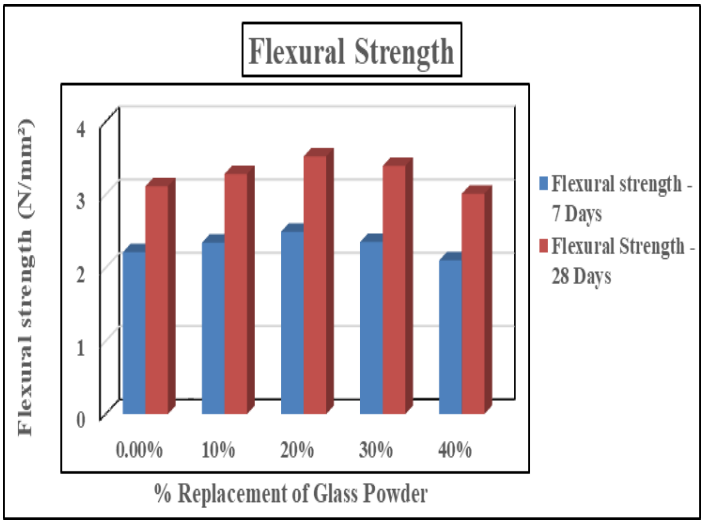

Fig- 6 Flexural Strength of Concrete.

3.4 DURABILITY TEST

3.4.1 Acid Attack Test

This test was conducted to check the resistance of the concrete cube towards acid attack. This test involves preparation of concrete cube of standard size 150 mm x 150 mm x150mm. Three cubes were selected after proper curing for 28 days. And later these cubes were completely submerged in 5% concentrated sulphuric acid solution and left them there for another 28 days. Later these samples were taken out and the surface were cleaned carefully. Then the weight of the samples was noted down. Then the percentage decrease in weight was checked by subtracting with its original weight before the test was conducted. Later the compressive strength test was conducted and the reduction in compressive strength was also noted down.

Sl. No.	Initial Weight of cube	Weight after test	% Reduction in weight
1.	8.77	8.09	7.75
2.	8.81	8.31	5.67
3.	8.75	8.23	5.94

3.4.2 Sulphate Attack Test

Generally speaking, any type of soil will contain varieties of sulphates like magnesium sulphate sodium sulphate potassium sulphate calcium sulphate etc. This sulphates when come in contact with the concrete will start attacking in the form of sulphate salts. This reaction can happen only when the sulphate salts are in the form of solution. Hence the rate of sulphate attack is dependent on the concentration of sulphate salts and as well as the rate at which salt can diminish. Whenever sulphate solution comes in contact with outer surface of the concrete starts moving towards the inner portion of the concrete structure this rate depends on lot of parameters. One of them is porosity. Hence the permeability of concrete and its density will become very critical factors to resist the sulphate attack. Sulphate attack represents a process in which the volume of cement slurry in the given concrete or cement mortar will be increased due to the chemical reaction between the sulphate and the concrete. If we consider hardened concrete calcium aluminates hydrates (C-A-H) good react with aluminium salts on outer surface of the concrete. Has the strength of the sulphate solution increases the rate of its attack also increases. In this project we have performed sulphate attack test by using magnesium sulphate solution. For this purpose, concrete cube specimen of size 150 mm X 150 mm X 150 mm were 50 used. These concrete cubes were your for 28 days. After 28 days of curing they were taken out why at the water on the surface of these cubes. Left them for 2 to 3 hours for drawing in normal room temperature. And then these cubes were completely immersed in 5% magnesium sulphate solution for 7 & 28 days. Later these cubes were taken out and testing was performed.

$MgSO4 + Ca(OH)2 + 2H2O = CaSO4.2H2O + Mg(OH)2$”

Sl. No.	Initial Weight of cube	Weight after test	% Reduction in weight
1.	8.68	8.06	7.207
2.	8.72	8.20	5.92
3.	8.84	8.30	6.10

4. CONCLUSIONS

Based on the experimental study the following conclusion has been drawn.

1. The concrete mix gets harsher and less workable with increases of Glass powder content therefore, use of admixture becomes necessary could not obtained the proper workability

2. The maximum compressive strength of concrete increased by 24.2% at 7days and 7.5% at 28 days up to 20% of Glass Powder but it Decreases by 20.3% at 7days and 3.2% at 28 Days.

3. The maximum Split Tensile Strength of concrete increased by 12.5% at 7 days and 18% at 28 Days up to 20% of Glass Powder but it Decreases by 3% at 7 days and 3.8% 28 Days.

4. The maximum flexural Strength of Concrete concrete increased by 13% at 7 days and 27.5% at 28 Days up to 20% of Glass Powder but it Decreases by 6% at 7 Days and 17% at 28 Days

5. The workability of concrete is decreased with the increasing of Glass Silica Powder in concrete.

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