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PARTIAL REPLACEMENT OF CEMENT IN CONCRETE BY GLASS POWDER

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ABSTRACT

Concrete is a construction material composed of cement, aggregates (fine and coarse aggregates) water and admixtures. Today many researches are ongoing into the use of Portland cement replacements, using many waste materials like pulverized fly ash (PFA) and ground granulated blast furnace slag (GGBS). Like PFA and GGBS a waste glass powder (GLP) is also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also it is act as a filler material.

In this study, waste glass powders have been used as replacements to the concrete ingredient cement and the mechanical properties like compressive strength are measured. Also we were studied the size effect of glass powder on strength of concrete.

For checking strength effect of replacement of cement by glass powder, the cement is replaced at 5%, 10%, 15% and 20%. It is found from study, Initial strength gain is very less due to addition of GLP on 7th day but it increases on the 28th day. The present study shows that waste glass, if ground to particle size 150 micron shows a pozzolonic behavior. It reacts with lime at early stage of hydration forming extra CSH gel thereby forming denser cement matrix. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. The results showed that the maximum increase in strength of concrete occurred when 15% replacement was done with glass powder.

Keywords- *waste glass powder; concrete; strength; replacement Partial Replacement of Cement in Concrete by Glass Powder*

1. INTRODUCTION

Concrete is the most widely used as construction materials in the world. In fact, concrete is used in virtually everything and there is still no substitutes are available for many of its application. Without concrete, the community and society today could not exist. In recent years, there has been an increasing incentive to minimize the environmental effect of the construction industry through programs such as the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, which rewards points for sustainable construction practices.

Today many researches are ongoing into the use of Portland cement replacements, using many waste materials and industrial by products, for example, pulverized fly ash (PFA) and ground granulated blast furnace slag (GGBS). Like PFA and GGBS, a glass powder (GLP) is also used as a binder with partial replacement of cement which takes some part of reaction at the time of hydration; also it is act as a filler material Partial replacement of cement with milled waste glass benefits the microstructure and stability of cementitious materials.

Manufacturing processes, service industries and municipal solid successful utilization of glass as fine aggregate will turn this wastes are the sources of production of numerous Waste materials. Concerns related with disposal of the generated wastes have tremendously increased with the Increasing awareness about the environment. Solid waste management is one of the major environmental concerns in the world. Waste utilization has become an attractive alternative to disposal because of the scarcity of space for land filling and due to its ever increasing cost.

The use of waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. Storage and safe disposal of waste glass is major problem for municipalities everywhere and this problem can be reduced or eliminated by reusing waste glass.

1.1 Objective

The objective of the research is to study the effect of the use of „Glass Powder" as a replacement of cement to assess the pozzolanic nature of fine glass powder when mixed in concrete and to know the extent to which glass powder can replace cement.

1.2 Characteristics of Material used

Cement

- The cement used for this experiment is Ultratech ordinary Portland cement (OPC) of grade 53.
- It has confirmed to the requirement of Indian standard specification IS: 269-1963.

Glass powder

- Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and CaCO3 at high temperature followed by cooling during which solidification occurs without crystallization.
- Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing.
- Glass is an amorphous (non – crystalline) that is essence a super cooled liquid and not a so

Source of Glass–

- Sand is filtered through three different size screens having three different sizes.
- The finest sand makes the finest glass the largest sand makes the strongest glass.
- Sand is melted in crucible to make glass.

Source 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

Applications & Properties of Glass–

- Glass is a uniform amorphous solid material, which is generally produced when the viscous molten material cools very rapidly to below its glass transition temperature, without giving sufficient time for a regular crystal attice to form.
- The most familiar form of glass is the silica-based material used for windows, containers and decorative objects.
- Glass falls in the category of biologically inactive material that can be formed with very smooth and impervious surfaces.

Type	WGP	OPC	SF	FA
SiO2	72.61	20.33	89.75	47.80
Al2O3	1.38	4.65	0.14	23.40
Na2O	12.85	0.24	0.19	0.72
K2O	0.43	0.59	0.34	1.70
Cao	11.42	61.78	0.38	3.36
MgO	0.79	3.29	0.05	0.81

Table no. 1- Comparison of waste glass powder with cement and other pozzolans

Aggregate

- Natural river sand of maximum size 4.75 mm was used as fine aggregate
- Crushed stone of maximum size 20 mm was used as coarse aggregate

1. EXPERIMENTAL INVESTIGATION

1.1 Preparation of glass powder

The entire glass sample collected is broken into pieces and then it is sieved through 150 micron sieve is consider for this test.

1.2 Casting of Specimen

- There were four type of mix considered; of which One control mixture S-1 (without glass powder) was designed according to Indian Standard Specification IS: 10262(1999) (1: 1: 2, W/C ratio = 0.42) to achieve 28 days strength 25 MPa.
- The other four concrete mixes were made by replacing the cement with 5%, 10% 15%, and 20% of glass powder weight.
- The details mixture proportions are given in Table

Mix Identity	Mix Proportion
S1	100% Cement
S2	95% Cement + 5% WGP
S3	90% Cement + 10% WGP

S4	85% Cement + 15% WGP
S5	80% Cement + 20% WGP

2.3 Procedure

- The control mix was M25 designed according to the design mix in the IS: 10262(1982). For all other mixes the proportions of sand, water and aggregates remained constant.
- With various proportions of cement was replaced by glass powder.
- All replacement was carried out by volume. Normal tap water was used for casting and curing.
- The test specimen was cast in steel moulds of steel of standard dimensions i.e. 150X150X150 mm and is vibrated.
- All specimens were removed from moulds after 24 hours.
- Tests carried out for compressive strength

2.4 Experimental Setup

- The waste glass is collected from various places such as construction sites, industries, etc
- Then it is crushed to a size fine enough to achieve its pozzolanic behavior.
- Cement is now partially replaced by its weight by glass powder at varying amount such as 5%, 10% ,15% and 20 %.
- Now, 3 cubes such as three specimens for each combination – is to be casted for the whole and cured at room temperature.
- At the end of curing period, each specimen is tested for compressive strength and the average is recorded.

3. RESULT

3.1 Compressive Strength on 7th days

- MIX1 represents normal concrete of M25 grade. Table shows the 7 days compressive strength. For this three samples cube were taken and the average compressive strength is found to be 35.68 N/mm2. Fig-1 shows the graphical representation of compressive strength.

Sr. No	Mixtures	Compressive strength (N/mm2)			Average compressive strength (N/mm2)
		Cube-1	**Cube-2**	**Cube-3**	
1	M1	35.59	33.44	38.02	35.68

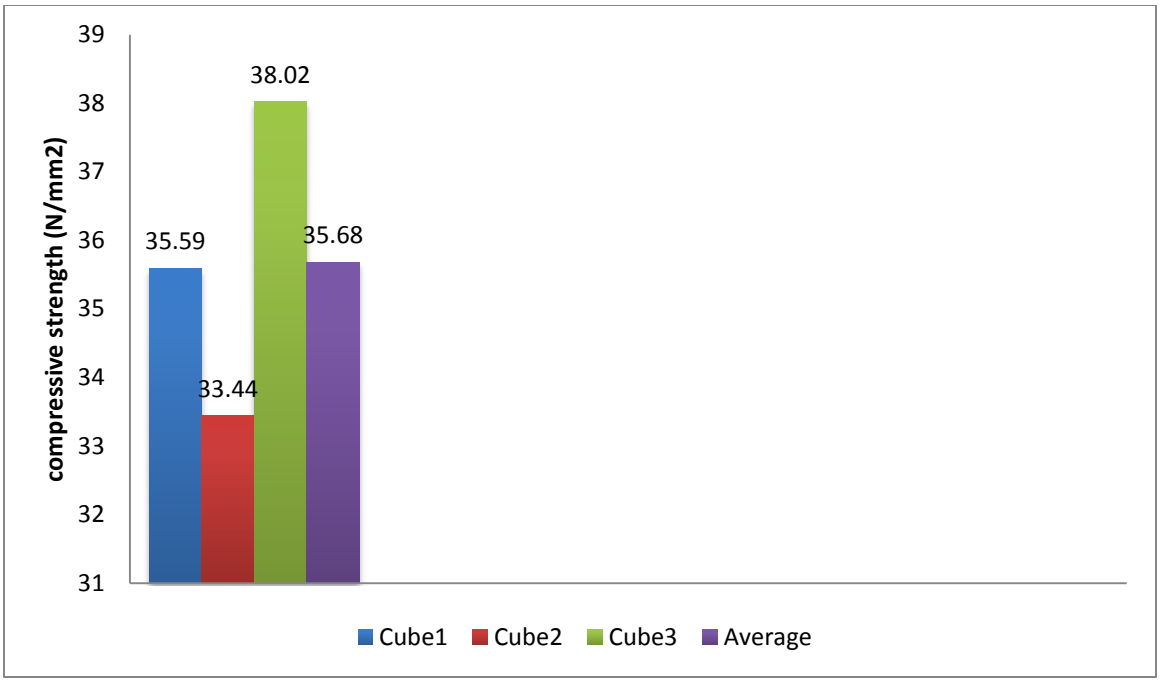

Fig 1: Compressive Strength of M25 Normal Concrete on 7th day

- MIX 2, MIX 3, MIX 4,& MIX 5 represent concrete containing glass powder of particle size 150 micron with replacement of cement 5%, 10%, 15% & 20% respectively. Total 9 cubes were casted 3 cubes for each mixture. Table and fig. 2 shows the compressive strength of sample on the 7^{th} day

Compressive strength of concrete replaced by glass powder on 7th day

Sr. No	Mixtures	Compressive strength (N/mm2)			Average compressive strength (N/mm2)
		Cube-1	**Cube-2**	**Cube-3**	
1	M1	35.59	33.44	38.02	35.68
2	M2	33.0	33.34	30.72	32.35
3	M3	31.7	30.1	29.00	30.26
4	M4	35.26	35.30	35.00	35.18
5	M5	38.40	42.08	42.47	40.98

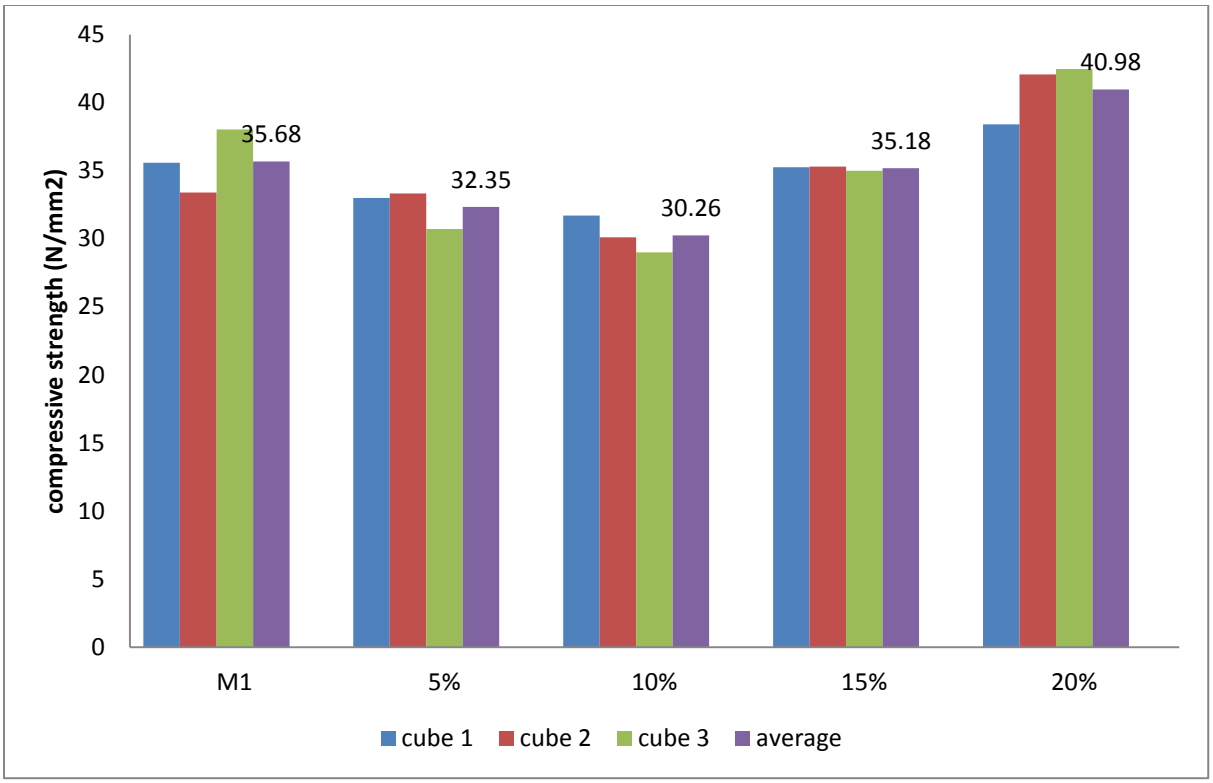

Fig 2: Compressive Strength of M25 Normal Concrete on 7th day

3.2 Compressive Strength on 14th days

- MIX1 represents normal concrete of M25 grade. Table and fig 3 shows the strength on 14thday. The average compressive strength is found to be 42.37 N/mm2.

Sr. No	Mixtures	Compressive strength (N/mm2)			Average compressive strength (N/mm2)
		Cube-1	**Cube-2**	**Cube-3**	
1	M1	40.44	42.92	43.76	42.37

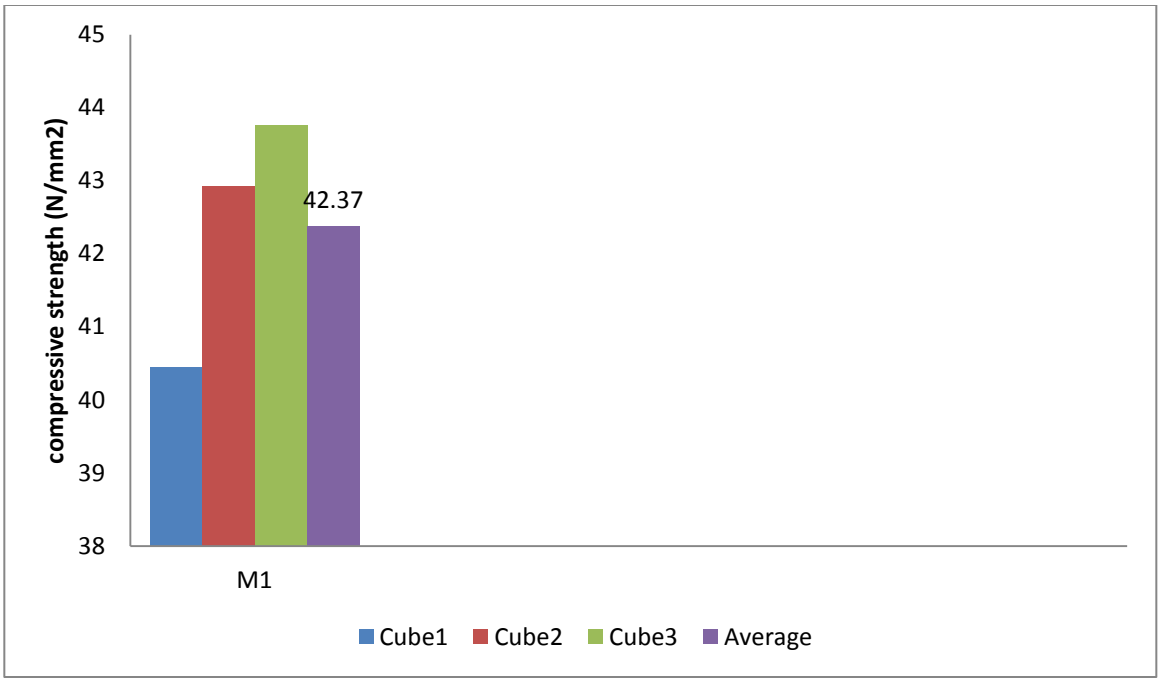

Fig 3: Compressive Strength of M25 Normal Concrete on 14th day

- MIX 2, MIX 3, MIX 4, & MIX 5 represent concrete containing glass powder with replacement of cement at 5%, 10%, 15% & 20% respectively. Table and fig.4 shows the compressive strength of samples on 14th day.

Sr. No	Mixtures	Compressive strength (N/mm2)			Average compressive strength (N/mm2)
		Cube-1	**Cube-2**	**Cube-3**	
1	M1	40.44	42.92	43.76	42.37
2	M2	34.15	36.34	33.83	34.77
3	M3	36.53	37.08	35.58	36.39
4	M4	42.32	39.92	41.04	41.09
5	M5	34.77	35.96	32.04	34.25

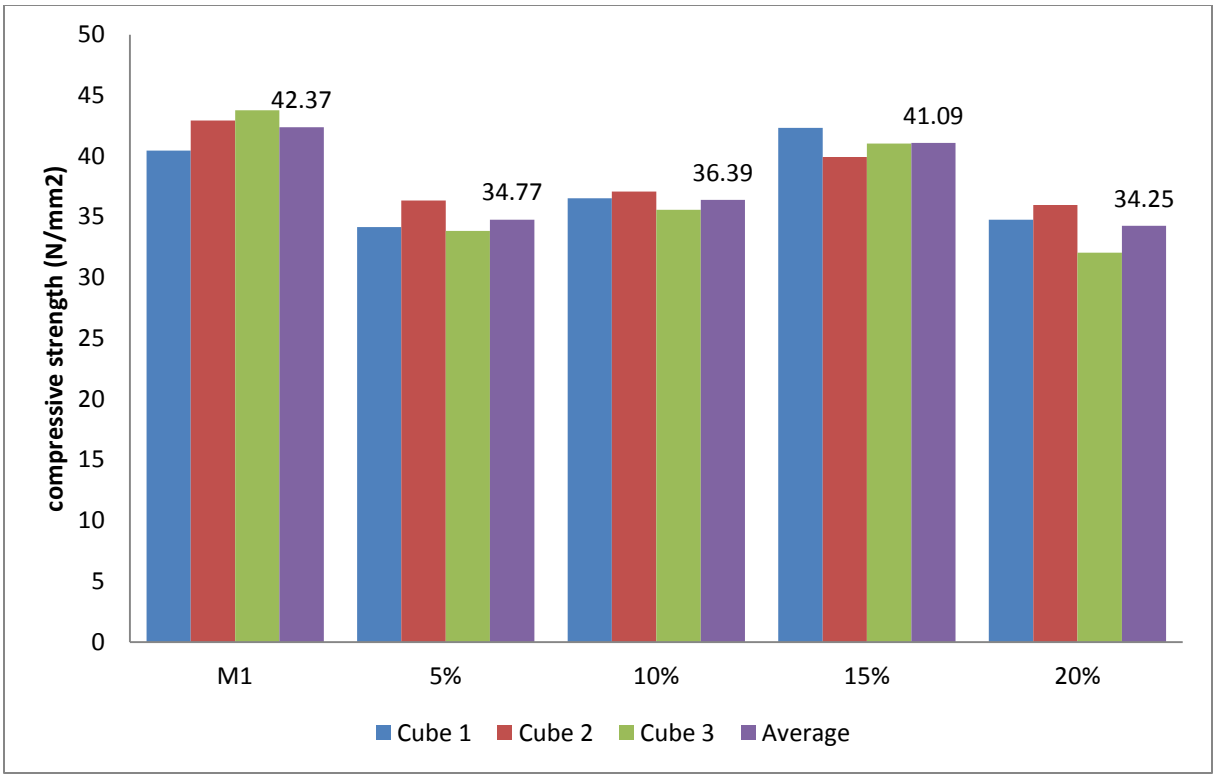

Fig 4: Compressive Strength of M25 Normal Concrete on 14th day

4. CONCLUSION:

From the test results is concluded that:

- At the level of 15% replacement of cement by glass powder meets higher strength as 14th days**.**
- compare to that of normal concrete and other percentage of replacement of cement onGlass powder concrete increases the compressive strength effectively, when compared with conventional concrete.
- On addition of Glass powder 7th day's rate of gain of strength is low but at 14th days it meets required design strength.
- The initial rate of increase of strength is more for 20% glass powder added concrete compared to 10% and 15% glass powder added concrete with respect to normal concrete for 7 days results.
- Considering the strength criteria, the replacement of cement by glass powder is feasible. Therefore we can conclude that the utilization of waste glass powder in concrete as cement replacement is possible.
- Finally test result shows that the compressive strength for 15% of glass powder replacement is maximum as compared to other mixes which is 41.09 N/mm2 for 14 days.

FUTURE SCOPE:

- The effect of glass materials on compressive strength of concrete as partially replacement of coarse aggregates and fine aggregates can be analyzed and studied.
- The replacement of glass with different water cement can be studied.
- Can be studied with different concrete mix proportions.
- In the present study the ordinary Portland cement was used. Further its mechanical properties can be compared by using different cement.
- Tests for chemical properties, tensile strength, slump loss, workability & many others can be done.
- Glass fiber can be introduced in concrete.

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