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# Studies on Glass Powder as Partial Replacement of Cement in Concrete Production

**Varinderjit Singh[1], Mr. Ajay[2]**

Research Scholar, Civil Engg Department, ICL Institute of Engg &Technology, Sountli[1]

Asst Professor, Civil Engg Department, ICL Institute of Engg &Technology, Sountli[2]

**Abstract:** Fly ash is a by product of Thermal power plants using coal as the fuel. The disposal of fly ash which is abundantly available in the country is the main problem. India has about 70 thermal power plants and produces an estimated 100 million tonnes of fly ash per annum. Such a huge amount of fly ash poses a variety of problems such as soil contamination, groundwater contamination and environment pollution.The aim of the present work is to use glass powder as a replacement of cement to assess the pozzolanic activity of fine glass powder in concrete and compare its performance with other pozzolanic materials like silica fume and fly ash. Glass is an ideal material for recycling; the use of recycled glass in new container helps save of energy. It helps in brick and ceramic manufacture, and it conserves raw materials, reduces energy consumption and the volume of waste sent to landfill. Due to this it increase the workability and decrease permeability and it having less Abrasion. By use of Glass Powder it Improved Flexural Strength.

**Keywords:** Glass Powder, Cement, Fly-Ash, Slump Test, Pozzolanic, Workability etc.

## I. INTRODUCTION

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and $CaC0_3$ 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 ideal material for recycling; the use of recycled glass in new container helps save of energy. It helps in brick and ceramic manufacture, and it conserves raw materials, reduces energy consumption and the volume of waste sent to landfill.

Wastes are produced by the Industries irrespective of the nature of their products. Disposal of wastes is a challenging task for industrial waste like fly ash and other waste products like glass, are causing environmental pollution, generally waste products like waste glass in powder form shows pozzolonic properties as it contains high $Sio_2$, therefore to some extent can replace cement in concrete in strength development.

Use of precious landfill space decreases possible area that can be used for landfills of other waste increasing the need to establish new expensive landfills. Location of most recycling plants are built within low income neighborhoods because of cheap labour and strict regulations may affect respiratory system if breathe in pollutants. Glass is Non-biodegradable, therefore it could result in serious impact after disposal. Fills of other waste increasing the need to establish new expensive landfills. Location of most recycling plants are built within low income neighborhoods because of cheap labour and strict regulations may affect respiratory system if breathe in pollutants. Glass is Non-biodegradable; therefore it could result in serious impact after disposal.

Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of green house gases, such as $CO_2$, to the atmosphere. Among the greenhouse gases, $CO_2$ contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently extensive research is on going into the use of cement replacements, using many waste materials and industrial by products.

The quantity of waste glass has slowly increased over the years due to the growing need and usage of glass products, this gives way for large quantity of waste glass. Most of these waste glasses can be recycled. At the same time today's annual global cement production has reached 2.8 billion tonnes, and is expected to increase to some 4 billion tonnes per year. Fly ash is a fine, glass powder recovered from the gases of burning coal during the generation of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. Fly ash forms a cementitious compound with properties very similar to that of Portland cement.

Because of this similarity, fly ash can be used to replace a portion of cement in concrete providing some distinct quality advantages, Usually plain cement concrete (PCC) is dense resulting in a tight and smooth surface with less bleeding. However addition of fly ash in PCC has been explored by different investigators in view of distinct

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architectural benefit with improved textural consistency. The main advantage with fly ash is that it is pozzolanic material. The pozzolanic activity is due to the presence of finely divided glassy silica and lime which produce calcium silicate hydrate. The growth and interlocking of this hydrate gives mechanical strength.

In the presence of water, the fly ash particles produced from a bituminous coal react with lime or calcium hydroxide to form cementing compounds similar to those generated on the hydration of Portland cement. Previous research findings and majority of current industry practices indicate that satisfactory and acceptable concrete can be produced with Class F fly ash replacing 15 to 30% of cement by weight.

Use of Class F fly ash in general reduces water demand as well as heat of hydration. The concrete made with Class F fly ash also exhibits improved resistance to sulphate attack and chloride ion ingress. By use of Fly Ash it decrease the Permeability And reduce Bleeding, segregation. Fly Ash Increase the strength.

The paper is ordered as follows. In Section II, It defines significance of the work. In section III, it describes the Experimental Investigation In which it Defines Material used. In section IV, it provides the proposed results of system. Finally conclusion is explained in Section v.

## II. SIGNIFICANCE OF THE WORK

Waste products are used to replace Cement which can be very beneficial .Basically in this topic three material are used cement , waste glass powder and fly ash. By use of all these materials increase durability and strength concluded that 30% fine glass, powder could be incorporated as cement or aggregate replacement in concrete without any long -term detrimental effects. Up to 50% of both fine and coarse aggregate could also be replaced in concrete of 32 MPa strength grade with acceptable strength have presented at 28 days only mix containing 20% GLP, had met the strength requirement for 40 MPa concrete. It showed that the fine glass at level of 20% had a potential to be used in the production of paving blocks.

A parametric experimental study for producing paving blocks using fine and coarse waste glass is presented. Some of the physical and mechanical properties of paving blocks having various levels of fine glass (FG) and coarse glass (CG) replacements with fine aggregate (FA) are investigated. The test results show that the replacement of FG by FA at level of 20% by weight has a significant effect on the compressive strength. [Mayur B, Vanjare and Mahure Shriram H. (2012)]reported that the addition of glass powder in SCC mixes reduces the self compatibility characteristics like filling ability, passing ability and segregation resistance. He also reported that the flexural strengths of the mixes were observed to decrease with in glass powder contents. The mechanical properties of SCC follow inverse relations with the glass powder contents for all grades of concrete.

The compressive strength decreases with even increase in glass powder contents. The average reduction in compressive strength for all grades was around 6%, 15%, and 20% for glass powder contents of 5% 10% and 11% respectively. It was found that the replacement of glass powder in cement by 2.0%, 30% and 40% increases the compressive strength by 19.6%, 25.3% and 33.7% respectively. Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete.

## III. EXPERIMENTAL INVESTIGATION

Experiments are conducted to investigate the effect on the mechanical properties of concrete when OPC is partially replaced by 10%, 20%, 30% and 40% of glass powder, fly-ash and their combinations. Different material and experimental tests are performed to check the quality of concrete. The materials should be suitable for the intended use in concrete and not contain harmful ingredients in such quantities that may be detrimental to the quality or the durability of the concrete. Concrete is made from a properly proportioned mixture of hydraulic cement, water, fine and coarse aggregates, and often, chemical or mineral admixtures. The most common hydraulic cement used in construction today is Portland cement.

The glass powder (less than 90 micron) used in the present study is brought from Karnal market. This material replaces the cement in mix proportion. Theoretically, glass is a fully recyclable material; it can be recycled without any loss of quality. There are many examples of successful recycling of waste glass: as a cullet in glass production, as raw material for the production of abrasives, in sand-blasting, as a pozzolanic additive, in road beds, pavement and parking lots, as raw materials to produce glass pellets or beads used in reflective paint for highways, to produce fiberglass, and as fractionators for lighting matches and firing ammunition. Waste glass can also be produced from empty glass bottles and pots, and come in several distinct colors containing common liquids and other substances. This waste glass is usually crushed into small pieces that resemble the sizes of gravels and sands. Therefore - as an alternative - there is a potential to partially replace the concrete mix aggregate with waste glass due to the lack of natural resources

Fly-Ash: Mineral admixtures like fly ash are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulphate attack; and to enable a reduction in cement content. Class F Fly ash obtained from Thermal Power Plant, Panipat was used in the present study.

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**Table 1: Physical Properties of Glass Powder**

| | | |
|---|---|---|
| 1 | Specific Gravity | 2.6 |
| 2 | Fineness Passing 150m | 99.5 |
| 3 | Fineness Passing 90m | 98 |

**Table 2: Properties of Waste Glass and Cement**

| Properties | Waste Glass | Cement |
|---|---|---|
| $Sio_2$ (%) | 70.22 | 23.71 |
| Cao(%) | 11.13 | 57.27 |
| Mgo(%) | _ | 3.85 |
| AI2O3(%) | 1.64 | 4.51 |
| $Fe_2o_3$(%) | 0.52 | 4.83 |
| $So_3$(%) | - | 2.73 |
| $Na_2O$(%) | 15.29 | _ |
| $K_2O$(%)<br>Ci(%) | _ | .37<br>0.0068 |
| Loss On ignition(%) | 0.80 | 7.24 |
| Undetermined | _ | 0.94 |
| density | 2.42 | 3.03 |
| Specific Surface Area | 133 | 437.6 |

**Table 3: Chemical Composition of Fly Ash**

| Oxide Composition | Fly Ash(%) |
|---|---|
| $Sio_2$ | 45.1 |
| $Ai_2O_3$ | 22.1 |
| $Fe_2O_3$ | 4.4 |
| Cao | 21.0 |
| Mgo | 1.7 |
| $SO_3$ | 2.7 |
| Loss On ignition | 2.1 |
| Specific Gravity(g/cm$^3$) | 2.66 |

## IV. RESULTS AND DISCUSSION

Mix Proportion and of testing Specimens

1. Mix Design: The concrete mix design was propoes by using Indian Standard for control concrete.The grade was M20.The mixture Will be prepares with the cement content of 330kg/m$^3$ and water to cement ratio of 0.53. The mix proportion of materials is 1:2.33:3.6 as per IS10262-2009.Then natural fine aggregate was used The replacement levels of cement ,glass powder were used in terms of 10%,20%,30% and 40% in concrete Chemical Admixture is not used here.
2. Durability Test: Water Absorption test82 cubes were casted and 13 cubes were retained for water absorption after 28 days curing respectively. This test is conducted to measure the water absorption which indirectly measures the durability. This test method is under the jurisdiction of ASTM Committee C09.The Water absorption coefficient (S) was calculated by using formula:S=1/t$^{1/2}$inmm/s$^{1/2}$

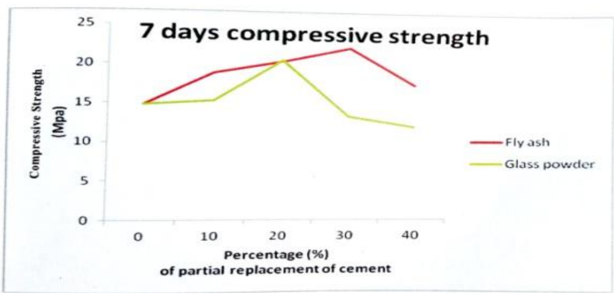


**Fig 1: Comparison of Average 7 day cube compressive strength of concrete with fly ash and glass powder (MPa)**

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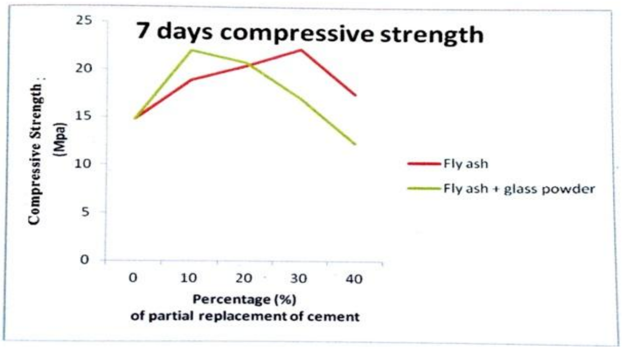


**Fig 2: Comparison of average 7 days cube compressive strength of concrete with fly ash and fly ash +glass powder (MPa)**

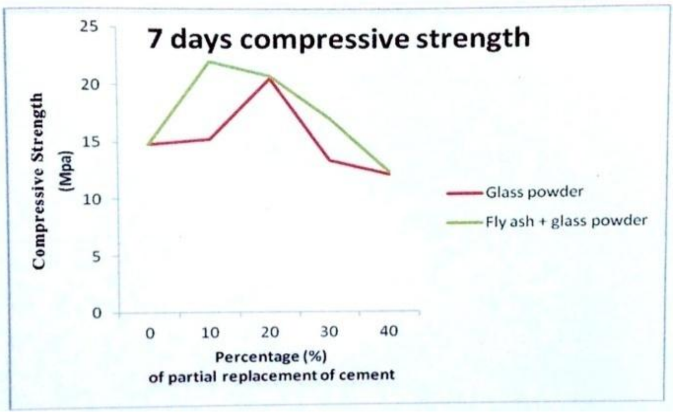


**Fig 3: Comparison of average 7 days cube compressive strength of concrete with glass powder and fly ash + glass powder (MPa)**

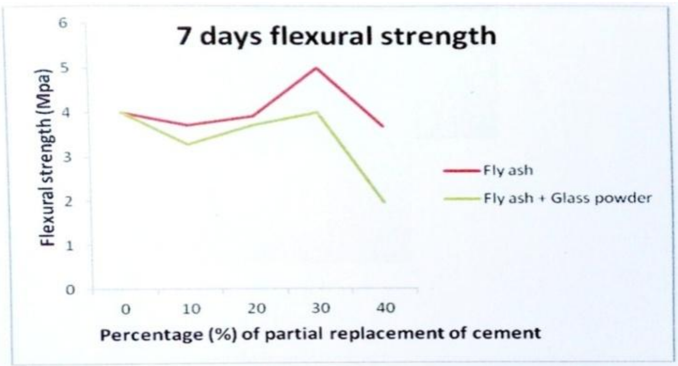


**Fig 4: Comparison of average 7 days beam flexural strength of concrete with fly ash and fly ash + glass powder (MPa)**

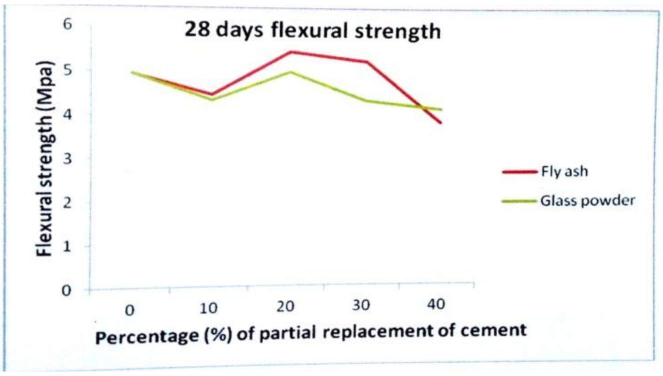


**Fig 5: Comparison of average 28 days beam flexural strength of concrete with fly ash and glass powder (MPa)**

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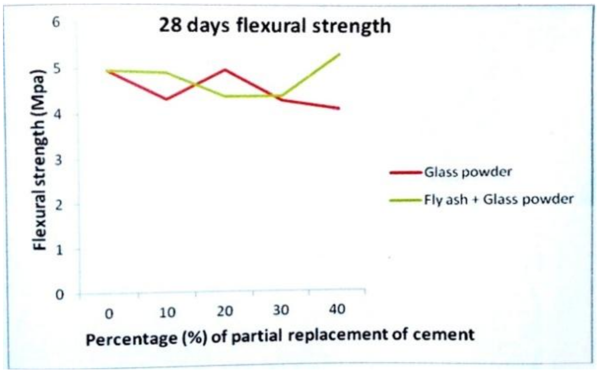


**Fig 6: Comparison of average 28 days beam flexural strength of concrete with glass powder and fly ash + glass powder (MPa)**

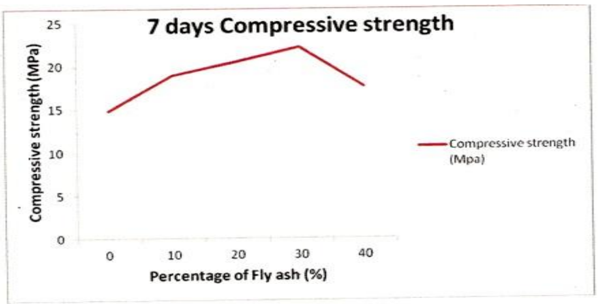


**Fig 7: Average 7 Days Cube Compressive Strength of Fly Ash (Mpa)**

A study of the values presented that compressive strength increases from 28% to 50% when cement is replaced by 10%, 20% and 30% of fly ash percentage and thereafter decreases with increase in fly ash. The compressive strength of concrete with different percentages of glass powder are calculated and presented in from the values.

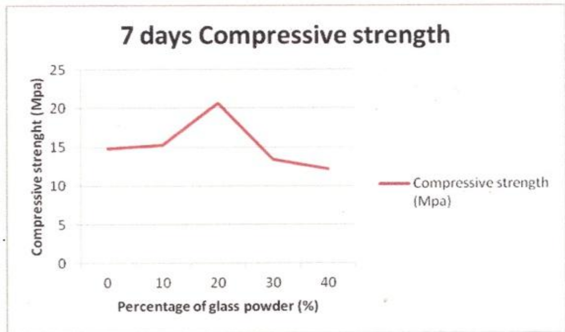


**Fig 8: Average 7 Days Cube Compressive Strength of Concrete with Glass Powder (Mpa)**

It is found that compressive strength increases from 3% to 39% when cement is replaced from 10% to 20% of glass powder and thereafter decreases with increase in glass powder.

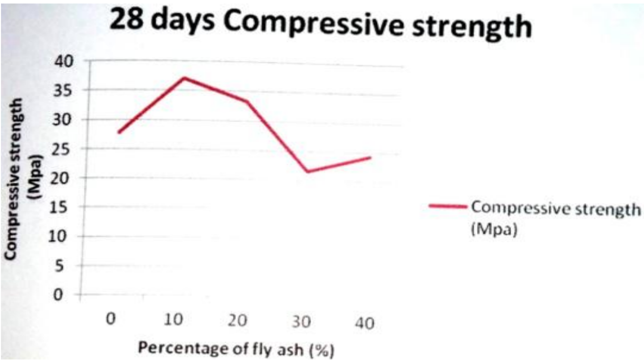


**Fig 9: Average 28 Days Cube Compressive Strength of Concrete With Fly Ash (Mpa)**

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The compressive strength of concrete with different percentages of fly ash + glass powder are calculated.

It is found that the compressive strength increases by 33% with the addition of fly ash upto 10% when compare to the compressive strength of Normal Concrete(NC) at room temperature and thereafter it starts decreases in fly ash percentages upto 30% then there is a slight increase with increase in fly ash.

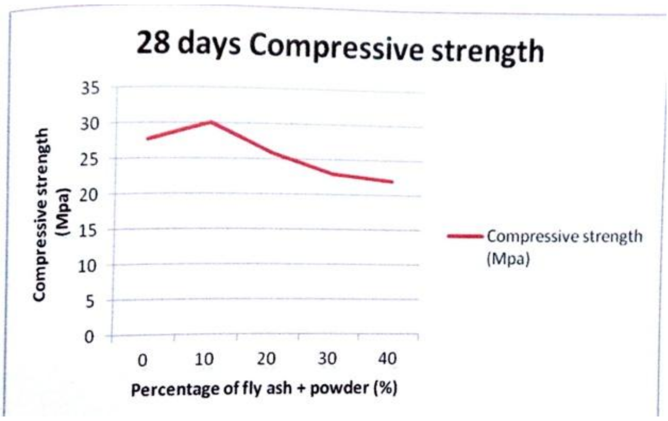


**Fig 10: Average 28 Day Cube Compressive Strength of Concrete with Fly Ash + Glass Powder (Mpa)**

It shows the 28 days compressive strength of concrete with fly ash + glass powder. A study of the values presented in Table 4.7 indicate that compressive strength increases by 9% with increase in percentage upto 10% addition and thereafter it starts decreases gradually.

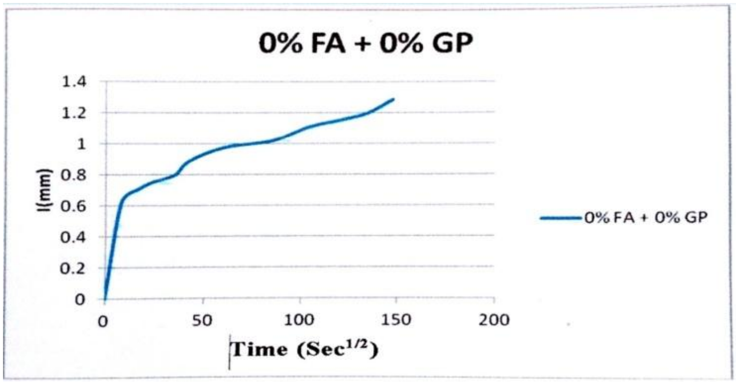


**Fig 11: Water Absorption Test on Cube with 0% fly ash+0% glass powder**

## V. CONCLUSION

The main objective of this study is to investigate the effect on the mechanical properties of concrete when OPC is partially replaced by 10%, 20%, 30% and 40% of glass powder, fly-ash and their combinations. In all specimen strength are in MPa and duration are in seconds respectively.

- Concrete prepared replacing 10, 20, 30 and 40% of cement by FA, GP and FA +GP atisfied results and resulted in desired grade of concrete.After 7 days compressive strength increases from 28 to 50% when cement is replaced by 10%, 20% and 30% of fly ash percentage and thereafter decreases with increase in fly ash.
- After 7 days compressive strength increases from 3 to 39% when cement is replaced from 10% to 20% of glass powder and thereafter decreases with increase in glass powder.
- After 7 days an increase of 49% in compressive strength upto 10% of cement replacement and thereafter decreases with the increase in Percentage of mix when cement is replaced by fly ash + glass powder.
- Alter 28 days compressive strength increases by 33% with the addition of fly ash upto 10% when compare to the comperssive strength of Normal Concrete (NC) at Room temperature and thereafter it starts decreases in fly ash percentages upto 30% then there is a slight increase with increase in fly ash.
- After 28 days compressive strength values of glass powder decreases from 8% to 36% with increase in percentage of glass powder when compare to the compressive strength of Normal Concrete(NC) at room temperature.

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