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# Experimental Investigations on Partial Replacement of Cement Using Glass Powder

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**ABSTRACT**

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass-consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required. The term glass contains several chemical diversities including soda-lime silicate glass, alkali-silicate glass and boro-silicate glass. To date, these types of glasses glass powder have been widely used in cement and aggregate mixture as pozzolana for civil works.

**KEY WORDS**: partial, glass powder, cement.

## 1. INTRODUCTION

The introduction of waste glass in cement will increase the alkali content in the cement. It also help in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering, for example, in cement, as pozzolana(supplementary cementitious materials), and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability. Therefore, it is considered ideal for recycling. Recently, Glasses and its powder has been used as a construction material to decrease environmental problems.

**1.1. Objectives:** This objective of the present study is to investigate experimentally the properties of concrete by partial replacement of glass waste for cement with the following test results:

- Total of six batches of concrete mixes required by the scope of the project. The concrete mixes consisted of every 10% increment of cement replacement from 0% to 30%.
- The investigation and laboratory testing on recycled cement concrete specimens such as compression test and flextural test for 7 and 28 days.

**1.2. Scope of the project:**

- Review and research of glass powder in concrete.
- Make the concrete specimens by using different percentage of wate glass powder.
- Investigation and laboratory testing on high strength concrete with waste glass powder.
- Analysis the results and recommendation for further research area.

## 2. MATERIALS AND METHODS

**2.1. Materials used:** Cement: Portland Pozzolano cement 53 Grade; Fine Aggregate: Natural River sand; Coarse Aggregate: Aggregate passing through 20mm sieve; Waste Glass powder: Powder retaining at 75µ sieve; Water: Ordinary portable water.

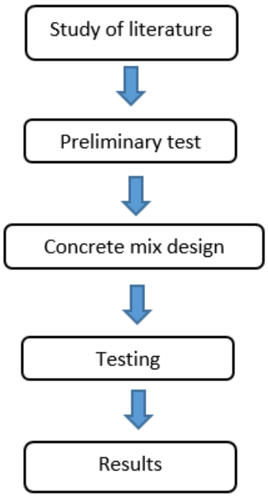
**Table 1: Material Details**

| Ingredient | Percentage (%) | Range |
|---|---|---|
| Lime (CaO) | 62 | 62-67 |
| Silica ($Sio_2$) | 22 | 17-25 |
| Alumina ($Al_2O_3$) | 5 | 3-8 |
| Calcium Sulphate ($CaSO_4$) | 4 | 3-4 |
| Iron Oxide ($Fe_2O_3$) | 3 | 3-4 |
| Magnesium (MgO) | 2 | 0.1-3 |

**2.2. Glass powder:** Glass is a rigid liquid i.e. super cooled liquid, static, not solid, not a gas but does not change molecularly between melting and solidification in to a desired shape.

**2.3. Application of glass powder:** Waste glass contain high silica (SiO2) i.e.72%. Waste glass when ground to a very fine powder (600 micron) SiO2 reacts with alkalis in cement (pozzolanic reaction) and form cementitious product that help contribute to the strength development and durability. When concrete contain waste glass powder it gives higher percentage of C2S, Low C3A, C4AF, C3S/C2S Content which result in production of less heat of hydration and offers greater resistance to the attack.

**2.4. Methodology:**




## 3. RESULTS AND DISCUSSION

**3.1. Preliminary test:**

**Table 2: Tests for cement:**

**Initial setting time**

| Times in minutes | Pointer reading from bottom | Times in minutes | Pointer reading from bottom |
|---|---|---|---|
| 0 | 0 | 55 | 0.5 |
| 5 | 0 | 60 | 0.5 |
| 10 | 0 | 65 | 0.5 |
| 15 | 0 | 70 | 0.5 |
| 20 | 0 | 75 | 0.5 |
| 25 | 0 | 80 | 1.5 |
| 30 | 0 | 85 | 1.5 |
| 35 | 0 | 90 | 1.5 |
| 40 | 0 | 95 | 2 |
| 45 | 0 | 100 | 2 |
| 50 | 0 | | |

**Final setting time**

| Times in minutes | Pointer reading from bottom |
|---|---|
| 140 | 37.5 |
| 170 | 38 |
| 200 | 39 |
| 230 | 40 |
| 230 | 45 |

**3.2. Tests for fine aggregate:**

**Table 3: Fineness modulus:**

| Sieve Designation | Weight retained gm | Cumulative weight retained in gm | Cumulative % weight retained | Cumulative % passing |
|---|---|---|---|---|
| 10mm | 0 | 0 | 0 | 100 |
| 4.75mm | 10 | 10 | 2 | 98 |
| 2.36mm | 12 | 22 | 4.4 | 95.6 |
| 1.18mm | 37 | 59 | 11.8 | 88.2 |
| 425 µm | 227 | 286 | 57.2 | 42.9 |
| 300 µm | 92 | 378 | 75.6 | 24.4 |
| 150 µm | 102 | 480 | 96 | 4 |
| Lower than 150 µm | 20 | 500 | 0 | 100 |
| Total | | | 247 | |

**Table 4: Test for course aggregate:**

| Sieve Designation | Weight retained in gm | Cumulative weight retained in gm | Cumulative % weight retained | Cumulative % passing |
|---|---|---|---|---|
| 75mm | 0 | 0 | 0 | 100 |
| 50mm | 0 | 0 | 0 | 100 |
| 25mm | 0 | 0 | 0 | 100 |
| 19mm | 750 | 750 | 37.22 | 62.78 |
| 16mm | 805 | 1555 | 77.17 | 22.83 |
| 12.5mm | 425 | 1980 | 98.26 | 1.74 |
| 9.5mm | 35 | 2015 | 100 | 100 |
| 6.3mm | - | - | 100 | 100 |
| 4.75mm | - | - | 100 | 100 |
| Total | - | - | 500.65 | - |

**3.3. Concrete mix design:**

**Table.5 : Assumed standard deviation as per IS: 456 – 2000**

| Grade of concrete | Assumed standard deviation N/mm2 |
|---|---|
| M10 | 3.5 |
| M15 | |
| M20 | 4.00 |
| M25 | |
| M30 | 5.00 |
| M35 | |
| M40 | |
| M45 | |
| M50 | |

**Table.6.Value of T**

| Nominal maximum size of aggregates (mm) | Entrapped air, as a % of Volume of concrete |
|---|---|
| 10 | 3.0 |
| 20 | 2.0 |
| 30 | 1.0 |

**Table 7: Approximate Sand and Water Content per Cubic Water**

| Nominal maximum size Of aggregate (mm) | Water content, per m³ Of concrete Kg | Sand as percentage of Total aggregate by Absolute volume |
|---|---|---|
| 10 | 208 | 40 |
| 20 | 186 | 35 |
| 40 | 165 | 30 |

**Table 8: The slump for each batch of Mix concrete**

| Percentage replacement of cement by glass powder | Slump value Mm | Percentage increase or decrease with respect to reference mix |
|---|---|---|
| 0% | 100 | Nil |
| 10% | 91 | -9 |
| 20% | 82 | -18 |
| 30% | 73 | -27 |

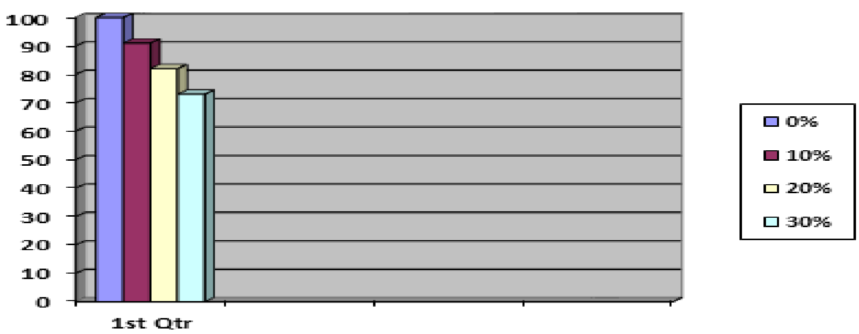



**Fig.1.Slump Test**

### 3.4. Compressive Strength:

**Table 9: Compressive Strength on Concrete Cubes At 7 Days**

| Percentage of replaced glass powder as cement content ( % ) | Sample 1 mpa | Sample 2 mpa | Sample 3 Mpa | Average mpa |
|---|---|---|---|---|
| 0 | 21.5 | 20.23 | 21.05 | 20.92 |
| 10 | 23.27 | 25.67 | 22.86 | 23.93 |
| 20 | 27.30 | 26.23 | 28.12 | 27.22 |
| 30 | 17.62 | 18.56 | 18.45 | 18.21 |

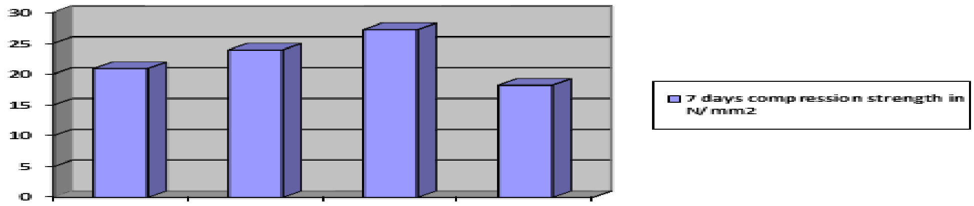



**Fig.2.Compressive Strength On Concrete Cubes at 7 Days**

**Table 10: Compressive Strength On Concrete Cubes at 28 Day**

| Percentage of replaced glass powder as cement content ( % ) | Sample 1 mpa | Sample 2 mpa | Sample 3 Mpa | Average Mpa |
|---|---|---|---|---|
| 0 | 27.05 | 26.89 | 27.81 | 27.25 |
| 10 | 29.77 | 31.02 | 28.87 | 29.89 |
| 20 | 33.50 | 34.57 | 36.98 | 35.02 |
| 30 | 24.44 | 26.80 | 24.32 | 25.2 |

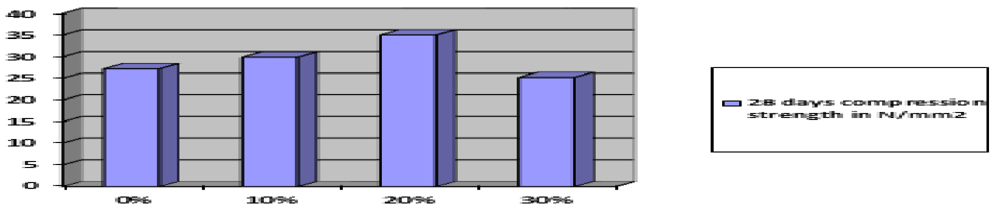



**Fig.3.Compressive Strength On Concrete Cubes at 28 Days**

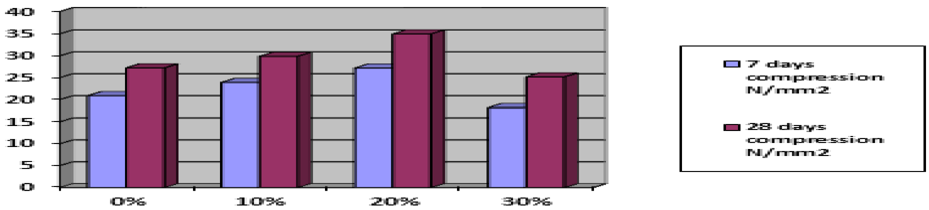



**Fig.4:Comparison of 7 Days and 28 Days**

### 3.5. Split Tensile Test:

**Table 11: Split Tensile Test on concrete at 28 Days**

| Percentage of replaced glass powder as cement content ( % ) | Sample 1 mpa | Sample 2 mpa | Sample 3 mpa | Average mpa |
|---|---|---|---|---|
| 0 | 5.80 | 4.58 | 4.50 | 4.96 |
| 10 | 5.54 | 5.77 | 4.87 | 5.39 |
| 20 | 6.45 | 6.12 | 5.87 | 6.30 |
| 30 | 5.10 | 4.76 | 4.23 | 4.70 |

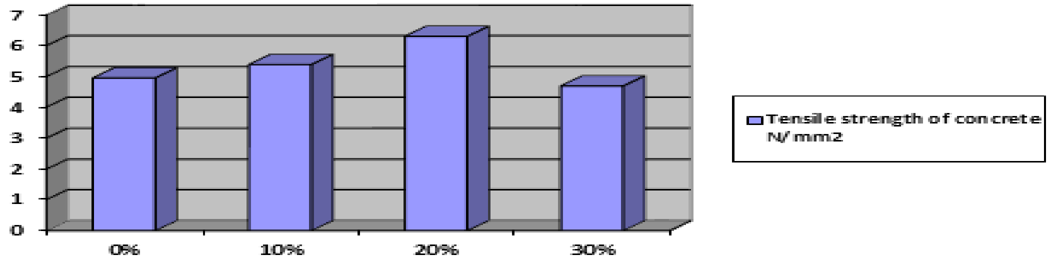



**Fig 5: Split Tensile Test on concrete at 28 Days**

## 4. CONCLUSION

Based on experimental observations, the following conclusions are drawn:

Higher strength was achieved when 20% cement was replaced by glass powder in concrete. The density of concrete reduces with the increase in the percentage of replacement of cement by glass powder. The workability decreased as the glass content increased Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio. Considering the strength criteria, the replacement of cement by glass powder is feasible. It is recommended that the utilization of waste glass powder in concrete as cement replacement is possible. Strength properties were affected when concrete produced by replacing cement by glass powder was subjected to attack. Waste glass powder in appropriate proportions could be used to resist such attack.

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