# STUDY ON REPLACEMENT OF CEMENT WITH WASTE GLASS POWDER IN CEMENT CONCRETE

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***Abstract:*** ***Many researches have been currently going to modify and improved the concrete properties by the addition of different types of materials. This paper represents the Optimum use of the waste glass with the concrete mixture and will also help in achieving the desired results. thus, in this paper we utilized different type of recycled glass that has high percentage of silicon dioxide (SiO2) with different concentrations. The main aim of study is to find the utilization of waste glass as a partial replacement material for cement in concrete to serve to basic purposes. Waste glass powder of particle size less than 90 micron is used in this work. The work was divided into percentages ranging from 0%-30%, with milky white glass powder. A constant water/cement 0.40 is used and grade of concrete is M30. A series of tests are conducted to study the effect of glass powder on strength of concrete. Necessary tests to be done are slump test, compression tests on concrete cubes, split tensile tests on cylinder, flexure tests on beams. Tensile and flexural strength up to different age are to be done and compared with those of conventional concrete.***

***Keywords: Waste Glass powder, Compressive Strength, Flexural Strength and Split Tensile Strength.***

## I. INTRODUCTION

One of the most consumed man-made materials in construction field is concrete. It is the combination of cementitious materials, water, aggregates and also different types of admixtures in a particular ratio. Fresh concrete has a property of plasticity, which means before casting it behaves like plastic but as time goes, it gets hard like rock. These hardening properties happens due to chemical reactions between cement and water, it gets stronger with long time period. Since last century, the concrete structures durability was based on ordinary Portland cement, round steel bars of mild steel, which was easily available in market. As time spent, these materials also changed with their physical appearance, properties and strength. For example, Pozzolana cement is used in place of Ordinary cement and TMT bars are in use in place of mild steel bars. Glass is a non bio-degradable material and is not suitable for landfills. A lot of waste glass comes from the industries which pollutes our environment. To make our environment pollution free concrete industries had used this waste glass in concrete and also as supplementary cementing material. By using the waste glass as the replacement in concrete reduces the pollution caused by glass waste and also the pollution caused during the production of cement. A glass is an inorganic product of fusion of mixture of silica, calcium carbonate and soda ash which is cooled to a rigid condition without crystallization. The glass being mainly a silica-based material in amorphous form can be used in cement-based applications. The main disadvantage of using crushed glass as a replacement to aggregate in concrete is expansion and cracking. This expansion and cracking is caused due to alkali silica reaction in the concrete. Ground glass is considered as pozzolanic materials and can exhibit properties similar to other pozzolanic materials. It has been found that using glass in mortar applications caused more expansion compared with mortars without glass particles. This expansion can in some cases cause deterioration to the material.It was found that if the glass was ground to a particle size of 300μ or smaller, the alkali- silica reaction (ASR) induced expansion could be reduced. In fact data reported a show that if the waste glass is finely ground, under150μ, and this effect does not occur and mortar durability is guaranteed. It is also well know that typical pozzolanic materials might features high silica content, an amorphous structure and have a large surface area. Fine particles of glass usually present pozzolanic activity beneficial to the concrete, while coarse particles are usually deleterious to concrete due to alkali silica reaction (ASR).

## II. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Parameshwari. et al. [1] studied the effect of glass powder which is replaced with cement in concrete and the compressive strength was checked for the cubes of (150 x 150x 150) at different ages. Compressive strength was more when compared with normal concrete and was 44.9 N/mm2 after 28 days. The finely grounded glass powder does not contribute to alkali silica reaction and gives higher strength than large sized glass powder.

Lalitha et al. [2] studied the effects of glass powder which was used in different replacements as 5%, 10% and 15% with cement in concrete by weight of cement. Cubes were casted to check the strength of waste glass concrete and then compared with the concrete with 0% replacement. Compressive strength is higher at 5% replacement of waste glass powder and is more than

  

control concrete. Further the strength starts decreasing on increasing the glass powder content. The reason is the high magnesia content present in the glass powder which is used in this work, as excess magnesia content makes the strength decrement. The glass powder used in this work has magnesia content of 4.18% but the permissible limit of magnesia content in cement is 1-3%.

Siddesh et al. [3] studied the effect different particles is of glass powder in cement. During the investigation cement is being replaced by 150 micron and 300 micron particle size separately for every 10%, 20%, 30% and 40% and these results are compared with normal concrete at 0% replacement. Super plasticizer (conplast430) of 0.5% by weight of cement was used.Compressive strength increase or particle size less than 150 micron up to 30% and then decreases but for 300 micron particle size the strength decreases for every replacement.

Shruthi et al. [4] studied the effect on properties of concrete. To check the strength, the glass powder is replaced by cement by 5%, 10%, 15%, 20% and 25% by weight. Strength was checked at different ages of concrete.The compressive strength shows improvement due to the continuous increase of waste glass powder. The strength increases up to 15% replacement and then stars decreasing, it is due to the alkali silica reaction freed during the hydration of cement. The increase in the strength up to 15% is by the pozzolanic reaction and due to the filling of voids by glass powder and giving rise to dense concrete micro structure.

Hongjian et al. [5] studied the behavior of concrete using waste glass as a replacement of cement in different percentages and also as an additive. Also 15% glass powder was used as an additive to check the impermeability against chloride and water.The strength starts decreasing with increase in the glass powder replacement more than 15% at the age of 7 days. However at 28 days and 91 days the strength increases up to 30% and then decreases by little amount but not less than the normal concrete without replacement of glass powder. When the glass powder replaced more than 30%, the later age increase in the strength was not observed.

Fabrice et al. [6] divided this work into groups as: group 1 with 0% replacement, group 2 with 10% replacement, group 3 with 20% replacement, group 4 with 30% replacement and group 5 with 40% replacement with both green and clear glass powders.Three beams of (length of 50cm and width of 10cm) were casted for each and every replacement. Rate of testing for beams was 0.1kn/sec.Flexural strength for both glass powders was done at 7 days and 28 days of age. Flexural strength starts increasing with increase in glass powder up to 30% replacement and then starts decreasing with increase in glass
powder replacement. The strength was higher at 30% and was higher than both clear glass and normal concrete. Also the green glass gives more strength at 7 and 28 days at 30% replacement of glass powder. Due to the higher consumption of lime/ calcium oxide by green glass powder gives higher strength than clear glass with same replacement.

Parameshwari et al. [7] used glass powder in concrete in replacement of cement and determined the effects of glass powder on concrete. Cement in concrete was replaced by 10%, 15% and 20% by weight of cement. Fine aggregate of maximum size 4.75 mm was used and coarse aggregate size was between 4.75 mm and 20mm.Flexural strength of the concrete with glass powder in different percentages increases with increase in glass powder replacement in concrete. By correlating the flexural strength of normal concrete with glass powder concrete, glass powder concrete shows higher flexural strength. The finely grounded glass powder does not contribute to alkali silica reaction and gives higher strength than large sized glass powder.

Shruthi et al [8] in their research used glass powder as a replacement of cement in concrete. To check the strength effect, the cement is replaced by 5%, 10%, 15%, 20% and 25% by weight.The flexural strength shows improvement due to the effect of glass powder increment. Flexural strength increases up to 15% replacement and then stars decreasing. The decrease in the strength is due to the alkali silica reaction freed during the hydration. Flexural strength was checked at 28days and 56 days with the same replacement of glass powder and the flexural strength was more at 15% of glass powder replacement.The increase in the strength up to 15% is by the pozzolanic reaction and due to the filling of voids by glass powder. Beyond 20% replacement the strength of concrete starts decreasing because of the dilution effect.

Hongjian et al. [9] studied the effect of glass powder on concrete when cement is being replaced in different percentages. Also 15% glass powder was used as an additive to check the impermeability against chloride and water. Glass powder passed through 90 micron sieve and coarse aggregate with maximum size 10 mm was used. Grade of cement used is OPC43 and mix design to be designed is M50. Cylinders were casted to check the durability of the concrete. Rapid chloride penetration test was checked at 7 days 28 days and 91 days. Also water penetration resistance of concrete was checked at age of 28days.

## III. MATERIALS USED

The materials are described below-

CEMENT: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 53 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days as per IS 4031-1988. The various properties of the cement are described in Table 1.

Table 1

| S. No | Property details of cement | |
|---|---|---|
| 1 | Grade | 53-OPC |
| 2 | Consistency | 31% |
| 3 | Specific gravity | 3.14 |
| 4 | Fineness | 96 % |
| 5 | Initial setting time | 126 minutes |

  

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC. It confirms to IS 383-1970 which comes under Zone III.

The physical Properties of sand like Fineness Modulus, Specific Gravity and water absorption are 2.41, 2.65 and 1.21% respectively.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse gravel of 20mm and crushed aggregate of 10mm are mixed in 60:40. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity and water absorption are 6.68, 2.63 and 0.40% respectively.

GLASS POWDER : -Glass is a non-bio-degradable material and is not suitable for landfills. A lot of waste glass comes from the industries which pollutes our environment. To make our environment pollution free concrete industries had used this waste glass as a replacement of aggregate, fine aggregate and cement and also as a supplementary cementing material. In my research, the glass powder is being partially replaced by cement in concrete. The particle size of glass powder used for this work should pass through 90 micron sieve. White colored glass powder is used in different replacement levels. Various proportion of material shown in Table No. 2

Table No. 2

| | |
|---|---|
| Grade designation | M 30 |
| Type of cement | OPC 53 |
| Maximum size of aggregate | 20 mm |
| Minimum cement content | 320 kg/m3 |
| Maximum water cement ratio | 0.40 |
| Workability | 100 mm (slump) |
| Type of aggregate | Crushed angular aggregate |
| Maximum cement content | 450 kg / m3 |
| Chemical admixture | Super plasticizer |

WATER: - Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

## IV. EXPERIMENTAL PROGRAMME

In this section, Glass powder with different proportion based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

COMPRESSIVE STRENGTH TEST: To examine the compressive strength of Glass powder with different proportion based specimens, cube of 150mm×150mm×150mm has been used in this experimental work. Several cubes has been casted to determine the compressive strength. firstly cement and sand are mixed uniformly in dry condition . Secondly coarse aggregates are added in this mixture. Now Glass Powder also added according to mix proportion to get the resultant mixture of M30 grade. Required dosage of water was added in the course of mixing. The cube moulds were demoulded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM) as per IS 516-1959. Compressive strength of concrete mixtures was measured at the ages of 7 and 28 days and shown in Table No. 3. There was an increase in compressive strength of cube concrete specimens produced with Glass powder.


Fig. 1 CUBE UNDER COMPRESSION TESTING MACHINE (CTM)

Table No. 3: Compressive strength of concrete after 7 Days and 28 Days
(In/mm2)

| S. No. | % age of glass powder | 7 Days Triplet sample values | Average Compressive Strength after 7 Days in N/mm$^2$ | 28 Days Triplet sample values | Average Compressive Strength after 28 Days in N/mm$^2$ |
|---|---|---|---|---|---|
| 1 | 0% | Sample 1= 27.2<br>Sample 2 =25.5<br>Sample 3 =26.2 | 26.3 | Sample 1= 34.0<br>Sample 2 =35.7<br>Sample 3 =35.3 | 35 |
| 2 | 10% | Sample 1= 28.3<br>Sample 2 =28.9<br>Sample 3 =29.0 | 28.70 | Sample 1= 38.5<br>Sample 2 = 37.26<br>Sample 3 = 39.2 | 38.32 |
| 3 | 20% | Sample1= 26.95<br>Sample 2 = 27<br>Sample 3 = 27.5 | 27.15 | Sample 1= 37.8<br>Sample 2 = 37.1<br>Sample 3 = 36.45 | 37.12 |
| 4 | 30% | Sample 1= 25.15<br>Sample 2 =25.0<br>Sample 3 =25.0 | 25.05 | Sample 1= 34.1<br>Sample 2 = 33.21<br>Sample 3 = 32.2 | 33.17 |

  

The work was divided in to 4 percentages; triplet specimens were casted for every replacement. Glass powder is replaced with cement as 0%. 10%, 20%, 30%. In table 3 the average results of compressive strength for 7 days and 28 days are summarized. The above fig 2 shows the compressive strength of normal concrete and replaced concrete with glass powder at the age of 7 days and 28 days.. The highest strength was recorded at 10% replacement of glass powder with cement when compared to normal concrete. When 10% glass powder is replaced with cement in concrete shows more strength by 9.48% as compared to normal concrete after 28Days.

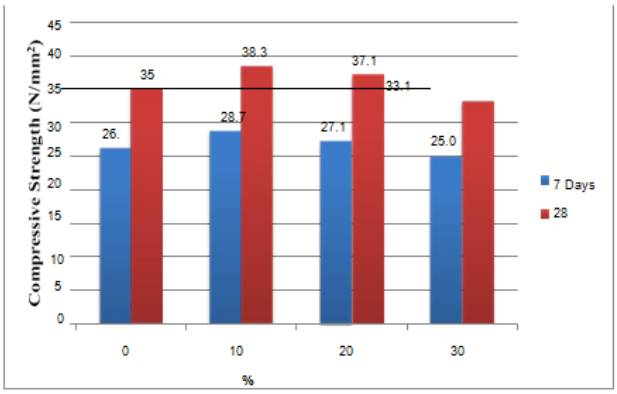


Figure 2: Compressive Strength after 7 Days and 28 Days in N/mm2

FLEXURAL STRENGTH TEST:- To examine the flexural strength of Glass powder based specimens, cylinder of size 150mm×150mm×70mm has been used in this experimental work. Several beams has been casted to determine the tensile strength. The beams specimens of different proportions were demoulded after 24 hours and transferred to the curing tank for 28 days . After that, beams were placed to the two point loading machine on which we apply the load manually. Note down the load value at which cracks starts developing on the beam. Table no. 4 shows the values of flexural strength of beams at different mix proportions.

Fig 3 Flexural Strength Testing machine

Table 4 Flexural strength of concrete after 7 days and 28 days in N/mm2

| S.NO | % age of glass powder | 7 Days Triplet sample values | Average Flexural Strength after 7 Days in N/mm² | 28 Days Triplet sample values | Average Flexural Strength after 28 Day in N/mm² |
|---|---|---|---|---|---|
| 1 | 0% | Sample 1= 2.0<br>Sample 2 =2.03<br>Sample 3 =2.07 | 6.1 | Sample 1= 2.48<br>Sample 2 =2.77<br>Sample 3 =2.50 | 6.75 |
| 2 | 10% | Sample 1= 2.53<br>Sample 2 =2.57<br>Sample 3 =2.10 | 7.20 | Sample 1= 2.90<br>Sample 2 =3.15<br>Sample 3 =2.05 | 8.1 |
| 3 | 20% | Sample1= 2.15<br>Sample 2 =2.25<br>Sample 3 =1.92 | 6.32 | Sample1= 2.18<br>Sample 2 =2.80<br>Sample 3 =2.17 | 7.15 |
| 4 | 30% | Sample 1= 1.73<br>Sample 2 =1.54<br>Sample 3 =1.99 | 5.26 | Sample 1= 1.75<br>Sample 2 =2.65<br>Sample 3 =2.96 | 6.36 |

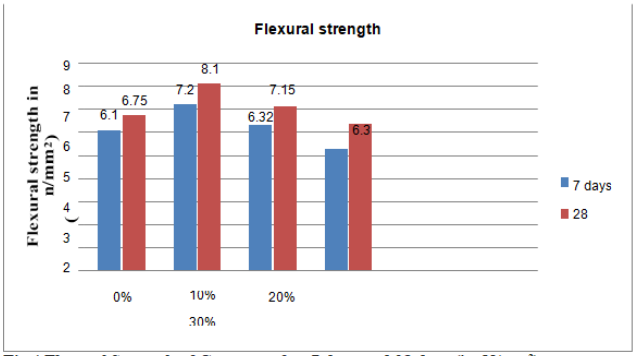


**Fig 4 Flexural Strength of Concrete after 7 days and 28 days (in N/mm²)**

In table 4 the average results of Flexural strength for 7 days are summarized. The fig 4 show the flexural strength of normal concrete and replaced concrete with glass powder at the age of 7 days. For normal concrete the strength achieved at 7 days 6.1 N/mm. As the glass powder increases the flexural strength increases. The strength increases up to 20% replacement and the n decreases. Lowest strength was noted at 30% replacement level and the maximum strength was recorded at 10% glass replacement levels. When the strength was compared with normal concrete, strength at 10% replacement levels was high. the average results of Flexural strength for 7 days are summarized. The fig 4 .shows the flexural strength of normal concrete and replaced concrete with glass powder at the age of 7 days and 28 days. For normal concrete the strength achieved at 7 days 6.1 N/mm. As the glass powder increases the flexural strength increases. The strength increases up to 20% replacement and then decreases. Lowest strength was noted at 30% replacement level and the maximum strength was recorded at 10% glass replacement levels. When the strength was

  

compared with normal concrete, strength at 10% replacement levels was high, at the age of 28 days, Glass powdered concrete shows high strength as compared to normal concrete. Strength of concrete increases as the glass powder replacement increases and also the strength increases as the age of concrete increases. When glass powder concrete is compared to normal concrete, the glass powder concrete at replacement levels 10% shows higher strength. The strength increases up to 20% and the decreases by small amount when compared to normal concrete.

SPLIT TENSILE STRENGTH TEST:- To examine the tensile strength of Glass based specimens, cylinder of size 150mm×300mm has been used in this experimental work . several cylinders has been casted. The cylinder moulds were demoulded after 24 hours and transferred to curing tank for 28 days. After that cylinders were tested horizontally under compression testing machine (CTM). The results shows that in general, there is an increase in splitting tensile strength of cylinder concrete specimens with the addition of Glass powder to the concrete at 28 days age.

Fig 5 Split tensile Strength machine

Table 5 Split Tensile Strength after 7 days and 28 days in N/mm2

| S.NO | % age of glass powder | 7 Days Triplet sample values | Average split tensile strength after 7 days in $N/mm^2$ | 28 Days Triplet sample values | Average split tensile strength after 28 days in $N/mm^2$ |
|---|---|---|---|---|---|
| 1 | 0% | Sample 1= 2.1<br>Sample 2 = 2.05<br>Sample 3 = 2.0 | 2.05 | Sample 1= 3.1<br>Sample 2 = 2.9<br>Sample 3 = 3.06 | 3.02 |
| 2 | 10% | Sample 1= 2.49<br>Sample 2 = 2.60<br>Sample 3 = 2.5 | 2.53 | Sample 1= 3.15<br>Sample 2 = 3.20<br>Sample 3 = 2.92 | 3.09 |
| 3 | 20% | Sample 1 = 2.18<br>Sample 2 =2.2<br>Sample 3 =2.1 | 2.16 | Sample1 = 3.20<br>Sample 2 = 3.0<br>Sample 3 = 2.95 | 3.05 |
| 4 | 30% | Sample 1 = 1.70<br>Sample 2 = 1.60<br>Sample 3 = 1.65 | 1.65 | Sample 1= 2.85<br>Sample 2 = 2.96<br>Sample 3 = 2.93 | 2.91 |

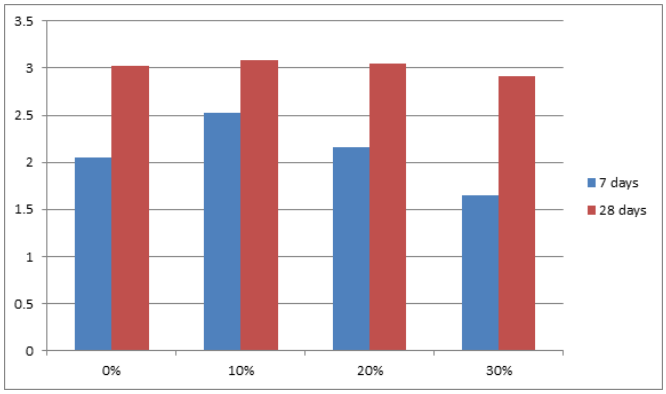


Fig 6 Split Tensile Strength after 7 days and 28 days in N/mm2

The work was divided into 4 percentages; triplet specimens were casted for every replacement. Glass powder is replaced with cement as 0%, 10%, 20%, and 30%. In table 5 the average results of split tensile strength for 7 days and 28 days are summarized. The strength starts increasing as the glass powder replacement increases in the concrete. For the normal concrete, the strength was recorded as 2.05 N/mm2. Maximum strength was recorded at 10% of replacement level when compared to normal concrete. Levels the strength increased by 2.3% the maximum strength achieved at 10% replacement of glass powder was 2.53N/ mm2 after 7 days and. On further increment of glass powder the strength decreases but was more as compared to normal concrete. After 28 days as the glass powder in the concrete increases the strength increases as shown in the fig. 6 the concrete containing 10% to 20% glass powder shows higher strength as compared to normal concrete. The maximum strength was recorded at 10% replacement of glass powder with cement in concrete. At 10% glass replacement.

## V. CONCLUSION

In this present study with the stipulated time and laboratory set up afford has been taken to enlighten the use of so called glasss powder based concrete in accordance to their proficiency. It was concluded that:

- Slump of the concrete decreases as the glass powder percentage increases. The workability of concrete decreases as the replacement level of glass powder increases.
- Compressive strength increases as the glass powder replacement increases and was found maximum at 10%. Compressive strength increases by 12% when compared to control concrete after 28 days
- Split tensile strength increased by 2.3% when compared to control concrete. The strength increases as the glass powder percentage in the concrete increases. High strength was recorded at 10%.
- Also the flexural strength increases as the glass powder replacement increases and the maximum strength was recorded at 10% replacement level.

  

- The increase in the strength up to 9.3% (After 7 Days) is due to the pozzolanic reaction of the glass powder. It may also be due to the filling of voids by glass powder.
- Beyond 10 % the strength starts to drop, this drop of strength may be due to the dilution effect. The pozollanic reaction requires the hydration component CH.
- Calcium hydroxide decreases because of the reduction of this chapter deals with the conclusion of the tests done in laboratory for freshly mixed concrete and hardened concrete, the cement content and also due to the consumption of CH by glass powder.
- Beyond 10% glass replacement, the heat of hydration decreases due to the presence of less amount of CH component. As the glass powder increases beyond 10%, the glass powder can play only the role of inert filler without being activated.

## VI. FUTURE SCOPE OF THE STUDY

The project work was emphasized on use of glass materials as partially replacement of cement. The use of glass waste in construction industry may further be studied; following are the areas where the utilization of waste glass may find its scope:

- Silica fumes are also pozzolanic in character like the waste glass; the use of silica fumes alongside the waste glass may also best study.
- The use of glass with concrete also termed as „glass concrete‟ may also be studies for construction.
- Waste Glass may further used for constructions.
- The further study may include analysis of the effect of glass materials on compressive strength of concrete as partially replacement of coarse aggregates and fine aggregates.

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