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# Experimental analysis of sheet glass powder in partial replacement of fine aggregate in concrete

**A.NaveenArasu[1], V.Dharani Priya[2], M.Shanthini[3], A.Vijaykrishnakumar[4], K.Chandru[5]**
[1]Assistant Professor, Dept. of Civil Engineering, Sri Eshwar college of Engineering, Coimbatore, Tamil Nadu,
[2&3] Third year students, Dept. of Civil Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu.
Email id :naveenanbu07@gmail.com, priyavenkat1945@gmail.com,shanthini2310@gmail.com,
vijaykk0309@gmail.com, chandrukrishnamoorthi99@gmail.com.

## 1. Abstract

*Waste management is becoming major problem for developing countries nowadays. In order to reduce the solid waste, we have planned to take one waste to use in manufacturing of concrete. Broken glass pieces is made as powder and used as a partial replacement for fine aggregate i.e.5%, 10%, and 15% for natural sand in concrete. Admixtures are used to reduce the water cement ratio in order to gain more strength in the high performance concrete. The water absorption properties of glass powder are very less compared to that of natural sand. Since the solid waste (glass) is used in the manufacturing concrete the cost is required only for crushing the waste glass therefore the overall cost can also be reduced. Compressive strength of cube at 7, 14, 28 days of duration and flexural strength at 28days were studied and compared with conventional concrete. Physical properties like fineness modulus, specific gravity, moisture, water absorption were studied and compared with conventional concrete mix. Based on the test results, the 15% replacement shows better results compared to conventional concrete.*

## 2. Introduction

Concrete is an artificial material obtained by cementing together fine and coarse aggregates (sand and broken stone) using a binding material. The strength of concrete depends on many factors like proportion of the component materials, amount of water used during mixing, size and grading of aggregates, method mixing/compaction temperature and humidity at the time of mixing, molding and curing etc.,

Glass is one of the man-made materials. Large amount of glass wastes is produced and disposed to landfill site day by day where glasses cannot be decomposed because it is non-biodegradable waste. It could be recycled indefinitely and used many times.

The most widely used fine aggregate in concrete is river sand and M-sand. Because of its increased cost and scarcity, it will make the way for usage of substituent materials. Increase of usage of crushed waste glass content in concrete will decrease the density so that the self-weight of the concrete is reduced.

Tex mix 150 is used as admixture for high performance concrete, water reducing admixture for producing quality concrete at reduced Water- Cement ratio. Produces dense concrete with improved workability.

**Fig 1.Waste glass powder**

## 3. Literature review

**Dhanraj Mohan Patil and Dr. KeshavK.Sangle [2013]** concluded that high compressive strength can be achieved when glass powder of small size (90 microns) can be used.

**Veenav Bhat, Bhavanishankar Rao (2014)** revealed that glass when crushed to very fine powder will react with cement contributes more strength. It also refers to identify at which percentage it will attains more strength. Water absorption can be reduced by increasing the amount of glass content. `

**R.Vandhiyan et al (2013)** determined that micro filler effect in glass powder will reduce the permeability of concrete and forms better bonding between the aggregates. He also suggested that workability can also reduce by decreasing the size of glass powder.

**Patil Dhanraj Mohan and Sangle Kehav K.** determined the test results from waste glass powder size ranging from 150µm to 90µm.He concluded that initial strength obtained is very less in 7$^{th}$ day but when compared to 28$^{th}$ day when adding glass powder in concrete.And also

use of glass particle size less than 90µm will attains more strength.

**Mohammad Iqbal Malik, Aarif Manzoor, Barkat Ayhmad**reveals that replacement of sand by 30% waste glass powder will increase the compressive strength at 28days.Workability of concrete will increase with increase in glass content. The slump value of the concrete increases with increases in glass content.

**Nassar Riz-Ud-Din and Soroushian Parviz** showed that introduction of millet glass waste in concrete will increase the slump of concrete which is higher than the conventional concrete mix which and absorption of water will decrease.

**Sadaqat Ullah Khan,Muhammad Fadhil Nuruddin,Tehmina Ayub** examines that usage of admixtures in concrete will decrease the settling time of concrete and bleeding can also be minimized with usage of ingredients in correct proportion.

**Pranali K. Kohad, Swapnil R. Satone [January- 2013]:** This study aims to use of marble powder as a partial replacement for the fine aggregate in the concrete. If the marble sludge powder as a partial replacement of fine aggregate it will help to reduce the environmental problems and it preserves the use of landfill for materials which cannot be recycled. Various tests have been conducted and from experimental investigation it has been understood that the compressive strength of the recycled fine aggregate with 30% replacement attains a high strength without adding chemical admixture. So from this paper it is understood that the partial replacement of fine aggregate with 30% of recycled aggregate gives a good compressive strength.

**Tomas U. GanironJr[2015] :**This experimental study aims the use of crushed concrete waste as a partial replacement for fine aggregate. In this the mortar mixture of concrete debris is compared with the conventional mortar mix. From this it is determined that the concrete waste mortar mixture is compared with conventional mortar of same proportion and various test are done and result is noted.

## 4.Material Properties

### a) Glass Powder

Waste Glass is crushed into fine powder (less than 4.75mm) is used in concrete mix. Generally, million tons of wastes are produced. In order to overcome the problem waste glass is used as partial replacement of fine aggregate in concrete.

**Table 1.Physical properties of sheet glass powder**

| Property | Value |
|---|---|
| Specific Gravity | 2.55 |
| Water Absorption | 1.66 |
| Fineness Modulus | 2.60 |
| Bulk Density | 1420 kg/m$^3$ |
| Void Ratio | 0.65 |

### b) Cement

Cement is one of the mainly used binding materials in construction field. It is very fine powder which is made from lime stone, clay, bauxite, iron ore etc. It is mixed with sand to form mortar and used for brick masonry.

**Table 2. Properties of cement**

| Property of Cement | Values |
|---|---|
| Fineness Of Cement | 7.5% |
| Grade Of Cement | 53 |
| Specific Gravity | 3.15 |
| Initial Setting time | 30 minutes |
| Final Setting Time | **600.**minutes |

### c)Fine Aggregate

Sand is naturally occurring material from rocks in the river banks. Different types of sand are used in construction but nothing can replace the properties of river sand. Sand passing through 2.36mm sieve size is used for casting the specimens.

**Table 3. Properties of Fine Aggregate**

| Properties | Values |
|---|---|
| Specific Gravity | 2.64 |
| Fineness Modulus | 2.25 |

### d) Coarse aggregate

Aggregate passing 20mm sieve and retained in 12.5mm is considered as coarse aggregate which is mixed up with cement and sand and used in concrete.

**Table 4. Properties of Coarse Aggregate**

| Properties | Values |
|---|---|
| Specific Gravity | 2.60 |
| Size Of Aggregates | 20 mm |
| Fineness Modulus | 2.65 |

**e)Water**

Casting and curing of specimens were done with the potable water as per IS 456:2000.

**Table 5. pH Value Test**

| WATER | pH VALUE |
|---|---|
| Test 1 | 7 |
| Test 2 | 7 |
| Test 3 | 7 |

## 5. Mixture Preparation for Cube Casting

**Table 6. Mix Proportion ($M_{50}$)**

| Concrete mix | Water | Cement | FA | CA | Admixture |
|---|---|---|---|---|---|
| M 50 | 153lit | 547 kg/m$^3$ | 726.11 kg/m$^3$ | 1008 kg/m$^3$ | 3.82 lit |
| | 0.34 | 1 | 1.32 | 1.84 | 0.006 |

**Table 7. Mix Proportions of Concrete**

| Glass Powder (%) | 5 | 10 | 15 | 20 |
|---|---|---|---|---|
| Cement (kg/m3) | 547 | 547 | 547 | 547 |
| FA (kg/m3) | 689.795 | 653.49 | 617.185 | 580.88 |
| CA (kg/m3) | 1008 | 1008 | 1008 | 1008 |
| Water (kg/m3) | 22.05 | 22.05 | 22.05 | 22.05 |
| Glass Powder(kg/m3) | 36.305 | 72.61 | 108.915 | 144.5 |

## 6. Experimental methodology

**i) Casting of Cubes**

Cubes were made (Fig. 3.9.2) using concrete mixture without GP and concrete mixture Containing GP as partial replacement of fine aggregate with various percentages (5%, 10%, 15% and 20%).

**Fig. 2. Casting of Concrete Cubes (M50)**

**ii) Curing of Concrete Cubes and Beams**

After casting, all the test specimens were stored at normal temperature in the casting place. They were de-moulded after 24 hours, and were put into a water-curing tank for 28 days at room temperature.

## 7. Test on fresh concrete

**i) Slump Cone test results**

**Table 8. Workability of all mixtures**

| Concrete mix | M 50 | GP 5% | GP 10% | GP 15% | GP 20% |
|---|---|---|---|---|---|
| Slump value | 40 | 38 | 35 | 33 | 30 |

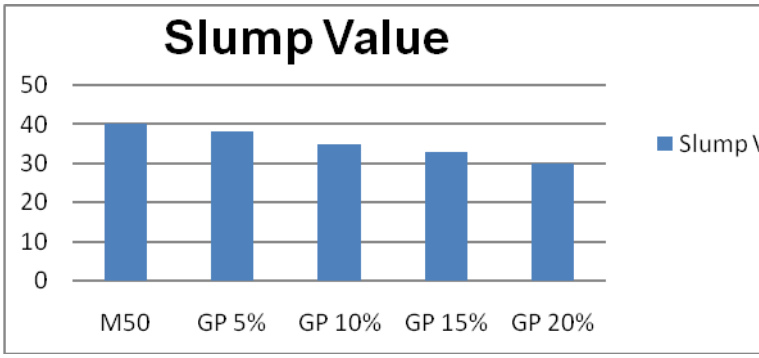



**Table 9. Compaction Factor Test (GP)**

| Concrete Mix | Partially compacted concrete (kg) | Fully compacted concrete (kg) | Comp |
|---|---|---|---|
| M50 | 11.56 | 13.84 | |

| | | |
|---|---|---|
| 12.82 | 15.16 | 0.845 |
| 12.87 | 15.93 | 0.807 |
| 12.3 | 15.26 | 0.806 |
| 12.1 | 14.96 | 0.808 |

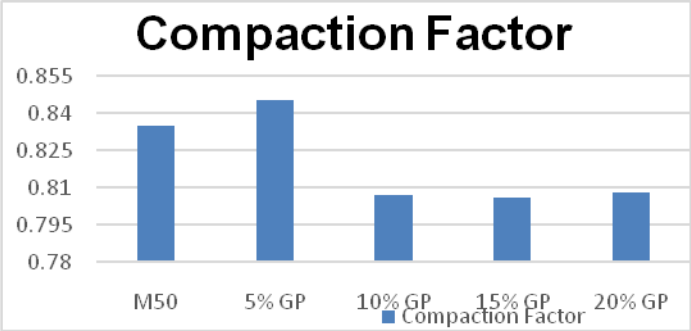
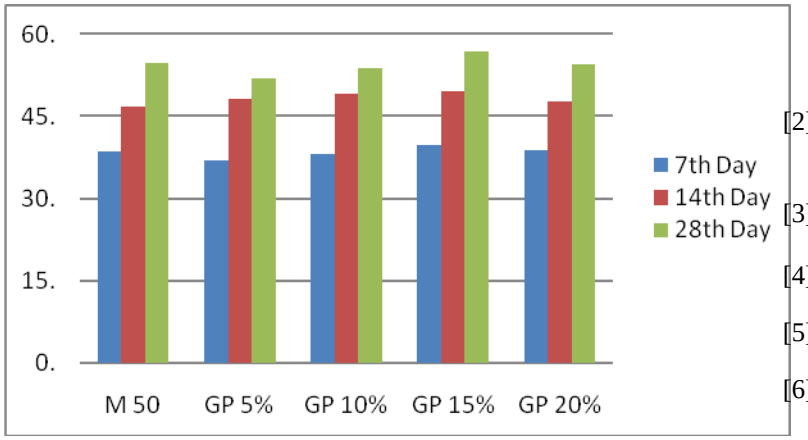



**Table 10. Compressive strength test (N/mm2)**

| Concrete Mix | 7th Day | 14th Day | 28th Day |
|---|---|---|---|
| M50 | 38.44 | 46.66 | 54.55 |
| GP 5% | 36.88 | 48.0 | 51.77 |
| GP 10% | 37.94 | 49.1 | 53.77 |
| GP 15% | 39.77 | 49.4 | 56.65 |
| GP 20% | 38.68 | 47.68 | 54.29 |




## 8.CONCLUSIONS

The present work investigated the physical and chemical properties of waste foundry sand. Concrete properties (compressive strength, water absorption and porosity) were analyzed for untreated GP and reclaimed GP as partial replacement of sand (5%, 10%, 15% and 20%). On the basis of the results from the present study, following conclusions are drawn.

Based on the test carried out on the five mixtures the following conclusion has been made:

- The fineness and high water absorption properties of the GP and Reclamation of GP reduce the workability of the concrete, and the workability of the concrete also decreases with rise in the GP substitution rate.
- Altogether ages of concrete, the strength properties of the concrete mixtures containing GP and Reclamation of GP up to 20% was comparatively on the point of the strength worth of the CC.
- The concrete mixtures of GP and Reclamation of GP 25% and 35% showed a decrease in compressive strength of just 1.6% and 5.7%, severally, at the age of 28 days when compared to the CC.
- Water absorption, voids, porosity decreases with addition of GP and Reclamation of GP compared to control mix.
- From the results obtained it is suggested that GP and Reclamation of GP with a substitution rate up to 25% can be used effectively as a fine aggregate in sensible concrete production while not reducing the concrete standard

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