Effect of Fine Glass and Quartzite Powder on Microstructure and Strength Properties of Concrete

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Abstract
Concrete is a vital construction material. It consumes a high number of natural resources like water, sand, and stones. Due to the increase in human population, the demand for new construction is at its peak and increasing day by day. Due to this, we utilize many natural resources. Researchers and scientists are searching for different ways in which they can reduce the amount or find alternates for use of other materials in the manufacture industry. The use of waste materials is one of them. In this, research has been done by using Waste glass powder and Quartzite powder in concrete to find alternates or partial replacements for natural resources in concrete. It was found that the joined effective use of glass powder and quartzite powder in concrete permitted the substitution of up to 15% glass powder and 30% quartzite powder. Various effects of these materials on concrete are discussed like effects on strength characteristics, and microstructure studies like X-Ray Diffraction (XRD) and Scanning Electron Microscope (SEM). This study includes research and literature study from various journals paper and then the conclusion was made up.

Key Words: Glass Powder; Quartzite Dust Powder; Mechanical Properties; X-Ray Diffraction (XRD); Scanning Electron Microscope (SEM).

1. INTRODUCTION
The electrical conductivity of plain and coarse glass powder changed concrete paste is portrayed in this work. The utilization of Glass Powder (GP) improves the concrete grains hydration. From strength and hydration testing, it was observed that 10% replacement of concrete by glass powder is the best amount [1–3]. Glass powder and fly ash treated types of cement had quite recently a 5% contrast in compressive strength at later ages. As far as decreasing expansion, glass powder–fly ash combinations that make up a 20% concrete substitution level are demonstrated to be pretty much as compelling as 20% fly ash. This boundary might be utilized to ascertain the adequacy of any concrete substitution material in a paste framework as it ages. At the predetermined water-to-cementing materials proportion (w/cm), a 5% concrete supplanting with glass powder was demonstrated to be fruitful, anyway at more noteworthy substitution levels, the dilution effect prevails. To decide its application in concrete, squashed Waste Glass powder (WGP) and used in mortar as a fractional concrete substitute (0, 10%, and 20%). Tentatively [4–6], the pozzolanic reactivity of waste glass powder was examined at concrete substitution levels of 0, 15, 30, 45, and 60% by weight. Glass powder included concrete after some time respond with glass powder and structure Calcium, Silicate, Hydrate (C-S-H) which help in making ultra-elite cement. Due to the elimination of macro porosity and biggest pores at a small size, X-Ray Diffraction (XRD) investigation result shows that Glass Powder (GP) when responding with concrete speed up the hydration process. When 100% silica was utilized instead of glass powder, the least compressive strength was noticed. Notwithstanding the natural
benefits, the substantial arranged with 20% GP replacement had higher 91-day compressive strength (7%), 28-day tensile strength (35%), and 28-day flexural strength (4%) than reference blends without GP [7–9]. Distinctive GP contents (0, 10%, 20%, 40%, and half) were utilized to substitute cement in customary Ultra High-Performance Concrete (UHPC), and their consequences for usefulness, hydration energy, microstructure, and mechanical attributes were contemplated. As per this exploration usefulness of substantial begin to diminish when there are expansions in a type of squashed glass in the type of totals or substitution to solidify. Because of the expansion of the squashed glass in concrete the presence of voids is less when contrasted with customary cement. This may likewise prompt expansion in the Compressive, Flexural, Split elasticity of cement. The substantial combination including Natural Mineral Aggregates (NMA) total had a droop worth of 40 mm, while the substantial blend including Glass Aggregates (GLA) total had a droop worth of 20 mm, demonstrating a half droop decline [7–12]. For instance, utilizing 20% Glass Aggregates (GLP) as a cement substitute in concrete blends including Glass Aggregates (GLA) and Natural Mineral Aggregates (NMA) totals raised slump value by 55% and 63%, separately. As indicated by this exploration glass powder, quartz powder, and silica exhaust help in making Ultra High-Performance Concrete (UHPC) due to improved miniature primary of cement. These materials give constructive outcomes on mechanical and miniature primary properties of cement. Miniature investigations like Mercury Interruption Porosimetry (MIP), XRD examination, and Spectroscopy analysis are performed Concrete compressive strength esteems with fractional substitution of cement with ground waste glass powder at 0%, 15%, 18%, 21%, 24%, 27%, and 30%. To research the conceivable utilization of this matrix in fiber cement composites, the Glass Powder Residue (GPR) was worn as limited substitution in cement paste up to half by weight. The supplanting of the coarse total with quartzite up to 100% in plain concrete cement was concentrated tentatively [7–15].

2. MATERIAL USED
Concrete is made by combining readily available materials acting as cement, aggregates, water, and so on. Throughout the project, Pozzolana Portland Cement (PPC) cement was used. Perfect Zone-II stream sand, with a maximal size of 4.75 mm was worn in this study. The machine crushed coarse aggregate that was angular in shape and less than 20mm in size were used to prepare concrete [16–18].

3. Glass Powder
Glass powder was prepared from squarding glass collected from local establishments. Glass shards are a tough substance. Glass powder was pulverized to the desired size for 30 to 60 minutes before being added to the concrete. Fig.1. shows the glass powder considered in this study. The physical, chemical properties and chemical creation are listed in Tables 1, 2, and 3.

| Properties             | Value |
|------------------------|-------|
| Specific gravity       | 2.67  |
| Fineness Passing 150µm | 99.5  |
| Fineness Passing 90µm  | 98    |

Table 1 Physical Properties of glass powder
| Properties      | Value  |
|-----------------|--------|
| pH              | 10.18  |
| Color           | Grayish White |

**Table 3 Chemical Composition of Glass Powder**

| Properties                               | Value  |
|------------------------------------------|--------|
| Silicon dioxide (SiO₂)                   | 71.09  |
| Sodium Oxide (Na₂O)                      | 10.46  |
| Iron Oxide (FeO₃)                        | 1.77   |
| Calcium Oxide (CaO)                      | 10.5   |
| Magnesium Oxide (MgO)                    | 1.56   |
| Potassium Oxide (K₂O)                    | 0.89   |
| Loss on ignition (LOI)                   | 0.60   |
| Sulfur trioxide (SO₃)                    | 0.03   |
| Aluminum Oxide (Al₂O₃)                   | 3.52   |
4. Quartzite Powder
Sandstone that has been transformed into a hard quartz rock is known as quartzite. Quartzite, unlike sandstones, is free of pores and has a smooth fracture; when hit [19–21], they pass through the sand grains rather than around them, providing a smooth surface rather than a granular one. In this study, machine smashed finely screened quartzite sand obtained from a nearby quartzite quarry was used.
Quartzite is a smashed stone that is extremely hard. Its adequacy and scraped area resistance are superior to most other materials. Because of its high silica concentration, quartzite is valued as a raw material. Fine aggregates are used to replace quartzite powder particle sizes ≤ 4.75mm in small quantities. Tables 4, 5, and 6 listed the physical, chemical, and chemical formation features.

| Table 4 Physical Properties of Quartzite Powder |
|-----------------------------------------------|
| Properties         | Value      |
| Specific gravity   | 2.67       |
| Bulk density       | 1.35g/cm³  |
| Melting Point      | 1710 °C    |
| Boiling Point      | 2230 °C    |

| Table 5 Chemical Properties of Quartzite Powder |
|-----------------------------------------------|
| Properties | Value |
| Humidity   | 1     |
| pH         | 11    |
| State      | Solid |

| Table 6 Chemical Composition of Quartzite Powder |
|-----------------------------------------------|
| Properties      | Value         |
| Loss ignition (%) | 0.12          |
| Silicon dioxide (SiO2) | 97.12         |
| Iron Oxide       | 0.13          |
| (Fe2O3)          | 2.16          |
| Calcium Oxide    | 0.07          |
| (CaO) Moisture   | Negligible    |
| Organic Matter   |               |

5. EXPERIMENTAL INVESTIGATION

Mix Design
Using Indian Standard as a control concrete, a concrete blend arrangement was presented. The grade was M30 was prepared according to IS 10262-2009. Glass powder was replaced with cement at 10%, 15%, and 20%, while quartzite powder was substituted with sand at 10%, 20%, and 30% levels. Here, no synthetic admixture is used. Workability of fresh concrete was maintained throughout the span of this task job, the ranged from 80mm to 100mm.

Compressive Strength
The concrete was relieved under usual conditions according to IS recommendation, with flexible levels of Glass powder substitution of the cement, and quartzite powder substituted with fine aggregates. The outcome of the compressive strength test for 7 and 28 days is displayed in table 7 and figure 2.
### Table 7 Compressive strength of cubes after 7 and 28 days

| Percentage of glass powder And Quartzite Powder | Strength of cube after 7 days (N/mm²) | Strength of cube after 28 days (N/mm²) |
|-----------------------------------------------|--------------------------------------|----------------------------------------|
| 0, 0                                          | 24.93                                | 36.04                                  |
| 10, 10                                        | 28.79                                | 38.79                                  |
| 10, 20                                        | 29.9                                 | 40.01                                  |
| 10, 30                                        | 8                                    | 41.90                                  |
| 10, 30                                        | 31.7                                 | 7                                      |
| 15, 10                                        | 31.82                                | 41.81                                  |
| 15, 20                                        | 31.76                                | 41.49                                  |
| 15, 30                                        | 32.16                                | 42.86                                  |
| 20, 10                                        | 32.31                                | 41.09                                  |
| 20, 20                                        | 32.77                                | 42.05                                  |
| 20, 30                                        | 30.09                                | 40.60                                  |

![Compressive strength of samples](image-url)

**Fig. 2.** Compressive strength of samples
As indicated by IS: 516-1959, the compressive strength of the pair ordinary and glass-added concrete was tried on a standard compression testing machine with a 3000 KN limit. Concrete cube samples of size 150mm × 150mm × 150mm, were tested for compressive strength at 7 days and 28 days. The concrete sample with 15% substitution of cement with Glass powder and 30% substitution of Quartzite powder plus fine aggregates displayed the best result at 7 and 28 days of testing when checked with nominal concrete samples without any replacement.

6. Flexural Strength Test

As per IS: 516-2002, Specimen of cement footers have been tried following multi-day of relieving to discover starting and last flexural strength of bars. A flexural testing machine is utilized to decide the strength of beams. In this Test, the concrete beam sample size i.e 150×150×700 was prepared to test for 28 days. The concrete sample with 15% replacement with Glass powder and 30% replacement with Quartzite powder with fine aggregates shows the best result at 28 days of testing when compared with the nominal concrete sample. Results are shown in Table 8 and the graphical representation is shown in fig.3.

| Percentage of glass powder And Quartzite Powder | Strength of cube after 28 days (N/mm²) |
|-----------------------------------------------|----------------------------------------|
| 0,0                                          | 4.50                                   |
| 10, 10                                       | 4.69                                   |
| 10, 20                                       | 4.87                                   |
| 10, 30                                       | 5.01                                   |
| 15, 10                                       | 5.34                                   |
| 15, 20                                       | 5.45                                   |
| 15, 30                                       | 5.57                                   |
| 20, 10                                       | 5.19                                   |
| 20, 20                                       | 5.01                                   |
| 20, 30                                       | 4.92                                   |
7. Split Tensile Strength Test

Examples of substantial chambers have been tried for 28 days to discover the introductory and last split elasticity of chambers. As indicated by IS 5816 -1999 code assists with acquiring the ideal worth. A compressive testing machine was utilized to discover strength. In this Test, the substantial chamber test size i.e 150mm width and 300mm long were set up to test for 28 days. The substantial example with 15% supplanting with Glass powder and 30% supplanting with Quartzite powder with fine aggregates shows the best outcome at 28 days of testing when contrasted and ostensible substantial example. The Results have appeared in Table 9 and the graphical portrayal is displayed in fig.4.

| Percentage of glass powder And Quartzite Powder | Strength of cube after 28 days (N/mm²) |
|-----------------------------------------------|---------------------------------------|
| 0.0                                           | 3.30                                  |
| 10, 10                                        | 3.36                                  |
| 10, 20                                        | 3.42                                  |
| 10, 30                                        | 3.79                                  |
| 15, 10                                        | 4.15                                  |
| 15, 20                                        | 4.24                                  |
| 15, 30                                        | 4.48                                  |
| 20, 10                                        | 4.29                                  |
| 20, 20                                        | 4.27                                  |
| 20, 30                                        | 4.19                                  |

![Fig.3 Flexural strength test values after 28 days of testing](image)

![Fig.4. Split Tensile strength test values after 28 days of testing](image)
8. XRD Analysis

XRD is a method for analysing elements that has a wide range of uses in research and industry. Singular molecules discharge X-beam photons of specific energy or frequency when actuated by an outer energy source, as indicated by XRD. The components present can be perceived and evaluated by estimating the number of photons of every energy radiated from samples. The XRD report of the samples with the best replacement under compression test is in table 10.

Table 10 shows the ICDD of compounds found

| Compound     | ICDD        |
|--------------|-------------|
| SiO2         | 01-089-8935 |
| C2S          | 01-076-0364 |
| Ca2SiO4H2O   | 00-012-0739 |
| CaCO3        | 01-086-2334 |

The sample with 15% glass powder and 30% quartzite powder replacement with cement and fine aggregates respectively is shown above. The SiO2, C2S, Ca2SiO4H2O and CaCO3 are the compounds formed as glass and quartzite powder react with other materials present in concrete. Calcium silicates contribute the most to cement strength whereas the di-calcium silicates are in charge of cement solidification over a lengthy period, resulting in maximum strength. The calcium carbonate formed gives early strength to concrete by increasing heat of hydration, see figure 5.

9. SEM Analysis

A checking electron magnifying lens (SEM) is an electron magnifying lens that provides images of a sample by analyzing the surface with engaged light emission. Figure 6 represents the SEM image for the best proportions used as replacement under compression test.

Fig.5. XRD Report of sample with Glass and Quartzite powder

Fig.6. SEM image of Glass and Quartzite mixed concrete
The microstructure and surface morphology of calcium silicate hydration and ettringite growth in concrete are examined using a scanning electron microscope (SEM). The positioning of Glass powder and Quartzite Powder in voids compared to regular cement has been a significant finding which can provide impermeable design. Pozzolanic reactions inside the concrete change the microstructure inside and build Calcium Silicate Hydrate (C-S-H), thus expanding strength.

10. CONCLUSION

The following conclusions were derived from the above-mentioned experiment using glass powder and quartzite powders:

- After performing the various tests, the most suitable percentage found out was 15% Glass powder and 30% Quartzite powder on replacement with cement and fine aggregates respectively.
- Massive increase in strength was recorded after performing various mechanical tests on the concrete samples. In compression, flexural and split tensile strength test an increase in 18%, 23%, and 35% respectively were observed when compared with a nominal concrete sample without any replacement.
- Finely ground glass is a great filler and may have sufficient pozzolanic properties to fill in as fragmentary substantial replacement; the effect of Alkali-Silica reaction appears to be diminished with glass particles.
- The SiO2 presence can pack the particles and decrease the volume which on the other hand decrease the free water present and help in imparting better strength to the concrete. Other compounds like the presence of calcite can speed up in achieving early strength of concrete.
- The decline at higher proportions could be due to the presence of unreacted access amount of Glass powder, which has resulted in the decline of the strength.

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