Effect of Fine Aggregate Replacement with Dolomite powder on GFRC Mechanical Properties

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Abstract. Portland cement, sand, water, acrylic copolymer, alkali resistant glass fibre reinforcement (GFR), and additives make up Glass Fiber Reinforced Concrete (GFRC). Dolomite is a calcium magnesium carbonate anhydrous carbonate mineral. The aim of this study is to find the flexural strength of the concrete, split tensile of beam, and compressive strength of Glass Fibre Reinforced Concrete (GFRC) with Dolomite Waste used as the partial sand (fine aggregate) substitute. In this direction, an investigation of strength was conducted to find the use of dolomite as a partial (10%, 20%, 30%, 40%, 50%, and 60%) substitute for fine aggregate in GFRC. The M25 grade of concrete was subjected to hardened concrete tests at the ages of seven and twenty-eight days. The findings of the tests are compared to those of standard concrete.

1. Introduction
Because of the growth in infrastructure and construction activities all over the world, concrete use is growing at a faster pace. Sand is one of the most important components of concrete, accounting for about 35% of the amount of concrete used in the building industry. Natural sand is in high demand in developing countries to meet the rapid infrastructure development [1]. As a result, developing countries such as India are experiencing a shortage of good quality natural sand. Increased mining of natural sand from riverbeds is causing a slew of issues, including a depletion of water-retaining sand, widening of river courses, and bank slides. Sand is becoming increasingly scarce these days, so researchers started looking for a low-cost, readily available alternate material to natural sand. Use of imported sand as an alternative building material will help to keep construction costs down. This paper explores the use of Eco sand to replace M sand. Eco-friendly sand is a type of very fine and smaller particle that is produced as a byproduct formed from cement manufacturing and can be used to improve the quality of concrete. Its micro-filling effect eliminates pores in concrete, resulting in improved moisture resistance and durability [2]. It has higher grading accuracy than many extracted aggregates. It is a cost-effective use of waste material that works similarly to naturally occurring sand.

The physical parameters of GFRC using eco sand are being investigated in this research. Green High Performance Concrete Using Eco friendly Sand and waste from Industries, Magudeaswaran P. Due to the use of 25% FA and a 40% substitution of eco sand, the flexural strength was improved at the period of 28 days. Investigation was done experimentally for Partial Replacement of Sand by M-Sand and Eco friendly Sand was performed [3]. Ecofriendly sand is a type of very fine particle that
produced as a byproduct of the cement manufacturing process and can be used to improve the quality of concrete. Its micro-filling effect in concrete decreases pores and improves moisture resistance and thus longevity. When natural sand is replaced with Eco sand, the compressive strength of concrete is increased by 10.60 percent when the comparison made with traditional concrete [4]. Indira M investigated the use of dolomite as a substitute for cement and fine aggregate. The eco sand is as fine as a filler, according to SEM and XRD, and has the potential to fill the pores in the transition zone of concrete. Eco sand replaced 15% of the sand in the mix, raising compressive strength by 24.02 percent and split tensile strength by 58.14 percent. However, 10 percent replacement mortar increased compressive strength by 10.45 percent [5]. A. Vishnu Manohar investigated the results of substituting eco sand for fine aggregate at 15%, 30%, 45%, and 60%. Based on the findings, they discovered that replacing 15% of fine aggregate in concrete with eco sand achieves the optimum strength [6]. The compressive strength value decreases as the % of eco sand increases. Dolomite powder was studied by Olesia Mikhailova. As a result, applying 25% dolomite powder to concrete improved early strength and densified the structure in the early stages without having any harmful effects on later ages. Aswani.J investigated the effects of partial cement replacement with crystalline silica in cement concrete. The findings show that when cement is substituted with crystalline dolomite silica, concrete strength increases up to 15%, after which the strength decreases. Durga.B investigated the effects of silica as a partial substitute for fine aggregate [7]. In the case of compressive power, the closest ideal replacement percentage was 60 percent with 39.30 N/mm².

2 Materials and Mix Proportioning

2.1 Materials and Properties

Portland Pozzolana Cement (PPC)

The cement which was used in the experiment was Portland pozzolana cement (PPC), which complies with the IS:1489-1991 standards. Table 1 lists the physical properties of the cement that was tested.

| S. No. | Properties          | Value             |
|-------|---------------------|-------------------|
| 1     | Cement Fineness     | 1.9               |
| 2     | SG of the Cement    | 2.9               |
| 3     | Normal Consistency  | 32 %              |
| 4     | Setting Time        |                   |
|       | Initial             | 20 min            |
|       | Final               | 203 min           |
| 5     | Soundness test      |                   |
|       | Le-Chat Expansion   | 1 mm              |

Glass Fibres

Alkali-resistance glass fibre with a cut length of twelve mm and a radius of 7 microns was used in this experiment. Silicon dioxide (SiO₂), lime (calcium oxide or CaO), and aluminium oxide are the three primary ingredients used to produce glass (Al₂O₃). Changing the proportions of certain elements and other minerals would produce very different glasses [8]. E-glass (so called because of its strong electrical insulation properties) is a widely used glass on the market.

Dolomite

ACC Cements, Coimbatore, produces dolomite, which is also known as Ecosand. Ecosand (finely graded silica) is a very fine particle that is a byproduct of cement manufacturing and can be used to
improve concrete production. Its micro-filling effect in concrete decreases pores and improves moisture resistance and thus longevity [9]. It is produced during the crushing of dolomite rock. Dolomite is priced at Rs. 2500 per unit. Figure 1 shows dolomite powder.

Figure 1. Dolomite powder

In the experimental study, OPC 53-grade is used. Table 2 denotes the physical properties of dolomite and M-sand.

| Test                  | M sand | Dolomite | Coarse aggregate |
|-----------------------|--------|----------|------------------|
| Specific gravity      | 2.59   | 2.51     | 2.88             |
| Fineness modulus      | 2.320  | 0.89     | 7.125            |
| Water absorption      | 2.84%  | 8.49%    | 0.31%            |
| Grading zone          | Zone II| Zone IV  | -                |

**Sieve Analysis**

Finely graded silica has a particle size distribution that is similar to that of silt (less than a 0.075mm). The eco sand sample was fineness tested according to the IS 2386: 1963(Part 1) standard. Table 3 displays the result of Sieve Analysis for M sand replaced by Dolomite-waste.

| % Replacement of dolomite in FA | Fineness modulus | Grading zone |
|---------------------------------|------------------|--------------|
| 0                               | 2.320            | II           |
| 10                              | 2.196            | II           |
| 20                              | 2.179            | II           |
| 30                              | 1.889            | III          |
| 40                              | 1.831            | III          |
| 50                              | 1.609            | III          |
| 60                              | 1.505            | III          |
| 70                              | 1.287            | IV           |
| 80                              | 1.131            | IV           |
| 90                              | 0.99             | IV           |
| 100                             | 0.92             | IV           |

The chemical composition of the dolomite discovered by EDAX testing is shown in Table 4.

| Chemical composition | DOLOMITE | M SAND |
|----------------------|----------|--------|
| SiO₂                 | 58-60%   | 68.62% |
| Al₂O₃                | 2-3%     | 16.73% |
2.2 Mix Proportioning

IS:10262-2009 is used to create the mix template. Considering the water / cement ratio as 0.45, the proportions used for M25 grade are 1:1.74:3.06 (ZONE II) and 1:1.65:3.16 (ZONE III). A total of seven Dolomite mixes are used, with 0%, 10%, 20%, 30%, 40%, 50%, and 60% of Dolomite in each.

3. Experimental Investigation

3.1 Concrete

M25 concrete was used to cast the specimens. Table 5 lists the amounts of the mixer used in the concrete mix.

| Materials   | Quantity (kg/m³) |
|-------------|------------------|
| Cement      | ZONE II | ZONE II |
| Fine aggregate | 687      | 688     |
| Coarse aggregate | 1217     | 1256    |
| water       | 198.25   | 198.16  |

3.2 Specimen Details

A mix proportions of M25 grade concrete were used to make the concrete. The experimental programme used various percentages of fibres, such as 0, 0.03, 0.06, and 0.1. By volume of concrete, glass fibres were applied to the mix. With a measured volume of water and plasticizer, the whole mixture was homogeneously mixed. The compressive strength test specimens were 150mm x 150mm x 150mm measurement. Split tensile strength of the test specimens weighed 150mm in diameter and 300mm in length. The flexural strength test specimens were 100 x 100 x 500mm in scale. These specimens were cast and examined according to IS specifications after seven days and twenty-eight days of curing.

Three cubes, three tubes, and three prisms were cast for each replacement ratio. Figure 2 shows the specimens.

3.3 Compressive strength

IS 516-1959 was used to conduct compression tests on concrete cubes. Table:6 shows the test results, and figure 3 shows the graph.
### Table 6. Compressive strength of GFRC

| % Replacement of dolomite | Compressive Strength (N/mm²) |       |       |
|---------------------------|------------------------------|-------|-------|
|                           | 7 days                       | 28 days |       |
| 0                         | 16.552                       | 28.885 |
| 10                        | 20.092                       | 31.201 |
| 20                        | 21.785                       | 33.042 |
| 30                        | 18.878                       | 28.845 |
| 40                        | 16.673                       | 25.042 |
| 50                        | 12.075                       | 20.255 |
| 60                        | 10.587                       | 21.581 |

![Figure 3. Dolomite replacement vs strength of Compression](image)

### 3.4 Split tensile strength

It is the industry standard measure for assessing concrete tensile strength. STS tests were carried out in compliance with the IS 5816-1970 standard. Table 6 shows the test findings, and figure 4 shows the difference in split tensile strength of cylinders.

### Table 7. Split tensile strength of GFRC

| % Replacement of Dolomite | Split Tensile Strength (N/mm²) |       |       |
|---------------------------|-------------------------------|-------|-------|
|                           | 7 days                        | 28 days |       |
| 0                         | 1.547                         | 1.943  |
| 10                        | 4.496                         | 2.147  |
| 20                        | 1.762                         | 2.224  |
| 30                        | 1.467                         | 1.850  |
| 40                        | 1.280                         | 1.601  |
| 50                        | 1.495                         | 1.631  |
| 60                        | 1.021                         | 1.356  |
3.5 Flexural strength
IS 516-1959 was used to conduct the flexural strength test. Table 8 displays the test effects, and figure 5 depicts the difference in prism flexural power.

| % Replacement of Dolomite | Flexural Strength (N/mm²) | 7 days | 28 days |
|---------------------------|---------------------------|--------|--------|
| 0                         | 3.897                     | 5.986  |
| 10                        | 3.733                     | 6.889  |
| 20                        | 4.042                     | 7.756  |
| 30                        | 3.856                     | 6.658  |
| 40                        | 2.987                     | 4.970  |
| 50                        | 2.744                     | 4.369  |
| 60                        | 2.459                     | 4.058  |

4. Conclusions
- Compressive strength is increased by 18 percent, split tensile strength is increased by 14 percent, and flexural strength is increased by 28 percent when 20 percent dolomite is substituted.
- Based on the observations, we discovered that replacing 20% of fine aggregate (sand) with eco sand in GFRC results in the highest strength. The compressive strength value decreases when the percentage of eco sand gets increased.
• Eco sand (finely graded silica) is a locally usable, low-cost, and inert industrial solid waste that, like construction waste, poses a disposal problem.
• The size of eco sand ranges from nm to μm, and this physical property allows us to use it to fill voids.

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