

Experimental Investigation on Partial Replacement of Cement with Dolomite Powder, Fly Ash by Using Slag Sand in Concrete

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Abstract:

Cement is one of the most important constituents of concrete. Most of the properties of concrete depend on cement. Cement is manufactured by calcining argillaceous and calcareous materials at a high temperature. During this process, large amount of CO₂ is released into the atmosphere. India is the second largest producer of cement in the world. It is estimated that the production of one ton of cement results in the emission of 0.8 ton of CO₂. The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of CO₂. Dolomite powder is obtained by Pulverising the sedimentary rock-forming mineral dolomite and Dolomite powder has some similar characteristics of cement. Using dolomite powder in concrete can reduce the cost of concrete and may increase the strength to some extent. Fly ash use in concrete improves the workability of plastic concrete, and the strength and durability of hardened concrete. Fly ash use is also cost-effective. When fly ash is added to concrete, the amount of Portland cement may be reduced. Sand plays a vital role in the construction arena. The sand acts as a filler material and it binds with all the aggregates and voids are eliminated to the full extent. Nowadays due to mining resources being exhausted and to find a replacement of sand, the authors have chosen slag sand which consists essentially of glass containing alumina silicates of lime and silicates. The slag sand percentage instead of natural sand has been changed gradually and the results showed a positive trend it proved that slag can be partially replaced for the strength attainment obtained from can be used as a replacement material for cement in concrete up to a certain percentage. The main aim of this experimental study is to evaluate the performance of concrete by partial replacement of dolomite powder and fly ash with cement by using slag sand. In this investigation, a mix design of Standard concrete M60 grade will be made in the replacement of cement with dolomite powder at various percentages of 0%,5%,10%,15%, and 20%, and 5%,10% and 15% of fly ash. In experimental investigation sufficient number of cubes will be cast to study the compressive strength.

Key words: Dolomite powder, fly ash, slag sand, M60.

I. Introduction

1.1 General:

The most often used building material worldwide is concrete. Concrete is used extensively in infrastructure construction, including buildings, industrial structures, bridges, highways, dams, and other structures. Due to its ability to take on a variety of geometrical shapes, concrete is known to be the most widely used structural material. It consists of cement, water, and both fine and coarse particles. Recent research on Dolomite powder, Fly ash, and slag sand has revealed a higher scope for their use as cement and fine

aggregate in concrete. Up to a specific amount, dolomite powder, which is produced by powdering the sedimentary rock-forming mineral dolostone, can be used in place of cement in concrete. It was obtained from Sri Damodaram Sanjeevaiah Thermal Power Station Nellore, dried, and subsequently used.

Current research is looking at using Industrial wastes like Dolomite powder, Fly ash, and slag sand are being studied as potential substitutes for cement and Fine aggregate in the production of concrete. This research looks at the manufacture and characterization of on Dolomite powder, Fly

ash, and slag sand, and assesses the quality of building materials including cement, sand, and coarse aggregate. In addition, the experimental research of fresh and cured concrete qualities was measured and discussed.

1.2 Objectives of Research:

The following are the key goals of this investigation:

- a) To figure out the appropriate mix ratio for the partial substitution of cement with Dolomite powder and Fly ash by the sampling specimen's strength-to-weight ratio.
- b) Figuring out the compressive strength of the specified material in order to evaluate the possibility of partial concrete substitution.
- c) Using the test results as a reference, recommending the addition of Dolomite powder and Fly ash in the most approximative portion.

ii. Review Of Literature

Preethi Getal (2015), conducted research on the subject of "an investigation on effects of using dolomite powder as a partial replacement material to cement". "M20 grade cement was substituted for dolomite powder at percentages of 0%, 5%, 10%, 15%, 20%, and 25%. At a replacement of 10%, the maximum compressive and flexural strengths were discovered to be 31.24 N/mm² and 8.48 N/mm², respectively. At 15% replacement, the maximum tensile strength was discovered to be 4.25 N/mm². The highest improvement in compressive and flexural strength measured at 28 days was 10.4%.

Chepuri Jaswanthi Yoga, B Ajitha, They noted that Metakaolin and marble dust strength tests ranged from 0% to 20% and fine aggregate was fully replaced with slag sand and that they were done. The mix used was M60. The replacement experiments were carried out using 99 conventional cubic specimens of size 150mm*150mm*150mm, as well as 99 cylinders of 15cm and 20cm in height. The results showed that the replacement of cement with 15% Metakaolin and 10% Marble powder gave better results. When the percentage of Metakaolin is above 15% and by not altering the percentage of Marble powder to 10% there is a reduction in the strength of the concrete. The use of Metakaolin

with marble powder saves the environment and produces green concrete. The ideal proportion for Metakaolin is 15%, while for Marble powder it is 10%.

L. Zeghichi attempting to replace sand with GBF crystalline slag. The compressive strength of concrete cubes was tested to see how it would change if sand were replaced with granulated slag in any proportion (30%, 50%, or 100%). Test results were obtained 3, 7, 28, 60, and 5 months following the endeavour. According to tests, the tensile, flexural, and compressive strengths of concrete are increased when all of the natural coarse particles are substituted with crystallized slag. When natural aggregates are totally replaced with slag aggregate, the strength is decreased (38%), but with time, the strength is increased.

Salim Barbhuiya (2011): He carried out an investigation to explore the possibilities of using dolomite powder for the production of SCC. Test results indicated that it is possible to manufacture SCC using fly ash and dolomite powder. The mix containing fly ash and dolomite powder in the ratio 3:1 was found to satisfy the requirements suggested by the European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC) guidelines for making SCC. Compressive strengths of SCC with 75% fly ash and 25% dolomite powder were found to be satisfactory for structural applications.

R Dharsana et al their work "Experimental study on strength property of concrete by partial replacement of fine aggregate with dolomite powder." In this research, dolomite powder is studied as a replacement for fine aggregate in the following proportions: 10%, 20%, 30%, and 40%. Concrete's compressive, split tensile, and flexural strengths when compared to control concrete. According to this study, 30% is the ideal replacement percentage for dolomite powder in fine aggregate; after that, replacement increases for all cubes, cylinders, and beams and declines with additional addition. There is also more concrete.

II. Experimental Investigation

This research focuses on the methodology that will be applied such as material characterization,

concrete mix, and estimating the quantity of substances required for the specimens which might be going to be examined.

3.1 Materials Used:

A. Cement:Grade 53 ordinary Portland cement, as per, IS: 12269-1987, was utilized in this investigation. Throughout the investigation, the cement utilized was locally available Sri chakra

brand 53 Grade Ordinary Portland Cement. The cement’s physical characteristics as determined by different tests in accordance with Indian standard IS12269:1987. As indicated in the table, the various tests performed on cement include initial and ultimate setting time, as well as specific gravity.

Table 1: Cement's Physical Characteristics

| S.no | Property | Test result |
|------|----------------------|-------------|
| 1 | Normal consistency | 29% |
| 2 | Specific gravity | 3.11 |
| 3 | Initial setting time | 65min |
| 4 | Final setting time | 550min |
| 5 | Soundness | 3mm |
| 6 | Fineness (sieve) | 95% |

B. Fine Aggregate-Slag Sand: Slag Sand is an alternate material to River Sand. Natural resources are being disrupted sensitively as a result of the rapid extraction of river sand, which is being employed widely in the building sector as per with cement. Natural sand gives less compressive strength when compared with slag sand. The bonding strength varies due to the kind of stones used. When the truck changes the fineness modulus is changed so the mix has to be changed

often and then. Slag sand is obtained at the end from the iron and steel industry. It is formed by quenching molten iron in a blast furnace slag in water or steam and then drying and finally grinding it to a fine powder. It is a non-metallic product. Slag sand has a major constituent CaO which increases compressive Strength. The major advantage of Slag sand is it limits the increase of temperature and makes the heat of hydration reaction a bit slower.

Table 2: Preliminary Tests on Slag Sand.

| S.no | Preliminary Tests | Results |
|------|-------------------|---------|
| 1 | Specific Gravity | 2.65 |
| 2 | Bulking of Sand | 46.15% |

C. Coarse Aggregate:The coarse materials utilized in this research are 20 mm natural stone coarse aggregates that are locally available. Laboratory tests on coarse aggregate were performed as per

IS: 2386 (part III)- 1963 to determine the various physical properties and they can be shown in the table as follows.

Table 3: physical characteristics of Coarse aggregate

| S.no | Property | Test result |
|------|------------------|-------------|
| 1 | Specific gravity | 2.77 |
| 2 | Water absorption | 0.5% |

D. Dolomite Powder: Dolomite powder shares some cement-like characteristics. Concrete's cost

can be reduced by using dolomite powder, and its strength may be slightly increased. This Dolomite

powder capable of passing through a 90µm sieve of 50 kgs was transported from Astrra chemicals in E

Fly ash: From the combustion of pulverized coal and transported by the flue gases of boilers by pulverized coal, Fly Ash is produced. It was transported from Sri Damodaran Sanjeevaiah Thermal Power Station Nellore, dried and subsequently used. Likewise, the specific gravity of Dolomite powder is 2.5

F. Water: Concrete must be mixed with clean water that has no dangerous quantities of oils, acids, alkalis, organic compounds, or other deleterious chemicals. In this investigation, we used portable tap water from the college campus water plant that met the IS456-2000 standards for casting concrete and curing the specimens.

3.2 Mix proportions: To attain M60 grade strength, the concrete was designed in accordance with IS 10262-2009, and a water to cement ratio of 0.35 was employed. Distinct mixes of cement by dolomite powder at various percentages of 0%,5%,10%,15% and 20% and 5%,10% and 15% of fly ash were tested to analyze the strength characteristics in terms of Compressive Strength.

Chennai. Likewise, the specific gravity of Dolomite powder is 2.85.

Six cubes are cast for each mix and tested for hardened properties.

IV. RESULTS AND DISCUSSIONS

4.1 General: The tests were done on both freshly mixed and hardened concrete. The Fresh concrete mixture was tested for slump and workability. Hardened concrete tests include compressive strength test is performed.

4.2 Fresh Properties of Concrete:

Workability is tested in terms of slump cone and compaction factor test, which decrease as Slag sand is replaced with fine aggregate and Dolomite powder and Fly ash are replaced with cement, respectively. The slump cone and compaction factor test with % replacement is depicted in the graph below.

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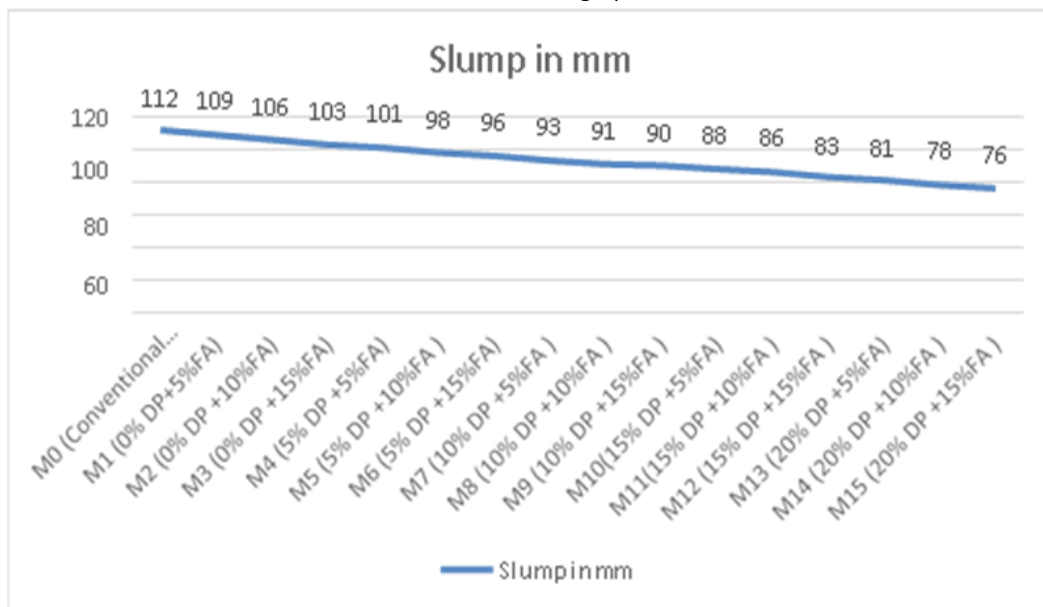


Figure 1: Slump with different mixed proportions of DP&FA.

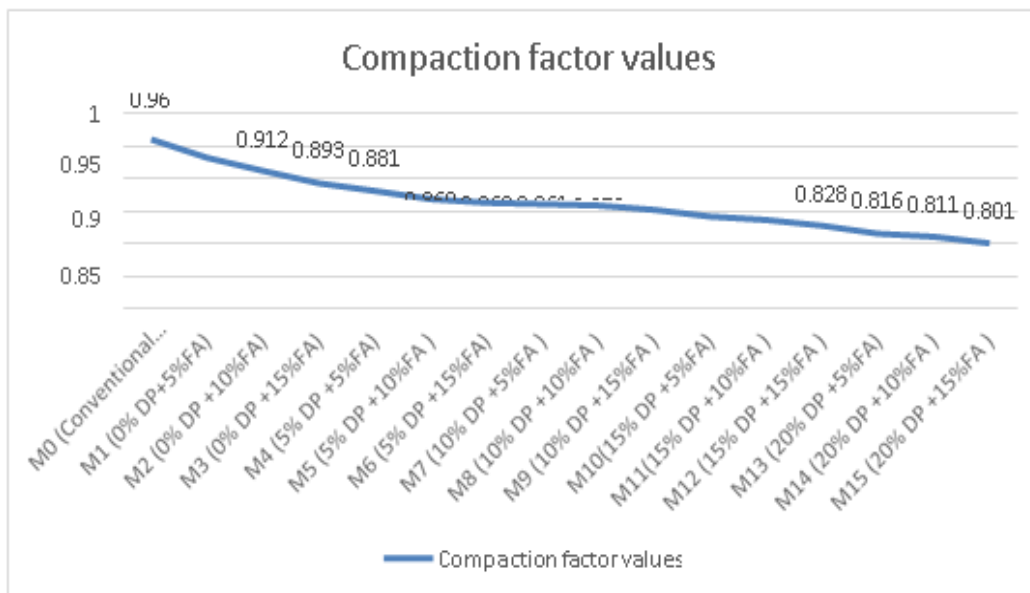


Figure 2: Compaction factor values with different mixed proportions of DP&FA.

4.3 Casting of specimens:

The moulds that were used to cast cubes, cylinders, and beams were carefully cleaned. A thin layer of oil was applied to the interior surface of the moulds to prevent concrete adherence and leakage. Then, using a tamping rod, the concrete was poured into the greased moulds (cubes, beams, and cylinders). Tests were conducted at 3, 7 and 28 days of age.

4.4 Curing:

Curing is the process of creating an atmosphere conducive to the setting and hardening of concrete. From the time the specimens leave their moulds until they are shipped to the testing laboratory, the specimens are completely immersed in a pond of water with 50 mm of water

over them. If possible, keep the temperature between 10°C and 25°C.

4.5 Hardened Properties Of Concrete:

Testing hardened concrete is crucial for assessing and confirming the quality of cement concrete work. The test methodologies should be precise, simple, and easy to apply.

A. Compressive strength test:

It is a key property of hardened concrete. concrete’s compressive strength development mostly depends on the proportion of Dolomite powder, Fly ash, and Slag sand utilized in concrete mixes. The compression testing equipment was used for the compressive test, and the failure load and cube compressive strength were evaluated 3, 7, and 28 days after curing.

Table 4: Compressive strength test results

| Mix.ID | 3 Days strength (N/mm ²) | 7 Days strength (N/mm ²) | 28 Days strength (N/mm ²) |
|---------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|
| M0 (Conventional mix 0%DP+0%FA) | 24.17 | 38.3 | 55.76 |
| M1 (0% DP+5%FA) | 25.22 | 38.6 | 59.42 |
| M2 (0% DP +10%FA) | 27.9 | 38.9 | 59.67 |
| M3 (0% DP +15%FA) | 28.3 | 39.10 | 61.04 |
| M4 (5% DP +5%FA) | 28.9 | 39.32 | 61.9 |
| M5 (5% DP +10%FA) | 30.4 | 39.47 | 62.93 |
| M6 (5% DP +15%FA) | 30.8 | 39.72 | 63.14 |
| M7 (10% DP +5%FA) | 31.10 | 40.4 | 64.8 |
| M8 (10% DP +10%FA) | 31.4 | 40.94 | 65.12 |
| M9 (10% DP +15%FA) | 31.89 | 41.2 | 69.4 |

| | | | |
|---------------------|------|-------|-------|
| M10(15% DP +5%FA) | 32.5 | 42.32 | 71.6 |
| M11(15% DP +10%FA) | 30 | 41.8 | 66.5 |
| M12 (15% DP +15%FA) | 28.5 | 39.68 | 64.60 |
| M13 (20% DP +5%FA) | 28.2 | 39.30 | 63.42 |
| M14 (20% DP +10%FA) | 27.6 | 38.45 | 62.95 |
| M15(20% DP +15%FA) | 27.3 | 37.3 | 61.40 |

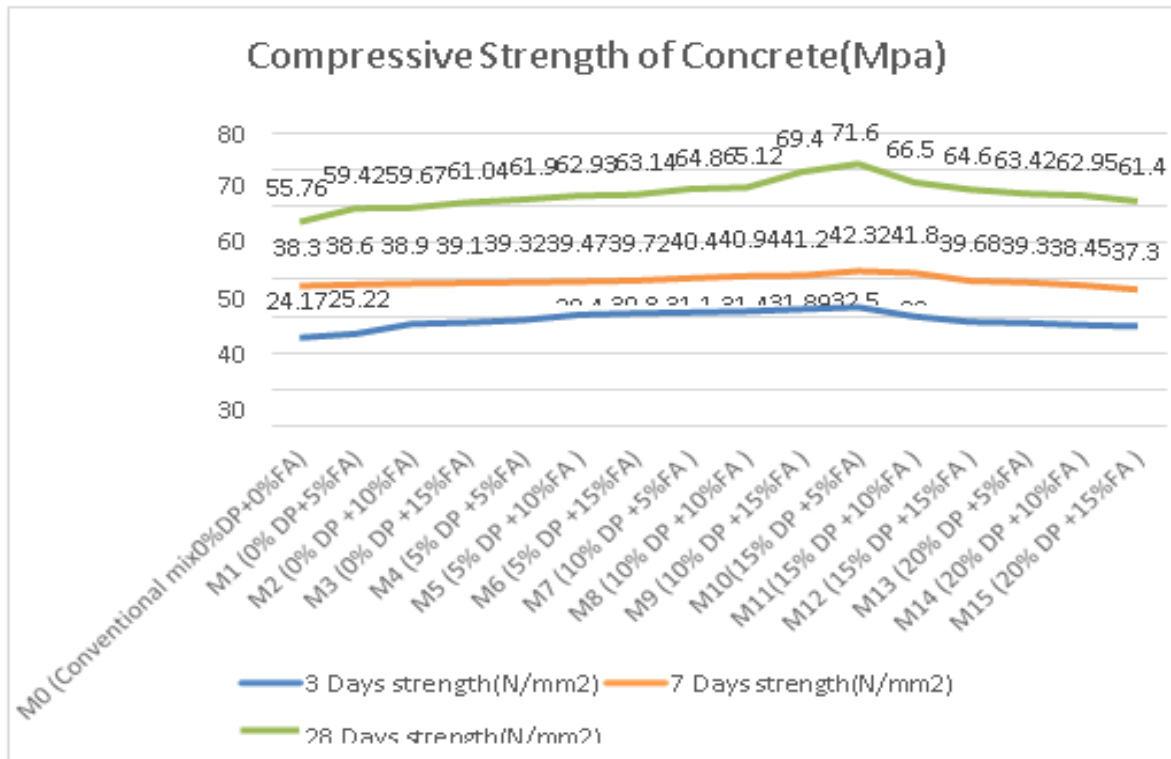


Figure 3: compressive strength with different mixed proportions of DP&FA.

V. Conclusion

In this work, the effect of the use of Slag sand to fully replace fine aggregate and cement with Dolomite powder and fly ash was investigated. Based on the early research, mix 15%DP+5%FA was determined to be the optimum mix in terms of compressive strength. All mixes were put through a workability test. Mechanical characteristics such as cube compressive strength was determined for all of the mixes. The results obtained were compared to the control mix (M0). The following results were reached according to the experimental investigation/

i. The workability of the concrete as measured by the slump and compaction factor reveals that as Fly ash and Dolomite powder replacement increases, the slump decreases. The compaction factor also decreases as Fly ash and

Dolomite powder content increases, and the findings are within the typical range of concrete.

ii. The DP and FA obtained have lower specific gravity than the OPC, which means mass replacement will produce a significantly higher volume of cementitious materials.

iii. It was reported that Dolomite powder and Fly ash has almost the same percentage of all the key chemical elements of cement as OPC, meaning that it will act as an acceptable alternative if the proper proportion is used.

iv. Compressive strength increased up to 15% and 5% with Dolomite powder and Fly ash substitution, respectively, and then dropped at the remaining proportions. The compressive strength was increased by around 22.12% on the 28th day compared to the control mix (M0).

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