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Studies on Strength Characteristics of Normal Concrete with Dolomite and GGBS as Admixtures

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ABSTRACT: Concrete is the most widely used construction material in civil engineering constructions because of its good compressive strength and stability. The concrete industry is looking for supplementary cementitious material or industrial by-products with the objective of reducing the carbon dioxide emission which is harmful to environment. Dolomite powder is the supplementary cementitious material obtained by powdering mineral Dolostone. This paper deals with the effective utilization of dolomite powder in concrete production as a partial replacement of cement. The mechanical properties of M30 grade concrete are studied with partial replacement of cement by Dolomite powder in the percentages of 5%,10%,15%,20% and 25%.The optimum percentage of dolomite in concrete corresponding to maximum strength will be identified, keeping this optimum percentage of dolomite as constant, cement is further replaced with Ground Granulated Blast Furnace Slag (GGBS) in percentages of 5%,10%,15% and 20%.The test results indicate that the maximum strength was observed in a mix consisting 10%dolomite with 10%GGBS.This paper focus on investigating behaviour of M30 concrete by partial replacement of cement by dolomite powder and granulated blast furnace slag.

KEYWORDS: Dolomite, GGBS, Compressive strength, Flexural strength, Split tensile strength, M30 grade concrete.

I. INTRODUCTION

Concrete is one of the most extensively used construction materials in the world, with two billion tons placed worldwide each year. It is attractive in many applications because it offers considerable strength at a relatively low cost. Concrete can generally be produced of locally available constituents. It can be cast into a wide variety of structural configurations. Also it requires minimal maintenance cost during its service life. Portland cement industry is responsible for approximately 7% of global CO₂ emission. Partial replacement of portland cement by one or more additives to obtain blended cements not only provides reduction in CO₂ emission and savings in energy in cement production but also supplies durable cementitious systems to the construction industry.

1.1 HISTORY OF CONCRETE

According to the usage of concrete, it can be traced back to the period as early as 3rd century B.C. when the Romans were using concrete made with lime, broken stones and sand to build temples and other buildings. First, the surface of the concrete was left rough and finished it with a form of stucco. Later on, they began to produce a decorative finish by embedding small stones in the top concrete surface. They finally incorporated broken terra-cotta roof tiles over concrete surface by embedding them at the outer surface of the concrete. This has led towards manufacturing of clay bricks. After the collapse of the Roman Empire, the subject of concrete technology fell to disuse and remained unknown until the time of Renaissance. Around 15th century the book series 'De architecture' written by Roman architect and Civil Engineer Marcus Vitruvius Pollio has become a famous objective for the study of architecture. But it was until the end of 18th century when the research on concrete was resumed in the year 1824, the essential ingredient in the modern concrete 'Portland cement' was discovered.

1.2 LIMITATIONS OF CONCRETE

According to U.S. Department of Army (1999), there are certain limitations for the applications of concrete where concrete causes cracking and excessive deflection in the structural members which detract from appearance, serviceability and useful life of the concrete structure.

1.2.1 Low tensile strength

Concrete members which are subjected to the tensile stress should be reinforced with the steel bars to prevent cracking and failure during construction.

1.2.2 Thermal movements

When the concrete is about to set and harden, the heat of hydration would raise the temperature inside concrete and next it gradually cools. Changes in the temperature cause early cracking and severe thermal strains inside concrete. Beside this, hardened concrete expands and contracts when there are changes in the temperature. In order to prevent this kind of failure in concrete, expansion and contraction joints should be provided in concrete structural elements.

1.2.3 Drying shrinkage and moisture movements

When concrete is dry and hard, it shrinks due to the loss of moisture in concrete. This kind of moisture movements may cause unsightly cracks. To arrest cracks, control joints should be provided. To prevent drying shrinkage, the newly laid surface concrete should be kept moist continuously during the curing process.

II. LITERATURE SURVEY

This chapter deals with the review of the existing literature on the use of Dolomite and GGBS as partial replacement of cement in the concrete. The most important investigations, related to the current investigation, are summarized and salient facts which seem to emerge from the research discussed

Deepa Balakrishnan and Paulose K. C. [1] had studied the workability and strength characteristics of self-compacting concrete containing fly ash and dolomite powder. She made high volume fly ash self-compacting concrete with 12.5 percent, 18.75 percent, 25 percent and 37.5 percent of the cement (by mass) replaced by fly ash and 6.25 percent, 12.5 percent and 25 percent of the cement replaced by dolomite powder. The mixes were then tested for mechanical properties like, cube compressive strength at 7th day, 28th day and 90th day, cylinder compressive strength at 28th day, split tensile strength, and flexural strength at 28th day. From the results she concluded that better mechanical and physical properties of concrete can be obtained with the replacement of cement with fly ash from 12.5% to 18.75%.

Kamal M.M et al [2] evaluated the bond strength of self-compacting concrete mixes containing dolomite powder. Either silica fume or fly ash was used along with dolomite powder to increase the bond strength considerably. Seven mixes were proportioned and push-out test was carried out. The variation of the bond strength for different mixes was evaluated. The steel concrete bond adequacy was evaluated based on normal bond strength. The results showed that the bond strength increased as the replacement of Portland cement with dolomite powder increased. All Self Compacting Concrete (SCC) mixes containing dolomite powder up to 30 % yielded bond strength that is adequate for design purpose. The availability of this type of concrete provided unique merits for faster construction. From the results he concluded that the shear strength of RC beams were better than that of the conventional SCC without dolomite powder.

III. OBSERVATIONS

To achieve the objectives of the study, an extensive experimental programme was planned which included evaluation of workability properties at fresh stage and compressive strength, split tensile strength, flexural strength, density properties at 28-days age of concrete containing without crystalline admixture and with crystalline admixture. This chapter outlines the experimental programme planned for this study in detail. The properties of the concrete making materials, concrete mix details, casting, curing, workability of concrete, details of tests performed on hardened concrete are presented.

3.1 MATERIALS USED AND THEIR PROPERTIES

The materials used in the present investigation are as follows

1. Cement
2. Natural Fine Aggregates
3. Natural Coarse Aggregates
4. Water
5. Dolomite
6. GGBS

3.1.1 Cement: In this present investigation Ultratech brand cement of ordinary Portland cement (OPC) of 53 Grade was used which satisfies the requirements of IS: 12269-1987. The following tests are conducted on cement.

Tests on cement

Following tests are conducted to know the physical properties of cement.

1. [Fineness](#)
2. Consistency
3. [Initial and Final Setting Time](#)
4. Soundness
5. Specific gravity
6. Compressive strength

The test results of physical properties of cement are shown in Table-3

Table 3. Physical Properties of Ultratech Brand 53 grade (OPC) cement

S.no	Physical tests	Obtained results	Requirements as per IS codes
1	Fineness	4%	Not>10% as per IS 4031 part 1
2	Standard Consistency	32%	IS 4031 part 4
3	Initial Setting time	55 min	Not less than 30 minutes as per IS 4031 part 5
4	Final setting time	230 min	Not more than 600 minutes as per IS 4031 part 5
5	Soundness	3mm	Not>10mm as per IS 4031 part 3
6	Specific gravity	3.12	IS 2720 part 3 (3.15)
7	Compressive strength	53MPa	IS 4031 (Part 6)

3.1.2 Fine Aggregate

Locally available sand collected from River Tungabhadra was used as fine aggregate. The following tests are conducted on fine aggregate according to IS: 383-1987. The Sand is confirmed to Zone-II according to BIS.

Test on fine Aggregate

1. Sieve Analysis of Fine Aggregate
2. Specific Gravity of Fine Aggregate
3. Bulk density

The test results of Fine aggregates are shown in Table.4

Table 4. Physical Properties of Fine Aggregates

S.no	Properties	Results
1	Bulk density, kg/m ³	1602
2	Specific gravity	2.66
3	Fineness modulus	3.22

3.1.3 Coarse Aggregate: The crushed aggregate available from the local quarry was used in the present work as coarse aggregate. In this experiment the aggregate was used of 20mm and tested as per IS: 2386-1963(I, II, III) specification. The following tests are conducted on coarse aggregate.

Tests on Coarse Aggregate

1. Sieve Analysis of Coarse Aggregate
2. Specific Gravity of Coarse Aggregate
3. Bulk density

IV. TEST RESULTS AND DISCUSSION

In this chapter, Compressive strength, Split Tensile strength and Flexural Strength of various concrete mixes using Dolomite as a cement replacement and combination of Dolomite and GGBS as a cement replacement in the concrete. Results were analyzed with respect to compressive strengths, split tensile strength and Flexural Strengths. **The results of the present investigation are presented both in tabular and graphical forms in order to facilitate the analysis, interpretation of the results is carried on each phase of the experimental work.**

4.1 DOLOMITE AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

In the phase-1, M30 grade concrete is prepared by using Dolomite as the partial replacement of cement. The mix proportions used for the concrete mixes are shown in Table.44. The compressive strength, split tensile strength, flexural strength of reference Mix A and all other mixes prepared, using Dolomite as the partial replacement of cement

Mix Designation	Replacement Details	Cement (kg/m ³)	Dolomite (kg/m ³)	Coarse aggregate (kg/m ³)	Fine aggregate (kg/m ³)	Water (kg/m ³)
Mix A	0% Dolomite	425	0	1206	662	192
Mix B	5% Dolomite	403.75	21.25	1206	662	192
Mix C	10% Dolomite	382.5	42.5	1206	662	192
Mix D	15% Dolomite	361.25	63.75	1206	662	192
Mix E	20% Dolomite	340	85	1206	662	192
Mix F	25% Dolomite	318.75	106.25	1206	662	192

Strength results of Dolomite as replacement of cement in concrete

Mix No.	Replacement Details	Compressive Strength (MPa)	Split Tensile Strength (MPa)	Flexural Strength (MPa)
Mix A	0% Dolomite	41.48	2.78	3.59
Mix B	10% Dolomite	42.51	2.94	3.71
Mix C	15% Dolomite	46.37	3.32	3.87
Mix D	20% Dolomite	42.28	2.82	3.32
Mix E	25% Dolomite	38.27	2.80	3.20

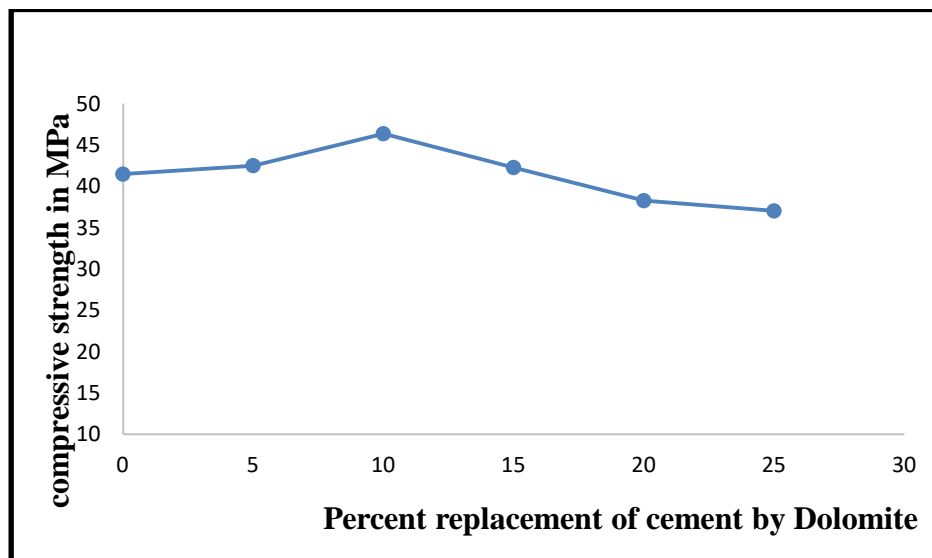


Figure 8. Compressive strength at 28 days for Mixes A to F

It was observed that the increase in compressive strength gradually up to 10% replacement of cement by using Dolomite and then decreased. The maximum compressive strength was obtained 46.37 N/mm² at 10% use of Dolomite in the concrete. Maximum compressive strength was obtained with Mix C at 10% use of Dolomite in concrete (46.37 N/mm²) which was 12.6% more compared to reference Mix A (41.48 N/mm²). Variation of compressive strength of M30 grade with different percentage replacement of cement by using Dolomite is shown in Figure.8.

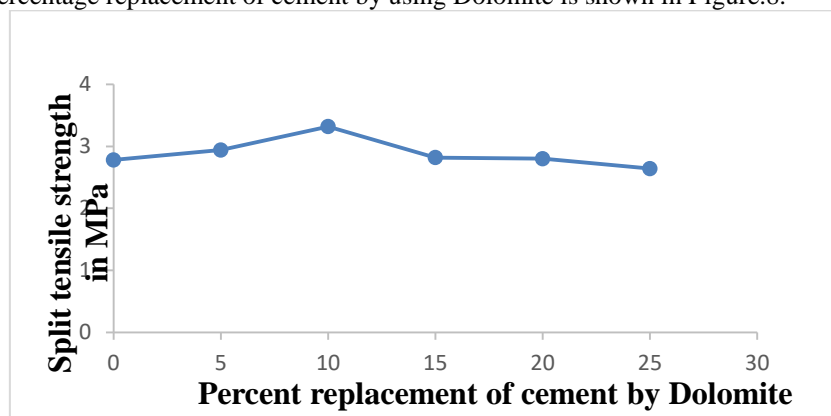


Figure 9.Split Tensile Strength at 28 days for Mixes A to F

It was observed that the increase in split tensile strength gradually up to 10% replacement of cement by using Dolomite and then decreased. The maximum split tensile strength was obtained 3.32 N/mm^2 at 10% use of Dolomite in the concrete. Maximum split tensile strength was obtained with Mix C at 10% use of Dolomite in concrete (3.32 N/mm^2) which was 19.42% more compared to reference Mix A (2.78 N/mm^2). Variation of split tensile strength of M30 grade with different percentage replacement of cement by using Dolomite is as shown in figure.9.

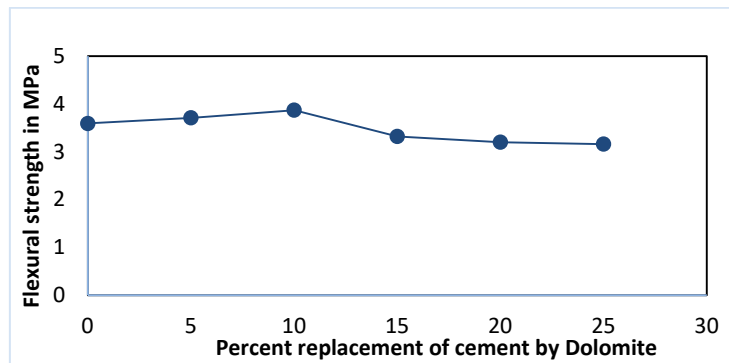


Figure 10. Flexural tensile Strength at 28 days for Mixes A to F.

It was observed that the increase in flexural strength gradually up to 10% replacement of cement by using Dolomite and then decreased. The maximum flexural strength was obtained 3.87 N/mm^2 at 10% use of Dolomite in the concrete. Maximum flexural strength was obtained with Mix C at 10% use of Dolomite in concrete (3.87 N/mm^2) which was 7.8% more compared to reference Mix A (3.59 N/mm^2). Variation flexural strength of M30 grade with different percentage replacement of cement by using Dolomite is as shown in figure.10.

V. CONCLUSION

The following conclusions are drawn from physical tests and experimental investigations conducted over normal conventional concrete (control mix) and blended concrete mix (cement along with Dolomite powder and GGBS)

- 1) Dolomite powder along with GGBS can be used as pozzolonic materials to replace cement partially upto 10% in preparing concrete. Use of dolomite powder along with GGBS may enhance strength at 28 days.
- 2) Dolomite along with GGBS may act as a filler material which acts as a volume matrix to reduce the porosity of concrete.
- 3) Workability characteristics of concrete admixed with Dolomite and GGBS are similar to those of normal conventional concrete.
- 4) Plastic and shrinkage properties in concrete with Dolomite powder and GGBS are to be investigated.
- 5) Dolomite and GGBS may be used partially to enhance the strength properties of concrete which makes the mix economical than conventional concrete.
- 6) Based on the experimental investigations, the strength properties of concrete are significantly improved with the use of Dolomite powder and GGBS in preparing concrete.
- 7) Applications of Dolomite powder and GGBS as pozzolonas in partial replacement of cement in preparing self compacting concrete mixes are to be studied for future investigations.
- 8) Improvement of Bond strength characteristics of normal conventional concrete and self compacting concrete mixes with the applications of Dolomite powder and GGBS are to be investigated.

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