

Studies on Strength Characteristics of Normal conventional 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 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 focuses on investigating the 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 the basic civil engineering material used in most of the civil engineering structures. Cement, fine and coarse aggregates, admixtures and water are the basic constituents of concrete. Cement is the most important constituent material, since it binds the aggregates. Many materials are used to manufacture good quality concrete. Dolomite may be preferred as one of the construction materials to replace cement partially in concrete due to its higher surface hardness and density. Dolomite is a rock forming mineral with a chemical composition of $\text{Ca Mg}(\text{CO}_3)_2$. Dolomite is formed by the replacement of calcium in a calcium carbonate limestone deposit with magnesium. In dolomite calcium and magnesium ions exist in separate layers in crystalline matrix form. Dolomite has alternate layers of calcium and magnesium carbonate layers. It is hard and denser than lime stone, chemically inert and more impervious to acid attack. Dolomite is also preferred as a filler material in asphalt concrete applications due to its higher strength and hardness. Ground granulated blast furnace slag (GGBFS) is a by-product, a solid waste discharged by the iron and steel industry in large quantities. GGBS is obtained by quenching molten iron slag from blast furnace in water or steam. The quenching optimizes the cementitious properties and produces a glassy, granular product similar to the coarse sand. The product is dried and ground into fine powder called GGBFS. Dolomite and GGBFS are combinedly used as replacing materials to cement as filler and binder materials in concrete. Deepa Balakrishnan [1] *et al* has studied the workability and strength characteristics of self-compacting concrete containing flyash and dolomite powder. The test results

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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 percent replacement.. **Kamal M.M[2]** *et al* have evaluated the bond strength of self-compacting concrete mixes containing dolomite powder. Silica fume or fly ash was used along with dolomite powder to increase the bond strength of concrete considerably. Test results showed that the bond strength is increased as the replacement level of dolomite powder has been increased. The availability of this type of concrete provided unique merits for faster construction. Results also concluded that the shear strength of R.C.C beams were higher than that of the conventional SCC beams without dolomite powder. **Salim Barbhuiya[3]** studied the utilization of an alternative material like dolomite powder instead of limestone powder, for the production of self compacting concrete. Test results showed that mix containing flyash and dolomite powder in the ratio 3:1 satisfied the requirements of EFNARC guidelines for preparing self compacted concrete. **LesiaMikhailova[4]** has studied the effect of fine ground dolomite limestone on the mechanical properties of concrete mixes containing dolomite powder ranging from 0 to 30 percent by weight of cement with water cement ratio of 0.5. The test results showed that the compressive strength increased at 25% replacement of cement with dolomite powder. **Chaitra H.[5]** studied the effective utilization of waste material in concrete production as a partial replacement of cement and sand. The test results showed that the strength in compression, flexure and split tension has been increased at 40% GGBS and 40% Quarry sand. **S.Arivalagan[6]** had studied about the effects of GGBS as a replacement material in the concrete. [6] He has carried out the experiments by partially replacing cement by various percentages of GGBS for M₃₅ grade concrete for replacements of 20 to 40 percent by weight of cement, Results concluded that the concrete achieves an increase in the compressive strength for 20 percent replacement of cement at the age of 28 days. **ChanderGarg[7]** has studied about the behavior of ground granulated blast furnace slag and lime stone powder as partial replacement material to cement. The test results concluded that an increase in the compressive strength has been observed for 5 to 10 percent replacement of cement.

Table 1. Physical properties of cement

Test	53 grade
Fineness	10.5
Specific gravity	3.11
Normal consistency	31 percent
Setting time	
a) Initial setting time	32 Minutes
b) Final setting time	250 minutes
Soundness(Le Chatlier)	2.1 mm
Compressive strength at 28 days	55.6 MPa

Table 2. Physical properties of fine aggregate

Property	Value
Bulk Density(kg/m ³)	1602
Specific gravity	2.66
Fineness modulus	3.22

Table 3 Physical properties of coarse aggregate

Property	Value
Max .nominal size	20mm
Bulk Density(Kg/m ³)	1560
Specific gravity	2.85
Fineness modulus	4.6
Voids	
Loose state	41%
Compacted state	47%

Table 4: Properties of Dolomite and GGBFS

sProperty	Dolomite	GGBFS
Specific gravity	2.85	2.86
Colour	White	Grey

II. PREPARATION OF SPECIMENS

Ten concrete mixes designated as A(Control Mix), B(5% Dolomite), C(10% Dolomite), D (15% Dolomite) E(20% Dolomite), F(25% Dolomite), G(10% Dolomite+ 5% GGBFS), H(10% Dolomite+ 10% GGBFS), I(10% Dolomite+15% GGBFS), J(10% Dolomite+ 20% GGBFS) ,K(10% Dolomite+ 25% GGBFS) were used in the

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investigations presented in this report. Mix proportions are designed according to the principles of mix design of IS 10262-1982 and SP 23-1982 for M30 grade concrete. The water cement ratio used for the entire mixes is 0.45.

Table 5. Mix Proportions for Mixes A to K

Mix Designation	Cement (Kg/m ³)	Dolomite (Kg/m ³)	GGBFS (Kg/m ³)	Fine Aggregate (Kg/m ³)	Coarse Aggregate (Kg/m ³)	Water (Kg/m ³)
MIX A(Control Mix)	425	—	—	662	1206	192
MIX B(5% Dolomite)	403.75	21.25	—	662	1206	192
MIX C(10% Dolomite)	382.5	42.5	—	662	1206	192
MIX D(15% Dolomite)	361.25	63.75	—	662	1206	192
MIX E(20% Dolomite)	340	85	—	662	1206	192
MIX F(25% Dolomite)	318.75	106.25	—	662	1206	192
MIX G (10%Dolomite+5% GGBS)	361.25	42.5	21.25	662	1206	192
MIX H (10%Dolomite +10%GGBS)	340	42.5	42.5	662	1206	192
MIX I (10%Dolomite+15% GGBS)	318.75	42.5	63.75	662	1206	192
MIX J (10% Dolomite+20% GGBS)	297.5	42.5	85	662	1206	192
MIX K(10% Dolomite+25% GGBS)	276.25	42.5	106.25	662	1206	192

III. PREPARATIONS AND TESTING OF SPECIMENS

The exact proportions of cement, sand, coarse aggregate, Dolomite powder, GGBS powder were weighed accordingly as given in Table 5 and mixed thoroughly in the tray with water to the required quantities as per the design calculations according to I.S: 10262-2009. Test specimens were compacted on the vibrating table and kept for set for 24 hours. They are demoulded a day after casting and cured well in water up to the date of testing. Concrete cubes(150 x150x150 mm),cylinders(150x300 mm),prisms(100x100x500 mm) of standard sizes were casted and tested for 28-day compressive strength, split tensile strength and flexural tensile strength properties respectively the mean strength values are presented in Tables 6,7 and 8 respectively.Casting and testing of specimens are presented in photo 1 and 2.

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Table.6 Compressive Strength of M₃₀ concrete

Mix Designation	Compressive strength in MPa (28 DAYS)
Mix A	41.48
Mix B	42.51
Mix C	46.37
Mix D	42.28
Mix E	38.27
Mix F	37.03
Mix G	47.23
Mix H	48.34
Mix I	44.45
Mix J	38.62
Mix K	35.48

Table.7 Split tensile strength of M₃₀ concrete

Mix Designation	Split tensile Strength (28 days)
Mix A	2.78
Mix B	2.94
Mix C	3.32
Mix D	2.82
Mix E	2.80
Mix F	2.64
Mix G	3.43
Mix H	3.56
Mix I	3.13
Mix J	2.9
Mix K	2.7

Table.8 Flexural strength of M30 concrete

Mix Designaton	Flexural strength (28 Days) N/mm ²
Mix A	3.59
Mix B	3.71
Mix C	3.87
Mix D	3.32
Mix E	3.20
Mix F	3.16
Mix G	3.92
Mix H	3.98
Mix I	3.62
Mix J	3.13
Mix K	2.98

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Photo .1 Testing of cylinders



Photo.2 Testing of prisms

IV. RESULTS AND DISCUSSION

The 28-day cube compressive strength was determined by conducting tests on standard concrete cubes (150 x 150 x 150 mm) at the age of 28 days. It is observed that the compressive strength is increased gradually upto 10% replacement of cement by Dolomite powder. It is decreased for mixes with dolomite powder ranging from 15% to 25% replacement levels. The compressive strength is observed to be maximum (46.37 N/mm²) for Mix C with Dolomite alone at 10% replacement level. Similarly it is maximum for Mix H at 10% replacement of cement, individually with the combination of Dolomite and GGBS (48.34 N/mm²).

The 28-day Split tensile strength was determined by conducting tests on standard concrete cylinders (150 x 300 mm) at the age of 28 days. It is observed that the split tensile strength is increased gradually upto 10% replacement of cement by Dolomite powder. It is decreased for mixes with dolomite powder ranging from 15% to 25%. The split tensile strength is observed to be maximum (3.32 N/mm²) for Mix C with Dolomite alone at 10% replacement level similarly, it is maximum for Mix H at 10% replacement of cement individually with the combination of Dolomite and GGBS (3.56 N/mm²).

The 28-day Flexural tensile strength was determined by conducting tests on standard concrete prisms (100 x 100 x 500 mm) at the age of 28 days. It is observed that the flexural strength is increased gradually upto 10% replacement of cement by Dolomite powder. It is decreased for mixes with dolomite powder ranging from 15% to 25%. The flexural strength is observed to be maximum for Mix C (3.87 N/mm²) with Dolomite alone at 10% replacement level similarly it is maximum for Mix H at 10% replacement of cement individually with the combination of Dolomite and GGBS (3.98 N/mm²).

The maximum values of compressive strength, tensile strength in split tension and flexural tension at the age of 28 days for Mixes A to K are shown graphically in Figures 1 to 6 respectively.

The high calcium content present in the dolomite powder may cause increase in the compressive strength of concrete. This increase in strength has been observed up to 10% replacement level. No significant increase in strength has been observed for the replacement levels of Dolomite powder above 10%. The same trend has been observed for the increase in split tensile as well as flexural strength for Mixes A to K. Fineness of Dolomite powder may be the reason for developing the strength as it is incorporated as a filler material to replace cement partially.

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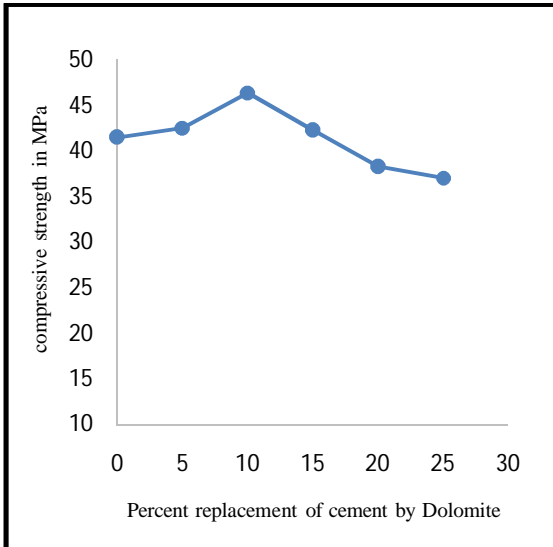


Fig.1 Compressive strength for Mixes A to F

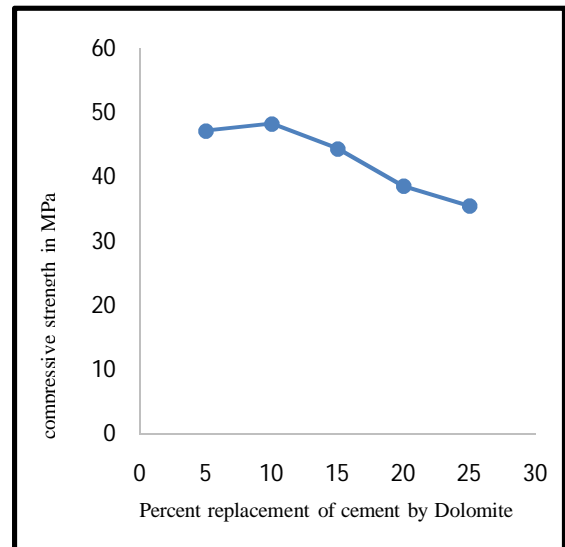


Fig.2 Compressive Strength for mixes G to K

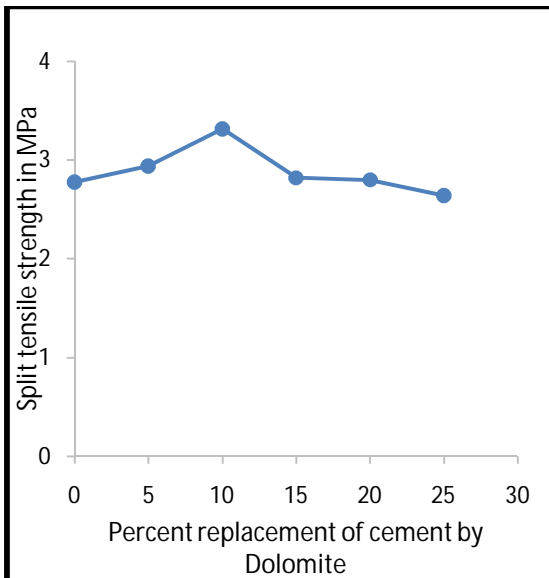


Fig.3 Split Tensile Strength for Mixes A to F

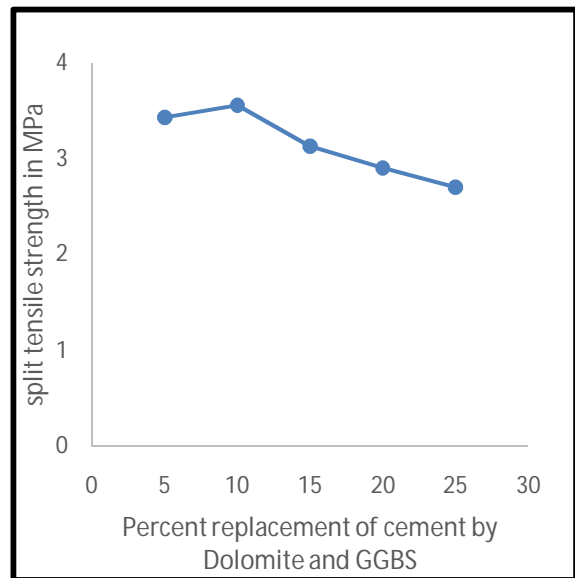


Fig.4 Split Tensile Strength for Mixes G to K

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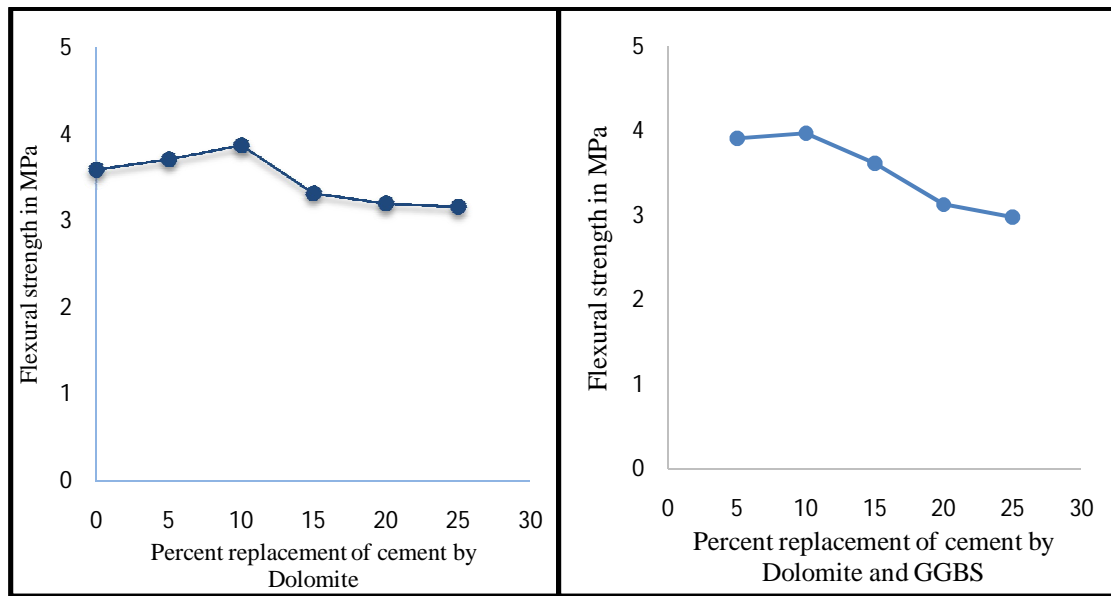


Fig.5 Flexural Strength for Mixes A to F.

Fig.6 Flexural Strength for Mixes G to I

V. CONCLUSIONS

The following conclusions can be drawn from the experimental investigations.

- 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 yet 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

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BIOGRAPHY



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