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Investigation on Strength Aspects of Concrete with Industrial Waste as Admixtures

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A B S T R A C T

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, M30grade concrete

INTRODUCTION

1.GENERAL

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 CO_2 emission. Partial replacement of portland cement by one or more additives to obtain blended cements not only provides reduction in CO_2 emission and savings in energy in cement production but also supplies durable cementitious systems to the construction industry.

1.3 FRESH CONCRETE

A fresh concrete is a concrete in the relatively fluid state and readily to be moulded but the shape of the fresh concrete would slowly change if the mould was immediately removed. The fresh concrete mixed would kept all the grains of the sand and gravel encased and held in place where it is called homogeneous. The quality and characteristic of the finish product normally influence by the degree of the plasticity and significant changes in the mix properties of the fresh concrete.

1.3.1 Workability

Workability stands for the relative ease or difficulty when placing and consolidating the concrete in the formwork. By using slump test, the consistency of the mixture can be measured and can be maintained as necessary to obtain the required workability that is needed for the specific condition and method of placement.To have a low slump,a very stiff mix is required and it is desirable for many uses.

1.3.2 Non segregation

The workability is controlled by the amounts and proportion of the fine to coarse aggregate used with a given quantity of the paste. A fresh concrete should be handled with care when mixing and compacting so that there would be minimum of segregation and the mixture would remain homogeneous.

Besides that, care must also be taken in handling so that it can prevent bleeding of the concrete. For example, fresh concrete should not be drop or free fall from more than 3 to 5 feet high to prevent the segregation to occur and cannot be transported over very long distances occur without a proper agitation.

1.3.3 Uniformity

The uniformity is determined by how accurate the ingredients are proportioned and mixed according to the specifications. Each batch of the concrete used must be proportioned and mixed exactly the same way so that to ensure the total structural mass had uniform structural properties. Besides that, the uniformity of the fresh concrete is important because it would affect the economy and strength considerations.

1.4 HARDENED CONCRETE

Hardened concrete is the end product for any concrete design. The most important properties of the hardened concrete are its strength, stress-strain characteristic, shrinkage and creep deformation, permeability and durability. The concrete strength is the greater significance because it is related to the structure of the hardened cement paste and given the overall picture for the quality of the concrete. The strength of the hardened concrete at a given age and under a given curing condition is mainly depending on the water-cement ratio and the degree of the compaction.

1.4.1 Strength of Concrete

According to the book by T.W.Love and U.S. Department of Army (1999), the strength of the concrete is where the concrete ability to resist the load in the compression, flexural or shear. The strength of the concrete is mainly determined by the water-cement ratio. By allowing additional water into the mixing process means to thin the paste and to allow it to coat more particles. But, if the water was too much, then it would affect the concrete's strength by reducing it due to the dilution of the paste.

1.4.2 Compressive Strength

There are various strengths of concrete but the determination of the compressive strength is the most important. Because the primary meant of the concrete is to withstand the compressive stresses. The strength of the concrete is influenced by the specimen size and shape, the method of the pore formation, water content, characteristics of the ingredients used, direction of loading and the method of curing.

LITERATURE REVIEW

2. GENERAL

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] hadstudied theworkability andstrength characteristics of self-compacting concretecontaining fly ash and dolomite powder. she madehigh volume fly ash self-compacting concrete with12.5percent, 18.75percent, 25percent and 37.5percentof the cement (by mass) replaced by fly ash and 6.25percent, 12.5percent and 25percent of the cement replaced by dolomite powder.

Kamal M.M et al [2] evaluated the bond strength of self-compacting concrete mixescontaining dolomite powder. Either silica flume orfly ash was used along with dolomite powder toincrease the bond strength considerably. Seven mixeswere proportioned and push-out test was carried out.The variation of the bond strength for different mixeswas evaluated. The steel concrete bond adequacy wasevaluated based on normal bond strength.

instead of limestone is a viable solution for producing Portland dolomite limestone cement.

Prince Arulraj. G and Prerthi. G [5] studied the effect of cement with dolomite powder on the mechanical properties of concrete. His study examines the possibility of using dolomite powder as a partial replacement material to cement. The replacement percentages tried were 0%, 5%, 10%, 15%, 20% and 25% by weight of cement.

MATERIALS

3. GENERAL

This chapter deals with the procurement and testing of materials for their physical properties like specific gravity, surface texture, fineness modulus, grading of zones, colour, chemical composition, bulk density in loose and compacted states, initial setting time of cement, concistency and concrete mix design for the materials like cement, pozzolonas (GGBS and Dolomite powder),fine aggregate (river sand), coarse aggregates(crushed granite metal) and water.

3.1 MATERIALS USED FOR CONCRETE

3.1.1. Cement

The cement used was Ordinary Portland Cement 53 (OPC 53). All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 32%.

3.1.2. Coarse Aggregate

Coarse aggregate of 60% passing 20mm and retained on 12.5mm sieve and 40% passing 12.5mm and retained on 10mm sieve was used. The specific gravity of coarse aggregate was 2.88 and fineness modulus is 3.11.

3.1.3. Fine Aggregate

River sand passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.66 and fineness modulus is 3.22.

3.1.4. Water

Portable fresh water, which is free from concentration of acid and organic substances, was used for mixing and curing of the concrete.

3.1.5. Dolomite

Dolomite powder is obtained by powderising the sedimentary rock forming mineral dolomite can be used as a replacement material for cement in concrete up to certain percentage. 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. Dolomite is a carbonate material composed of calcium magnesium carbonate ($CaMg (CO3)_2$). Dolomite is a rock forming mineral which is noted for its remarkable wettability and dispersibility.

Table1.Chemical composition of Dolomite powder

Chemical composition	**Percent by weight**
Silicon dioxide	0.60
Aluminium oxide	0.19
Ferric oxide	0.44
Calcium oxide	55.19
Magnesium oxide	37.71
Sodium oxide	0.39
Potassium oxide	0.01

EXPERIMENTAL PROGRAMME

4. GENERAL

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.

4.1 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

4.3 PREPARATION OFCONCRETE MIXES (A to K)

To proceed with the experimental programme, initially specimens of standard cubes (150 mm x 150 mm x 150 mm), cylinders (150 mm diameter x 300 mm height) and beams (100 mm x 100 mm x 500 mm), were taken and these specimens were cleaned fort dust particles and were brushed with oil on all the inner faces to facilitate easy removal of specimens for demoulding. The ingredients are weighed accurately using weighting machine as calculated. All the tools like the pan mixer, trowels, measuring jars, tamping rods, steel scale, head floats, gloves, masks, safety glasses and weighed ingredients assembled at a place and all precautions must be taken before commencing the mix.

Figure 4. compaction factor test

4.6 Tests on hardened concrete

4.6.1Cube Compressive strength

Compressive test was done confirming to IS: 516-1959. All the concrete specimens were tested in a Universal Testing Machine (UTM) of capacity 200 tones. Concrete cubes of size 150 mm x 150 mm x 150 mm were tested. crushing strength of concrete was determined by applying load at the rate of 140 kg/sq. cm/minute till the specimens failed. The maximum load applied to the specimens was recorded dividing the failure load by area of the specimens, ultimate compressive strength were calculated. Test setup is shown as follows.

Compressive strength , in MPa

Where,

P = Maximum load applied in KN

A = Area of specimen over which load is applied

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

Strength results of Dolomite as replacement of cement in concrete

Mix Designation	**Replacement Details**	**Cement kg/m^3**	**Dolomite (D) kg/m^3**	**GGBS (kg/m^3)**	**Coarse aggregate (Kg/m^3)**	**Fine aggregate (kg/m^3)**	**Water kg/m^3**
Mix G	10% D + 5%GGBS	361.25	42.5	21.25	1206	662	192
Mix H	10% D + 10% GGBS	340	42.5	42.5	1206	662	192
Mix I	10% D + 15% GGBS	318.75	42.5	63.75	1206	662	192
Mix J	10% D + 20% GGBS	297.5	42.5	85	1206	662	192

Mix K	10 % D + 25% GGBS	276.25	42.5	106.25	1206	662	192

CONCLUSIONS

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 admixtured 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 mixeswith the applications of Dolomite powder and GGBS are to be investigated.

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