Durable Concrete by Packing Density Method with Dolomite Powder as Partial Replacement to Cement

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Abstract - *Packing density is new mix design method used to design various types of concrete. To optimize the particle packing density of concrete, the particles should be selected to fill up the voids between larger particles with smaller particles and so on, in order to get a dense and stiff particle structure. Higher degree of particle packing leads to minimum voids, maximum density and cement and water requirement will be less. In this project, durable concrete is produced by packing density method with dolomite powder as partial replacement to cement.*

The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of carbon dioxide into atmosphere. Dolomite powder is obtained by powderising the sedimentary rock Dolostone. Dolomite powder has some similar characteristics of cement. Using dolomite powder in concrete we can reduce the cost of concrete and increase the strength. The replacement percentages tried were 0%, 5%, 10% and 15% by weight of cement. The compressive strength, flexural strength and split tensile strength of concrete with dolomite powder was compared with those of the reference specimens. The results indicates that replacement of cement with dolomite powder will increase the compressive strength,split tensile strength and flexural strength of concrete.

Key Words:**Packing Density, Dolostone, Dolomite powder.**

1.INTRODUCTION

There are different methods are available to proportionating various types of concrete. Packing density method of mix design is used for prenormal concrete, high strength concrete, no-fines concrete and self-compacting concrete etc. The subject of optimizing the concrete composition by selecting the right amounts of different materials has already aroused interest for more than a century. To optimize the particle packing density of concrete, the particles should be selected to fill up the voids between larger particles with smaller particles and so on, in order to obtain a dense and stiff particle structure. Initially the researchers, engaged on the packing of aggregates and proposed methods to design an ideal particle size distribution. Geometrically based particle packing models will facilitate to predict the water demand of concrete, and thus the material properties. The cement paste has to fill up the voids between aggregate particles and the "excess" paste will then disperse the aggregate particles to produce a thin coating film of paste surrounding each aggregate for lubricating the concrete mix. In general, the higher the packing density of the aggregate, the lower will be the volume of voids to be filled and larger will be the amount of paste in excess of void for lubrication. The carbon dioxide emission from cement production adversely affect the natural environment. By the replacement of cement with Dolomite powder, we can reduce the use of cement and thus the emission of carbon dioxide into atmosphere.

1.1 Dolomite Powder

Dolomite powder obtained by pulverising the sedimentary rock Dolostone. Dolomite is a carbonate material composed of calcium magnesium carbonate $CaMg(CO_3)_2$.It has some similar characteristics of cement. Dolomite is a rock forming mineral which is noted for its remarkable wettability and dispersibility.Dolomite has a good weathering resistance. Dolomite is preferred for construction material because of its higher surface hardness and density. Asphalt and concrete construction applications prefer dolomite as a filler material due to its higher strength and hardness. By the effective utilization of dolomite powder, the objective of reduction of cost of concrete can be met.

2. MATERIALS AND METHODS

The materials used and methods followed in the present study are described below.

2.1. Materials

ISI mark 43 grade OPC cement (brand-J K Super) was used for all concrete mixes. The cement used was fresh and without any lumps. Properties of cement is shown in Table 1. The M sand used for the experimental program was tested in the laboratory and the results were shown in Table 2. Crushed stone aggregate with a maximum particle size of 20mm was obtained from local quarry and was used as coarse aggregate. The properties of crushed stone aggregate were shown in Table 3. Dolomite powder was procured from Raidco Ltd, Payyanur. Dolomite powder was shown in Chart1.Properties of dolomite powder is given in Table 4. Sieve analysis of all fine aggregates and coarse aggregate was carried in the laboratory. The w/c ratio was kept constant for all the mixes. Mix proportion of M20 grade was used to produce the mixes. Packing density method of mix design was used for preparation of specimens.

Table 1: Properties of cement

Properties	Values
Fineness of cement	3%
Specific gravity	3.13
Consistency	31%
Initial setting time	78 minutes
Final setting time	253 minutes

Table 2: Properties of fine aggregate

Properties	Values
Fineness modulus	3.61
Specific gravity	2.225
Bulk density	1.447g/cc
Zone	II
Water absorption	1%

Table 3: Properties of coarse aggregate

Properties	Values
Fineness modulus	3.89
Specific gravity	2.905
Bulk density	1.563g/cc
Water absorption	2%

Chart 1: Dolomite Powder

Table 4: Properties of dolomite powder

Properties	Values
Fineness of cement	4%
Specific gravity	2.85
Consistency	29%
Initial setting time	80 minutes
Final setting time	268 minutes

2.2. Methods

Packing density method of mix design was used for preparation of specimens. The packing density of aggregate mixture was defined as the solid volume in a unit total volume. The aim of obtaining packing density is to combine aggregate particles in order to minimize the porosity, which allows the use of least possible amount of binder.

Cubical specimens of size 150mm x150mm x 150mm were casted for testing of compressive strength and cylindrical specimens of 150 mm diameter and 300 mm length were casted for split tensile test and beam specimens of 700mm x 150mm x 150mm were casted for flexural strength test. The moulds were cleaned and oiled properly before every pouring. The concrete was filled in the moulds in three layers, each layer being tamped with tamping rod. The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. The specimens were demoulded with care so that no edges were broken and were placed in the curing tank at the ambient temperature for curing. At the end of every curing period, the samples were taken and were tested.

2.3. Experimental Investigation

The aim of the present investigation was to experimentally study the suitability of using dolomite powder as partial replacement to cement by using packing density mix design method. The scope of this study includes the determination of the mechanical properties i.e. compressive strength, split tensile strength and flexural strength of dolomite concrete. The investigation was done by replacing 0%, 5%, 10% and 15% replacement of cement with dolomite powder for M20 concrete .Comparison of Indian standard code method and Packing density method were carried out. Based on the prepared mix design, cubes, cylinders and beams were casted. The mix proportion obtained by IS method was given in Table 5 and mix proportion obtained by packing density method was given in Table 6.

Table 5: Mix proportion of M20 concrete by IS method

Water	Cement	Fine aggregate	Coarse aggregate
192 L	383.16 kg	599.56 kg	1233.43 kg
0.5	1	1.56	3.22

Table 6: Mix proportion of M20 concrete by packing density method

Water	Cement	Fine aggregate	Coarse aggregate
188.7 L	377.41 kg	708 kg	1061.26 kg
0.5	1	1.88	2.81

2.3.1 Workability Test

Concrete slump test was used to determine the workability of concrete. The slump test was carried out as per procedures mentioned in IS: 1199 – 1959 in India. Equipments required for concrete slump test were slump cone, non-porous base plate, measuring scale and tamping rod. The results obtained from slump test were given in Table7 and Chart 2 shows the percentage replacement vs slump value curve.

Table 7: Slump Values

Percentage replacement	Slump (mm)
0	100
5	97
10	96
15	93

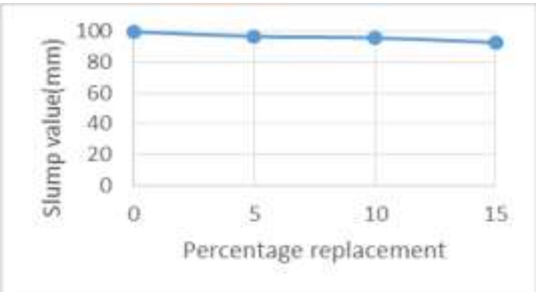

Chart 2: Percentage replacement vs slump value

It is observed that the slump decrease with increase in the percentage of dolomite powder in the concrete mix. The decrease of workability may be due to higher water absorption and very fine binders.

2.3.2 Compressive Strength Test of Concrete

The compressive strength test was conforming to IS 516-1959.The cubical moulds of size 150mmx150mmx150mm were used. The concrete mix was poured in the mould and tampered properly so as not to have any voids. After 24 hours these moulds were removed and the test specimen cured in water for 28 days. The top surface of these specimens were made even and smooth. These specimens were tested by compression testing machine. The load should be applied gradually at the rate of 140kg/cm^2 per minute till the specimen fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. The failure load and strength obtained for all mixes, CM (control mix-IS method),PD0 (0%dolomite), PD5 (5%dolomite), PD10 (10%dolomite) and PD15 (15%dolomite) on 28 days test was given in Table 8.Chart 3 showing percentage replaced versus compressive strength obtained for replacement of cement with dolomite for 28 days test.

Table 8: Compressive strength at 28 days

Dolomite content %	Tag	Compressive strength (Mpa)
0	CM	29.58
0	PD0	30.51
5	PD5	30.83
10	PD10	31
15	PD15	30.58

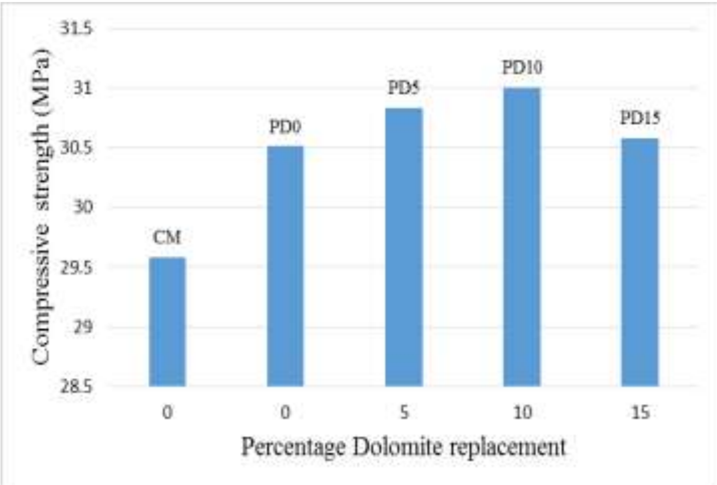

Chart 3: Percentage replaced vs compressive strength obtained for 28 days test.

The 28 days compressive strength increases with increase in percentage replacement up to 10 percentage replacement and after that compressive strength decreases. Compressive strength of specimens prepared by packing density method was more than that of IS method.

2.3.3. Split Tensile Strength Test

The split tensile strength obtained for different replacement percentage of cement with dolomite powder on

28 days test was given in Table 9.Chart 4 shows split tensile strength vs percentage replacement at 28 days test.

Table 9: Split Tensile Strength at 28 days

Dolomite content %	Tag	Split tensile strength Mpa
0	CM	3.19
0	PD0	3.23
5	PD5	3.32
10	PD10	3.34
15	PD15	3.25

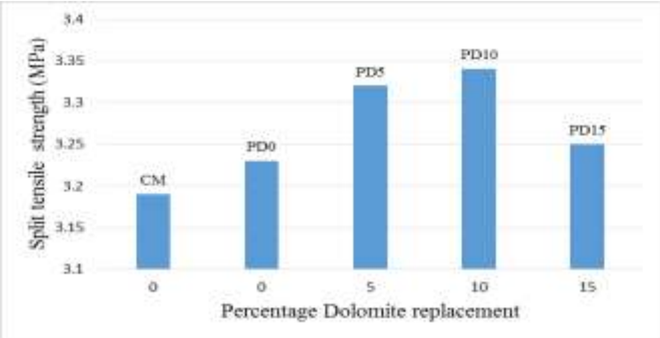

Chart 4: Percentage replaced vs split tensile strength obtained for 28 days test.

2.3.4. Flexural Strength Test

The flexural strength was expressed as modulus of rupture and was determined by three point loading test. The flexural strength obtained for different percentage replacement of cement with dolomite powder on 28 day test was given in Table 10.Chart 5 shows the variation of flexural strength with replacement percentage.

Dolomite content %	Tag	Flexural strength strength Mpa
0	CM	4.47
0	PD0	5.43
5	PD5	5.58
10	PD10	5.7
15	PD15	5.63

Table 10: Flexural Strength at 28 days

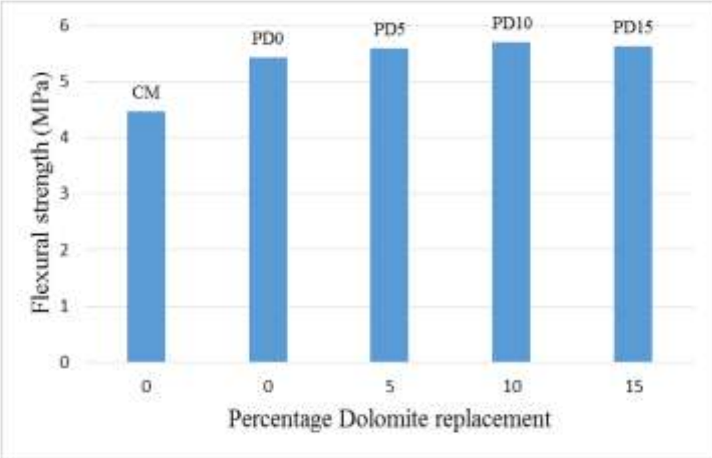

Chart 5: Flexural strength vs percentage replaced dolomite powder

The 28 days flexural strength increases with increase in percentage replacement up to 10 percentage replacement and after that flexural strength decreases. Flexural strength of specimens prepared by packing density method was more than that of IS method.

2.4. Summary

The effect of using dolomite powder as partial replacement to cement in concrete was investigated. Replacement percentages of 0, 5, 10 and 15% were adopted. Physical properties like specific gravity and gradation were determined. The influence of replacement of dolomite to cement on workability and mechanical properties of concrete were investigated. Comparison of packing density and IS method of mix design were carried out.

3. CONCLUSIONS

From the experimental investigation it can be concluded that,

i. The strength obtained by packing density method is more than that of IS method of mix design.

ii.The cement content reduced by using packing density method and also by replacing cement with dolomite powder.

iii.There is an enhancement in the strength of concrete up to 10% replacement of cement with dolomite powder.

iv.The 28 days compressive strength increases with increase in percentage replacement up to 10 percentage replacement and after that compressive strength decreases. The compressive strength obtained at 10 % replacement is 31 MPa.

v. The 28 days split tensile strength increases with increase in percentage replacement up to 10 percentage replacement and after that split tensile strength decreases. The split tensile strength obtained at 10% replacement is 3.34 MPa.

vi. The 28 days flexural strength increases with increase in percentage replacement up to 10 percentage replacement and after that flexural strength decreases. The flexural strength obtained at 10 % replacement is 5.7 MPa.

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