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Effect of Dolomite Powder on Mechanical Properties of M40 Grade Concrete When Cement was Partially Replaced

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Abstract: ***Cement is one of the most significant constituents of concrete. Most of the properties of concrete depend on cement. By calcining argillaceous and calcareous material at a high temperature in cement production. During this procedure, huge amount of Co_2 is discharged into the air. India is the second biggest manufacturer of cement on the planet. It is assessed that the generation of one tonne of cement brings about discharge of 0.8 tonne of Co_2. The decline in the utilization of cement will lessen the cost of concrete and outpouring of Co_2. Dolomite powder acquired by pulverizing rock forming mineral deposit of dolostone can be utilized as a trade material for cement in concrete up to certain percentage. Dolomite powder has a few comparative attributes of cement. Utilizing dolomite powder in cement can diminish the expense of cement and may expand the solidarity somewhat. Dolomite powder is a pozzolonic material which will improve not only the density but also strengthen the hardness of concrete. This paper inspects the likelihood of utilizing dolomite powder as partial substitution material to cement. The substitution rates attempted were 0 to 25% at a regular interval of 5% by weight of cement. The outcome demonstrates that substituting of cement with dolomite powder improves the compressive, split tensile and flexural strength of concrete.***

Keywords: ***concrete, cement, dolomite powder, compressive strength, split tensile and flexural strength.***

I. INTRODUCTION

Cement is the essential building material utilized in the greater part of the building structure. Numerous materials are utilized to make great quality concrete. Cement, coarse aggregates, fine aggregates, chemical admixtures, mineral admixtures, water are the constituents of concrete. Cement is the most significant constituent material, since it holds together the aggregates and opposes the climatic activity. Be that as it may, production of cement transmits about 0.8 tons of Co_2 into the air for 1 ton of cement made. Dolomite is a carbonate material made out of Calcium Magnesium Carbonate ($CaMg(Co_3)_2$).

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Dolomite is a stone forming mineral which is noted for its astounding wettability and dispersibility. Dolomite has a decent enduring weather resistance. Dolomite is favored for building material because of its higher surface hardness and thickness. Dolomite is preferred as a filler material for asphalt and concrete applications as it has higher strength and hardness. By usage of dolomite powder an improvement in early strength of concrete with no side effects over long term properties can be seen. By the compelling usage of dolomite powder, the target of decrease of expense of construction can be met. An endeavour has been made to investigate the plausibility of utilizing dolomite as a substitution material for cement. M40 grade concrete samples were made by supplanting 0 to 25% at a regular interval of 5% in cement with dolomite powder. The compressive, split tensile and flexural strength of the samples were tested at 3, 7and 28days of curing. Ideal substitution percentage of dolomite was resolved.

Most of the researchers are focused about utilization of other industrial or agro based wastages in partial replacement of cement in concrete production. So utilization of dolomite powder is a suitable solution.

Replacing of cement with dolomite powder in an investigation [1] is found to enhance the compressive strength of concrete for using M_{20} grade concrete. Another investigation [2] proved that compressive strength of cubes increased up to 15% of dolomite powder replaced in cement and a further increase reduced the compressive strength and split tensile and flexural strength increased up to 15% and 10% respectively and a further increase in both cylinders and beams reduced the strength and the grade used here is M_{30}. When dolomite powder and copper slag are used in an investigation [3] compressive strength and tensile strength are increased by replacing dolomite with cement in 10%, 20% and 30% and keeping copper slag replacement percentage constant at 25%. From an investigation [4] done by replacing cement with dolomite powder in the range of 5% to 25% it is found that at low replacement percentage 5% to 15% compressive strength is increased and at higher replacement percentage 20% and 25% compressive strength decrease drastically due to dilution. This experimental evaluation [5] found that replacing cement with dolomite powder will increase the compressive strength and flexural strength at 28 days by 10.4% and 17.8% respectively. By following the conclusions that are drawn by an investigation [6] state that the optimal percentage for replacement of dolomite and m-sand is 10% each and at this percentage the compressive and split tensile are said to have increased.

II. MATERIALS

In this investigation OPC 53 grade cement, fine aggregate (river sand), coarse aggregate (20mm), dolomite powder, water and chemical admixture to enhance workability are used.

A. Ordinary Portland Cement

Cement is a binder, a substance that sets and hardens independently, and binds other materials together. Many types of cements are available in the market. The commonly used cement is Portland cement. Portland cement is of 53-grade was used for the investigation. The specific gravity of Portland cement was 3.15.

TABLE:1

CHARACTERISTICS	OBSERVED VALUE
Normal consistency	32%
Initial setting time	65 min
Final setting time	270 min
Specific gravity	3.15
Compressive strength at 28 days	57 Mpa

B. Fine Aggregate

The most significant purpose of the aggregate is to help with creating workability and consistency in blend. The fine aggregate likewise helps the cement mixture to hold the coarse aggregate bits in suspension. This activity advances plasticity in the blend and averts the conceivable segregation of mixture and coarse aggregate. It ought to be strong, clean and be free from natural issues. It should not have any obvious measure of clay balls and other containment for example alkalis, salt, coal, rotted vegetation etc. River sand is used as fine aggregate. The specific gravity of river sand is observed to be 2.6.

TABLE:2

CHARACTERISTICS	OBSERVED VALUE
Grade zone	II
Specific gravity	2.6

C. Coarse Aggregate

The coarse aggregate is the biggest segment of concrete. It is artificially a stable material. Usage of coarse aggregate lessens the dry shrinkage and other dimensional changes happening by virtue of development of dampness. Hard broken rock stones were utilized as coarse aggregate in concrete. Size of coarse aggregate in the examination was 20mm. The specific gravity of the coarse aggregate was observed to be 2.64.

TABLE:3

CHARACTERISTICS	OBSERVED VALUE
Water absorption	0.5%
Specific gravity	2.64
Fineness modulus	6.8

D. Dolomite powder

Dolomite is a carbonate material made out of calcium magnesium carbonate CaMg $(Co_3)_2$. The term is likewise used to portray the sedimentary carbonate rock dolostone. Dolostone (dolomite rock) is made dominatingly out of the mineral dolomite with a stoichiometric proportion of half or more prominent substance of magnesium supplanting calcium, frequently because of digenesis. Dolomite is a stone forming mineral which is noted for astounding wettability and dipersibility just as moderate oil and plasticizers absorption. Dolomite has great weather resistance.

TABLE:4(Properties)

PROPERTY	DOLOMITE POWDER
Formula	$CaMg(Co_3)_2$
Specific gravity	2.85
Color	White
Tenacity	Brittle
Crystal system	Hexagonal
Sieve alanysis	Zone III
Moisture content	Nil

TABLE:5(Chemical composition)

CHEMICAL COMPONENT	% OF CHEMICAL COMPONENT
Total carbonate	97.4%
$CaCo_3$	54.3%
$MgCo_3$	45.6%
Al_2O_3	0.02%
SiO_2	0.3%
Fe_2O_3	0.04%

E. Water

Water is a significant element of concrete as it effectively takes an interest in the substance response with cement. The water, which is utilized for making cement ought to be spotless and free from destructive debasements like oil, alkalis, acids etc. water for making cement ought to have pH value somewhere in the range of 6 to 8. Locally accessible drinking water was utilized in this work.

F. Super plasticizer

Super plasticizer Master Rheobuild 920SH chemical India Ltd. was utilized as water diminishing admixture, it expands workability.

TABLE:6

State	Liquid
Color	Dark

Density	1.2
Chemical name	Naphthalene formaldehyde polymer
PH	8.40

III. EXPERIMENTAL INVESTIGATION

A. General

Tests were done on partial replacement of cement by dolomite powder to obtain mechanical properties of M_{40} grade concrete. The replacement percentages of 0%,5%,10%,15%,20%,25% were tried to get the test results. The materials like coarse aggregate, fine aggregate, cement, dolomite powder are experimented in laboratory for compatibility.

B. Mix proportion

The M40 grade concrete mix proportion is designed as per IS 10262-2009. The designed mix proportion is 1:1.72:3.11.and the w/c ratio used is 0.42.

C. Casting and Demoulding

The materials required were taken according to their mix and weighed in an electronic scale. Same was performed for every mix proportion and required specimens were casted. The concrete placed in moulds were permitted to set for 24 hours. After demoulding they were marked with markings like M1, M2, M3 etc., for every casted specimens according to their mixes and kept in curing tank which is maintained at an ambient temperature throughout the curing process. The concrete specimens were removed for their respective testing times which are 3, 7 and 28 days.

D. Compressive strength test

The specimen which is a cube of size 150mm x 150mm x 150mm were casted and experimented to obtain results in respective to IS 516-1969. For every test, 3 samples were taken on every 3 days, 7 days and 28 days.

E. Split tensile test

The specimen which is a cylinder of size 150mm diameter x 300 mm height were casted and experimented to obtain results in respective to IS 5816-1970. For every test, 3 samples were taken on every 3 days, 7 days and 28 days.

F. Flexural strength test

The specimen which is a beam of size 400mm x 100mm x 100mm were casted, cured and experimented on to obtain results. For every test, 3 samples were taken on every 3 days, 7 days and 28 days.

G. Concrete Mix

MIX	OPC Percentage	DOLOMITE POWDER percentage
M1	100%	0%
M2	95%	5%
M3	90%	10%
M4	85%	15%
M5	80%	20%
M6	75%	25%

IV. TEST RESULTS

A. Compression test

The values for the compressive strength of proportions 3 days, 7 days and 28 days are calculated and represented pictorially in the below chart Fig.1. It is found that the optimum replacement percentage is 10% and it has 7.6% increase in strength.

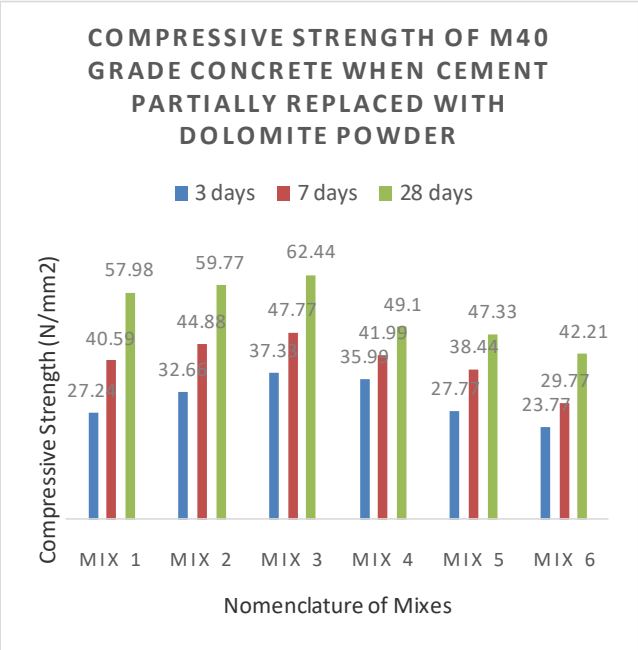

Fig.1

B. Split tensile test

The values for the split tensile test of proportions 3 days, 7 days and 28 days are calculated and represented pictorially in the below chart Fig.2. The optimum replacement percentage is observed at 10%.

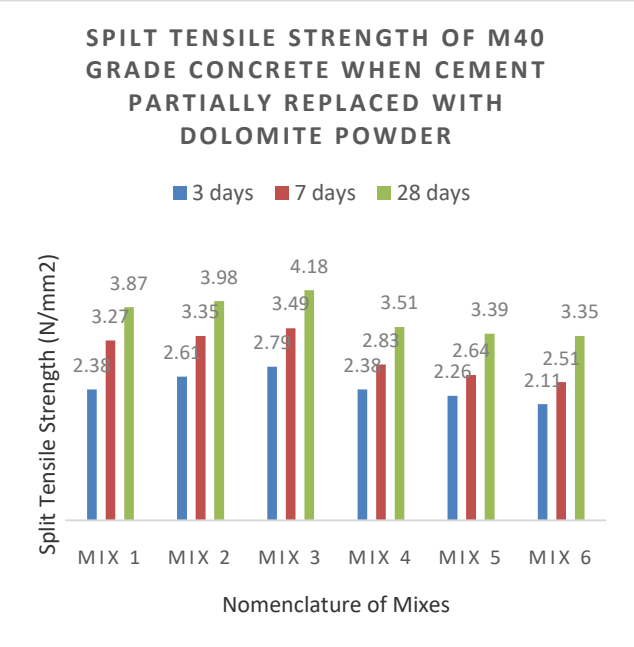

Fig.2

C. Flexural strength test

The values for the flexural strength test of proportions 3 days, 7 days and 28 days are calculated and represented pictorially in the below chart Fig.3. The optimum replacement percentage here is 10%.

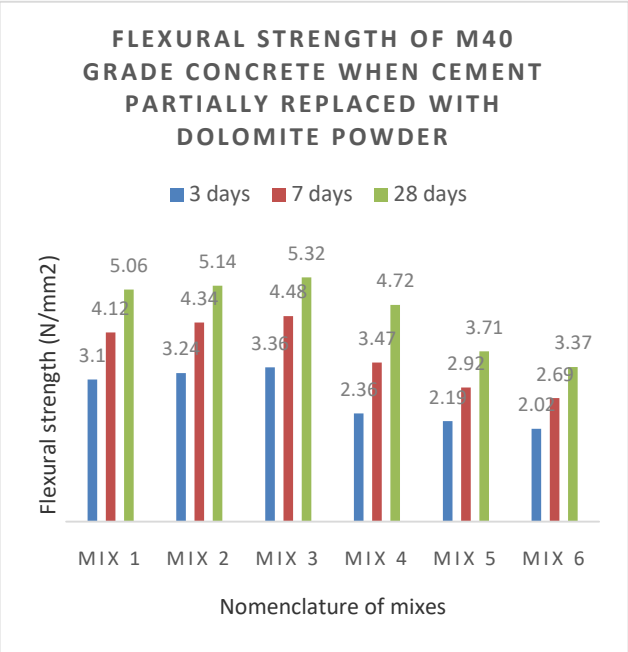

Fig.3

V. CONCLUSION

The below are the conclusions that are made from the investigation done:

1. The conclusions achieved from the investigation carried out are, when partially replacing dolomite in place of cement it is observed that compressive strength is increased by 7.6% in 'M3' i.e. at 10% replacement of dolomite in cement but a further increase in replacement of dolomite in cement reduced the compressive strength.
2. Even for 15% replacement of dolomite powder cement the compressive strength is in satisfactory level.
3. The split tensile strength is also noticed to be optimum at 10% dolomite replacement in cement and further increase in replacement gradually decreased the split tensile strength.
4. The replacement of dolomite powder in cement at 10% is also found to improve flexural strength.
5. By replacing dolomite powder with cement we reduce usage of cement which in turn reduce the overall cost of concrete and decreases the emission of Co_2.

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AUTHOR'S PROFILE

Dr. G V V Satyanarayana, Professor of Civil Engineering, completed his Ph.D from JNTUH, Hyderabad and has over Thirty two years of academic, Industrial and research experience in India. His Ph.D work was on Mechanical Response of Slab specimens with Mineral Admixtures Under Different Edge Conditions Subjected to Flexure, Punching Shear and Impact, Prior to PhD, he had earned Bachelors of Engineering in Civil Engineering from Osmania University, Hyderabad, and Masters of Engineering in Structural Engineering from JNTUH, Hyderabad. His research interests include developing modelling in FEM, various studies and applications of concretes like bi or triple blended concretes with bi-product materials, fibrous concrete etc., in which he has more than 16 publications, in various journals and conferences. He currently manages Co-Ordinator for M.Tech (STE) program at GRIET, Hyderabad and In-Charge for ACT laboratory and quality control In-Charge of GHMC consultancy works. He has been in this role since 2014. These GHMC consultancy for quality control are conducted for 3 Municipalities in GHMC, Hyderabad.

B.V.N Ravi Teja Reddy, has completed civil engineering from Gandhi Institute of Technology and Management (GITAM) university, Hyderabad, Telangana during 2013-2017 with 1st class. B.Tech project was on "Correlation of potential evapo transpiration to the actual evapo transpiration as per semi-arid tropical conditions". Presently pursing masters in Structural Engineering at Gokaraju Rangaraju Institute of Engineering and Technology (GRIET), Hyderabad. Participated in some of the major conferences conducted by institute of engineering (India) and also participated in some workshops like Modern developments in concrete and building technology keenly interested to perform experimental investigations on mechanical properties and some durability properties of cement replacement by-product materials. His interests are in special concrete. Under the guidance of Dr. G.V.V. Satyanarayana.