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Inquiry on Mechanical Properties of M30 Grade Concrete with Partial Replacement of Copper Slag and Dolomite Powder for Fine Aggregate and Cement

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Abstract: ***Concrete plays an important role in every construction. This paper is an experimental investigation to study the mechanical properties of the concrete with partial replacement of cement by dolomite powder and fine aggregate by copper slag. So, in this investigation, by usage of Dolomite powder in concrete on one side improves density and other side improves strength and hardness. Copper slag also increases density of concrete and toughness of concrete. The cement content replaced with dolomite and fine aggregate replaced with copper slag from 5% to 25% at regular intervals of 5%. In the designed mix proportion of M30 grade concrete is 1:2.17:2.95. The Superplasticizer Master Rheobuild 920SH of 0.5% dosage used as chemical admixture is added to the concrete to maintain 0.45 the water-cement ratio. The concrete cubes, cylinders were casted. The different mechanical properties like compressive strength, split tensile strength, flexural strength were tested after 3 days, 7 days and 28 days of curing from 5 to 25% at regular intervals of 5% replacement of cement with dolomite powder and 10% to 50% at regular intervals of 10% replacement of fine aggregate with copper slag.***

Keywords: concrete, cement, dolomite powder, fine aggregate, copper slag, compressive strength, split tensile and flexural strength.

I. INTRODUCTION

Concrete is an adaptable designing material utilized in most of the construction. It is fundamentally made out of cement, water, fine aggregate and coarse aggregate. It is eventually noticed that, concrete is very crucial as it is made in such a way that it is economical, highly durable with good workability and it can be made it into any form and size with high compressive strength. The usage of supplementary solidifying materials like dolomite powder, egg shell, rice husk, silica fume, sugarcane bagasse, metakaolin, fly ash and so on which are natural pozzolans and so forth in concrete generation is one of the answers for reducing the cement content in concrete and therefore reducing the Co_2 content into the environment. Along these lines, conditions for additional protective and eco-pleasing establishing material have increased eagerness for inadequate bond replacement material. Replacing of cement content in concrete by pozzolanic material like Dolomite powder in reducing the cost of the concrete which also improves the mechanical properties. Meanwhile, the fine aggregate partially replaced with copper slag improves the workability and density of the concrete. The excavation of sand from the river beds lessen the water head, therefore less pervasion of water into the ground resulting lower ground water level. Along these lines, conditions for additional protective and eco-pleasing waste materials have increased eagerness for inadequate replacement of fine aggregate. By using with different mineral admixtures in concrete like dolomite, copper slag not only improves mechanical properties but also other properties like workability. The partial replacement of dolomite and copper slag have increased the compressive strength and flexural strength in an investigation [1] for M20 concrete with being copper slag replacement is made constant about 20% and with varying dolomite replacements from 20% to 30% at regular intervals of 5%. Some researchers have found that [2], the compressive strength have increased with varying replacements of dolomite from 10% to 30% and replacement of copper slag being 25% throughout for a M25 grade concrete. Usage of dolomite powder reduces the cost of concrete [3] and increases the strength of concrete. This paper examined the possible usage of dolomite as a partial replacement of cement. The replacements done were 0%, 5%, 7.5%, 10%, 12.5%. The optimum percentage was found to be at 7.5%. From the research paper [4], it was concluded that copper slag and recycled aggregates might be used as partial replacements of fine aggregate which are waste products. Copper slag with lesser water absorption and higher strength than fine aggregate can be effective in concrete. Some researchers [5] have found that, by partially replacing cement with dolomite and fine aggregate by manufactured sand, the compressive strength increased for certain replacement and then decreased gradually.

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II. MATERIALS

The materials utilized for this trial work are OPC 53 grade cement, water, fine aggregate (river sand), coarse aggregate 20mm, Dolomite powder, Copper slag and water.

A. Ordinary Portland Cement

Cement used for all the concrete mixes in this experimental work is Ordinary Portland Cement. Fresh and no lumps were present in the cement used in this trial work. Cement was tested as per IS: 12269-1987. OPC 53 grade was used in this experimental work.

Table:1 Characteristics Of Cement

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

Fine Aggregate helps the mix to be workable and consistent. Aggregate passing through 4.75mm sieve and held on 75micron sieve is named as fine aggregate. Fine aggregate was tested as per IS:383-1970.

Table:2 Characteristics Of Fine Aggregate

CHARACTERISTICS	OBSERVED VALUE
Grade zone	II
Specific gravity	2.6
Fineness Modulus	2.2

C. Coarse Aggregate

Coarse aggregate is the largest percentage in the concrete mix. Coarse aggregate used in this experimental work is an angular shaped aggregate. The aggregates passing through the 20mm sieve and were held on 10mm sieve. Coarse aggregate was tested as per IS 383-1970.

Table:3 Characteristics Of Coarse Aggregate

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

D. Dolomite powder

The dolomite is an anhydrous carbonate mineral created out of calcium magnesium carbonate. Dolomite powder is obtained by crushing the dolomite mineral.

Table:4 Physical Properties Of Dolomite Powder

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

Table:5 Chemical Properties Of Dolomite Powder

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. Copper slag

Copper slag is a by-product of copper extraction by smelting process. During smelting, impurities become scoria that floats on the liquified metal. Scoria that's quenched in water produces angular granules that are disposed of as wastes are utilized in concrete for construction. Copper Slag used for this experimental work was collected from Sri Srinivasa Metalizers, Cherlapalli. The particle shape is multifaced. Its appearance is black and glassy. The specific gravity of the copper slag was found to be 3.15.

Table:6 Physical Properties Of Copper Slag

PROPERTY	DOLOMITE POWDER
Particle Shape	Multifaced
Appearance	Black and Glassy
Specific Gravity	3.15

Table:7 Chemical Properties Of Copper Slag

CHEMICAL COMPONENT	% OF CHEMICAL COMPONENT
SiO_2	33-35%
Fe_2O_3	40-44%
Al_2O_3	4-6%
CaO	0.8-1.5%
MgO	1-2%

F. Water

Water is the important factor in the concrete mix. When added, it reacts with cement to form a paste which helps in binding the ingredients in the concrete. Water also helps the concrete to hardened due to the hydration process caused between cement and water. The job of water is important in concrete due to the water to cement ratio plays an important role to get a perfect concrete mix.

G. Super plasticizer

Super plasticizer Master Rheobuild 920SH was used in this experimental work to improve the workability of the concrete.

TABLE:8 Properties of Super Plasticizer

State	Liquid
Color	Dark
Density	1.2
Chemical name	Naphthalene formaldehyde polymer
pH	8.40

III. EXPERIMENTAL INVESTIGATION

The mix design techniques utilized in various nations are mostly dependent on the empirical relationships, charts and graphs created from extensive trial examinations. A properly designed concrete mix should have least cement content without relinquishing quality so as to make in concrete mix. The aim of contemplating the different properties of the material of concrete, plastic concrete and hardened concrete, is to empower a concrete technologist to design a concrete blend for a specific strength and durability.

1. Mix proportion

In this experimental study, M30 grade of concrete was used and the mix proportions for cement, fine aggregate and coarse aggregate was taken as 1:2.17:2.95 which was designed as per IS:10262-2009, with a water-cement ratio as 0.45.

2. Casting and Demoulding

Weigh batching was done with the assistance of electronic scales. Batching was performed for each of the combination proportions. Tilting concrete mixture was used for mixing of concrete ingredients for about 2-3 minutes.

Placing and Compaction: First the cube, cylinder and beam moulds are cleaned and then oil is applied to them to avoid the bond between the moulds and the concrete. Placing of concrete into the mould is done in 3 layers with 25 blows given to each layer with the help of tamping rod. The air trapped in the fresh concrete which was put in the moulds is removed by the table vibrator. The fresh concrete is allowed to set for 24 hours after it is placed in the molds. Then they were marked with specific identification like M1, M2, M3 etc., for varying replacement percentages of dolomite and copper slag and were put in the curing tank at ambient temperature. The hardened concrete specimens were removed from the curing tank after 3, 7 and 28 days for testing.

3. Compressive strength test

The cubes of size 150mm x 150mm x 150mm were used to conduct the compression test in accordance with IS:516-1959. Three samples were used to test the compressive strength test after 3, 7 and 28 days curing.

4. Split tensile test

Spilt tensile strength test was performed according to IS 5816-1970, a standard test to get the tensile strength in indirect manner.

5. Flexural strength test

Flexural strength test is utilized to determine the flexural strength of concrete under bending. Flexural strength teste was performed according to IS:516-1959.

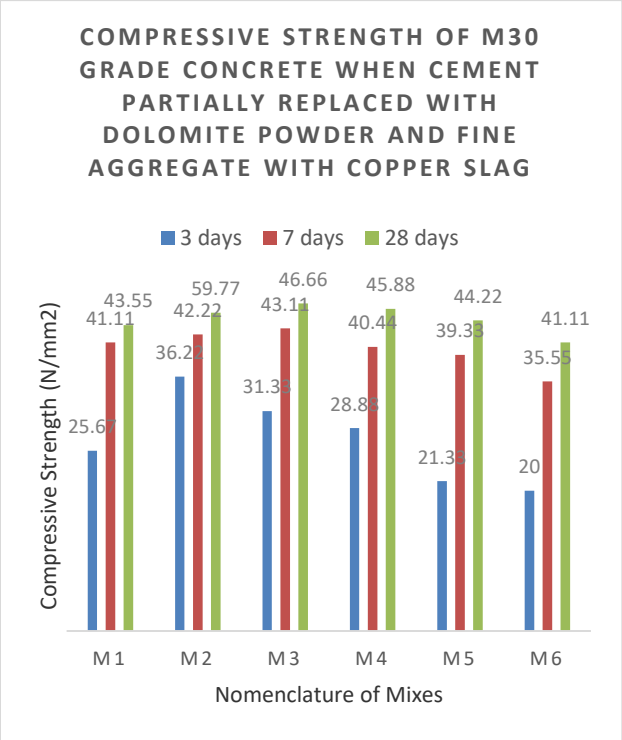
6. Concrete Mix

MIX	OPC Percentage	DOLOMITE POWDER Percentage	Fine Aggregate Percentage	COPPER SLAG Percentage
M1	100%	0%	100%	0%
M2	95%	5%	90%	10%
M3	90%	10%	80%	20%
M4	85%	15%	70%	30%
M5	80%	20%	60%	40%
M6	75%	25%	50%	50%

IV. TEST RESULTS

1. Compression test

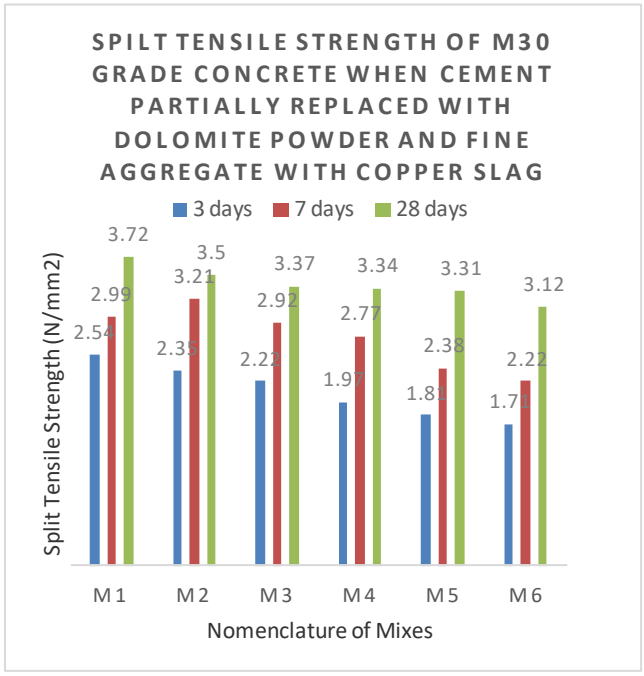
The Compressive strength for 3, 7 and 28days values are shown graphically in fig.1 below. It was observed that the compressive strength was optimum when 10% of cement replaced with dolomite powder and 20% of fine aggregate replaced with copper slag. It was also observed that 20% of cement replaced with dolomite powder and 40% of fine aggregate replaced with copper slag can be replaced which gives strength at par with conventional mix.



Fig(1) : Compressive Strength Results

2. Split tensile test

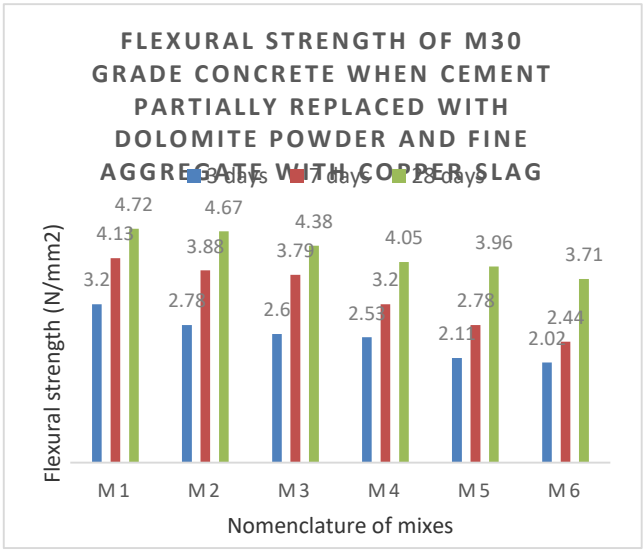
The split tensile strength for 3, 7 and 28days values are shown graphically in fig.2 below. It was observed that the split tensile strength was reduce gradually.



Fig(2) : Split Tensile Strength Results

3. Flexural strength test

The Flexural strength for 3, 7 and 28days values are shown graphically in fig.3 below. The flexural strength was observed to be gradually decreasing.



Fig(3) : Flexural Strength Results

V. CONCLUSION

Below are the conclusions that made from the inquiry are:

i. The partial replacement of cement with dolomite and copper slag with fine aggregate has increased the compressive strength
ii. The optimum compressive strength is observed at mix M3 i.e., at 10% replacement of cement with dolomite and 20% replacement of fine aggregate with copper slag.
iii. It was also observed that upto M5 i.e., at 20% dolomite and 40% copper slag can be replaced which gives compressive strength at par with conventional mix.
iv. The split tensile strength is observed to be gradually decreasing with the increase of replacement of dolomite and copper slag maybe due to reduce of interlocking between the ingredients of concrete mix.
v. The flexural strength is also observed to be decreasing with the increase of replacement of dolomite and copper slag.

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AUTHORS 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.

K. Yashwanth, has pursued his civil engineering from Gandhi Institute of Technology and Management (GITAM) deemed to be university, Hyderabad, Telangana during 2013-2017 with 1st class. His B.Tech project was on "Mix Design Using Recycled Fine Aggregate Replacing Conventional River Sand And Comparative Study". Presently pursing masters in Structural Engineering at Gokaraju Rangaraju Institute of Engineering and Technology (GRIET), Hyderabad. He has participated in some of the major conferences conducted by institute of engineering (India) and also attended some of the workshops like Modern developments in concrete and building technology. He is keenly interested to perform experimental investigations on mechanical properties and some durability properties of cement and fine aggregate replacement by-product materials. His interests are in special concrete. Under the guidance of Dr. G V V Satyanarayana.