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Investigation on Strengthening of Concrete with Partial Replacement of Dolomite and M-Sand for Cement and Fine Aggregate

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***Abstract*—Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. A study is conduct to determine the advanced concrete engineering properties viz. Compressive Strength, Tensile Strength, Flow Ability, Durability and Water Absorption Capacity of the partially replacement of river sand and ordinary Portland cement. This paper deals the fresh and hardening property of concrete made with m-sand as sand and dolomite powder as cement replacement in different percentage of amounts and also the experimental studies on physical and micro structural properties of manufactured sand are presented in this paper. While comparing the properties of natural sand (spherical particles), the manufactured sand(angular particles) gives better interlocking between the particles. Hence, enhancement in strength and durability characteristics may be obtained. For this study, three mixtures were prepared with a constant water-to-powder (cement) ratio and powder (cement) content. Fresh concrete properties were assessed by means of slump test and compaction factor test, while hardened properties were evaluated by means of compressive strength, split tensile strength and flexural strength at ages of 7, and 28days.For this study, the Samples of concrete (eg. cubes ,cylinders and beams) are made. It was found that 0.50 water/cement ratio produced higher compressive strengths, tensile strength and better workability for M25 mix, proportion for the mix is considered. These results compare favorably with those of conventional concrete. The concrete was found to be suitable for use as structural members for buildings and related structures.**

***Index Terms*—Cement, Fine aggregate, Course aggregate, Dolomite powder, M-sand and Compressive strength, split tensile strength and flexural strength**

I. Introduction

Concrete should not be confused with cement because the term, cement refers only to the dry powder substance used to bind the aggregate materials of concrete. Therefore, Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally coarse aggregate such as gravel, limestone, or granite, plus a fine aggregate such as sand), water, and maybe admixtures. Cement solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material and the reaction is exothermic. Concrete is used to make pavements, architectural structures, foundations, and motorways / roads, bridges / overpasses, parking structures, brick/block walls and footings for gates, fences and poles.

The recent development in the field of concrete technology represents a giant step toward making concrete a high tech material with enhanced characteristics. Concrete is the second most widely used material globally after water. Portland cement (PC) was considered to be the best building material for its high mechanical strength. However, ordinary PC does not only have insufficient durability performance and low resistance towards chemical attacks, the cement industry is also one of the most energy-consuming and greenhouse gases emitting industries and is responsible for 7% of the global carbon dioxide emissions. The urge for materials with less embodied energy and carbon footprint stimulated research on developing new and sustainable alternatives or blended cements with lower embodied energy to cope with the rapidly growing cement and concrete demand which is expected to double by 2050, due to the rapid structural and infrastructural development in developing countries. Blended cements, in which a percentage of PC is substituted with either slag and other mineral additives such as limestone and silica fume, are now commonly used, and which reduce the production of PC, as well as enhance the performance.

The only type of cement which excludes PC is alkali activated slag (AAS). Interest in AAS increased over the years due to its low embodied energy in production, superior mechanical performance and chemical resistance, although serious issues associated with significant shrinkage and carbonation have limited its application in construction.

II. Objectives of the Study

- To evaluate the workability with various proportions of added M-sand and Dolomite powder in M25 cement concrete mix.
- To study on the effect of using M-sand and Dolomite powder as partial replacement for sand and cement in M25

cement concrete mix in terms of compressive strength, split tensile strength and flexural strength.

- To determine the optimum percentage of M-Sand and Dolomite powder to be added as partial replacement for course aggregate M25 cement concrete mix.

III. Study about Dolomite and M-Sand

- Dolomite is a common rock-forming mineral. It is a calcium magnesium carbonate with a chemical composition of $CaMg(CO_3)_2$. It is the primary component of the sedimentary rock known as dolostone and the metamorphic rock known as dolomitic marble. Limestone that contains some dolomite is known as dolomitic limestone. The mineral dolomite is named after the rock in the Dolomite Mountains in Italy. The mountains are named after a French geologist named Deodat de Dolomieu (1750-1801).
- The artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation. When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector. Natural river sand takes millions of years to form and is not repleneshible. Because of its limited supply, the cost of Natural River sand has sky rocketed and its consistent supply cannot be guaranteed. Under this circumstances use of manufactured sand becomes inevitable. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas manufactured sand has no silt or organic impurities.

IV. Methodology

A. 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. The specific gravity of Portland cement was 3.15. The ordinary Portland cement of 53grade manufactured by the Dalmia Cement Company was used in the study, which is in accordance with IS 8112:1989.

B. Fine Aggregate

Locally available fresh river sand, free from organic matter, was used. The result of sieve analysis confirms to zone-I (according to IS: 383-1970). The most important function of the aggregate is to assist in producing workability and uniformity in mixture. The fine aggregate also assists the cement paste to hold the coarse aggregate particle in suspension. This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate. It should be durable, clean and be free from organic matters. It should not contain any appreciable amount of clay balls and harmful impurities such as alkalis, salt, coal, decayed vegetation etc. River sand was used as fine aggregate. The specific gravity of sand was found to be 2.56.

C. Coarse Aggregate

Crushed aggregate of 20mm size is brought from quarry. Aggregates of more than 20mm size are separated by sieving. Tests are carried out in order to find out properties of it. The coarse aggregate is the largest component of concrete. It is chemically a stable material. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. Hard broken granite stones were used as coarse aggregate in concrete. Size of coarse aggregate used in the investigation was 10mm.

The specific gravity of the coarse aggregate was found to be 2.68.

D. Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The water, which is used for making concrete should be clean and free from harmful impurities like oil, alkalis, acids etc. Water for making concrete should have pH between 6 and 8. Locally available drinking water was used in this work.

E. M-Sand

Natural or River sand are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days good sand is not readily available; it is transported from a long distance. Those resources are also exhausting very rapidly. So it is a need of the time to find some substitute to natural river sand.

The artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion). When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector.

Natural river sand takes millions of years to form and is not repleneshible. Because of its limited supply, the cost of Natural River sand has sky rocketed and its consistent supply cannot be guaranteed. Under this circumstances use of manufactured sand becomes inevitable. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas manufactured sand has no silt or organic impurities.

F. IS Code Provision

BIS Guidelines IS: 383-1970 for selection and testing of

Coarse and Fine aggregates available. Generally, Sand is classified as Zone I, Zone II, Zone III and Zone IV (i.e. Coarser to Finer). There is sieve designation for each zone. Gradation is made in accord with the usage of the sand. There are testing sieves, consists of 4.75mm, 2.36mm, 1.183mm, 600microns, 300 microns, 150 microns and a pan.

TABLE I
TYPICAL SIEVE ANALYSIS: COMPARISON OF RIVER & MANUFACTURED SAND

IS Sieve	% of passing(River Sand)	% of passing (Manufactured Sand)	Zone II (As per IS:383)
4.75mm	100	100	90-100
2.36mm	99.7	90.7	75-100
1.18mm	89	66.2	55-90
600micron	60.9	39.8	35-59
300micron	17.7	25.5	8-30
150micron	3.1	9.9	0-20
75micron	Max 3	Max 15	Max 15
	Zone II	Zone II	
Zone II Note: The gradation of manufactured sand can be controlled at crushing plant			

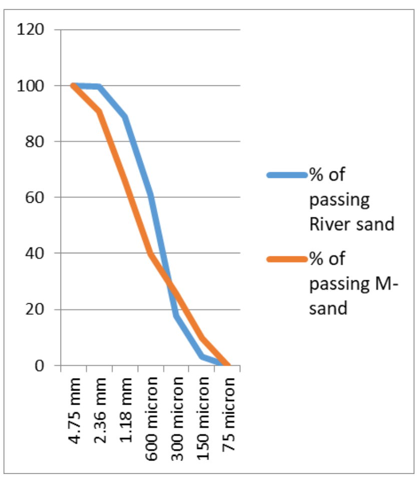

Fig. 1. Chart: Comparison of river & manufactured sand

G. *Dolomite Powder (DP)*

Fig. 2. Collection of materials

The dolomite powder was collected from the local market in Trichy. It was sieved by IS-90 micron sieve before mixing in concrete. Tests are carried out in order to find out the properties of dolomite powder. The test results are presented here.

Fineness of waste dolomite = 13%

Specific gravity = 1.5

Dolomite has good weathering resistance. The properties of the dolomite powder are given in Table-2.

TABLE II
PROPERTIES OF DOLOMITE POWDER

S. No.	Property	Dolomite Powder
1	Formula	$CaMg(CO_3)_2$
2	Specific gravity	2.85
3	Color	White, grey to pink
4	Tenacity	Brittle
5	Moisture content (%)	Nil
6	Crystal system	Trigonal
7	Sieve analysis	Zone III

V. RESULTS AND DISCUSSION

A. *Interpretation of Test Results*

The test results are reported and compared with the values obtained from various codes,. The test results such as compressive strength and split tensile strength with different proportions of coconut shell coarse aggregate are discussed below.

B. *Compressive Strength*

Compressive strength is the major parameter which influences other properties of concrete. Compressive strength of concrete specimen with sand and cement (control specimen) 28 days was found to be 33.6 N/mm^2

TABLE III
COMPRESSIVE STRENGTH COMPARISONS

Mix Type	Compressive Strength (7 Days) N/mm^2	Compressive Strength (28 Days) N/mm^2
CC	21.05	33.6
DP 10%	28.73	39.20
DP10%&MS 10%	27.30	37.43
DP10%&MS 20%	27.45	37.63
DP10%&MS 30%	28.39	39.95
DP10%&MS 40%	28.51	40.64
DP10%&MS 50%	28.33	39.16

From the above test results, it is clear that when cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder10% and sand is substituted with m-sand 10%, when the strength is increase compared with conventional concrete. Sand is substituted with m-sand 20%, 30%, 40% and 50% respectively. When the compressive strength is found to be reducing.

Compressive strength of the M25 Concrete mix, it is clear that when cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increase compared with conventional concrete. Sand is substituted with m-sand 10%, 20%, 30%, 40% and 50% respectively. When the compressive strength is found to be reducing.

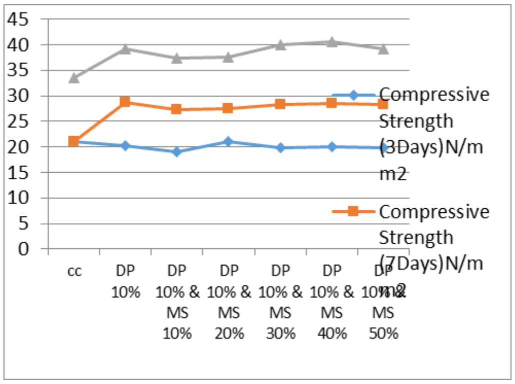

Fig. 3. Comparison of compressive strength

The graph is explained in 3 days, 7 days and 28 days compressive strength of result. When cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increase compared with conventional concrete. Sand is substituted with m-sand 10%, 20%, 30%, 40% and 50% respectively. When the compressive strength is found to be reducing.

C. Split Tensile Strength

Split tensile strength of concrete specimen with sand and cement (control specimen) 28 days was found to be 3.53 N/mm^2.

TABLE IV
SPLIT TENSILE STRENGTH COMPARISONS

Mix Type	Split Tensile Strength (28 Days) N/mm^2
CC	3.53
DP 10%	3.63
DP 10%&MS 10%	4.2
DP 10%&MS 20%	4.64
DP 10%&MS 30%	4.87
DP 10%&MS 40%	4.93
DP 10%&MS 50%	4.81

From the above test results, it is clear that when cement is substituted with dolomite powder 10%,when cement is substituted with dolomite powder10% and sand is substituted with m-sand 10%, when the strength is increase compared with conventional concrete. Sand is substituted with m-sand 20%, 30%, 40% and 50% respectively, the Split tensile strength is found to be reducing.

In Ranjith Kumar et al (2017), studied the properties of concrete incorporating dolomite powder, when cement is substituted with dolomite powder 10%, the Split tensile strength is found to be reducing.

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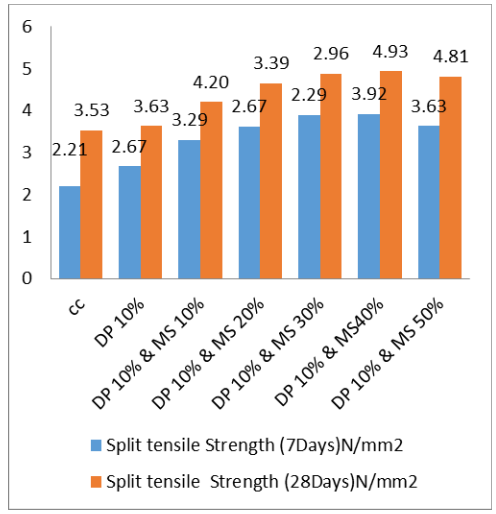

Fig. 4. Comparison of split tensile strength

Split tensile strength of the M25 Concrete mix, it is clear that when cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increased compared with conventional concrete. Sand is substituted with m-sand 20%, 30%, 40% and 50% respectively, the Split tensile strength is found to be reducing.

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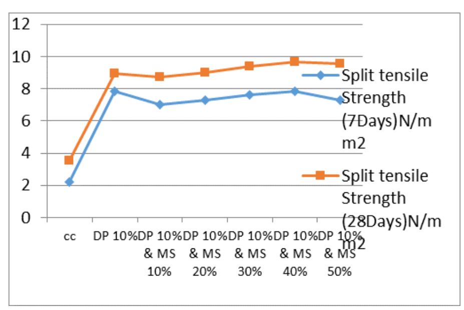

Fig. 5. Comparison of split tensile strength

The graph is explained in 7 days and 28 days Split tensile strength of result. when cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increased compared with conventional concrete. Sand is substituted with m-sand 20%, 30%, 40% and 50% respectively, the Split tensile strength is found to be reducing.

In Ranjith Kumar et al (2017), studied the properties of concrete incorporating dolomite powder, when cement is substituted with dolomite powder 10%, the Split tensile strength is found to be reducing.

D. Flexural Strength

Flexural strength of concrete specimen with sand and cement (control specimen) 28 days was found to be 4.06 N/mm^2.

TABLE V
FLEXURAL STRENGTH COMPARISONS

Mix Type	Flexural Strength (28 Days) N/mm^2
CC	4.06
DP 10%	8.92
DP 10%&MS 10%	8.75
DP 10%&MS 20%	8.98
DP 10%&MS 30%	9.41
DP 10%&MS 40%	9.69
DP 10%&MS 50%	9.56

From the above test results, it is clear that when cement is substituted with dolomite powder 10%,when cement is substituted with dolomite powder10% and sand is substituted with m-sand 10%, when the strength is increase compared with conventional concrete. Sand is substituted with m-sand 20%, 30% 40% and 50% respectively, the Flexural strength is found to be reducing. .

Preethi G et al 2012 studied that when cement is substituted with dolomite powder 15%, the Flexural strength is found to be reducing.

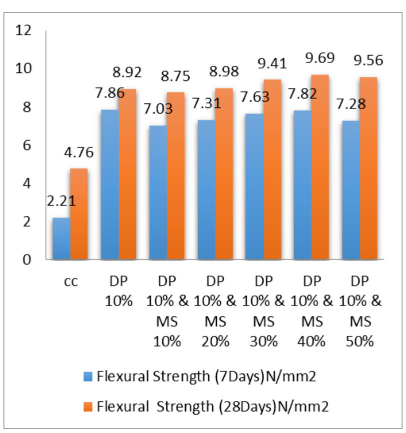

Fig. 6. Comparison of flexural strength

Flexural strength of the M25 Concrete mix, it is clear that when cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increased compared with conventional concrete. Sand is substituted with m-sand 20%, 30%, 40% and 50% respectively, the Flexural strength is found to be reducing.

Preethi G et al 2012 studied that when cement is substituted with dolomite powder 15%, the Flexural strength is found to be reducing.

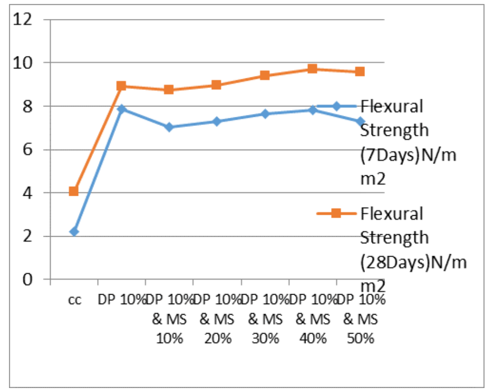

Fig. 7. Comparison of flexural strength

The graph is explained in 7 days and 28 days Flexural strength of result. When cement is substituted with dolomite powder 10%, when cement is substituted with dolomite powder 10% and sand is substituted with m-sand 10%, when the strength is increased compared with conventional concrete. Sand is substituted with m-sand 20% and 30% respectively, the Flexural strength is found to be reducing.

Preethi G et al 2012 studied that when cement is substituted with dolomite powder 15%, the Flexural strength is found to be reducing.

VI. CONCLUSION

- The target mean of M25 grade concrete is 31.6 N/mm2. The optimal replacement percentage of cement with dolomite powder 10% and sand with m-sand 40%, when the compressive strength is 40.64 N/mm^2.
- The optimal replacement percentage of cement with dolomite powder 10% and sand with m-sand 40%, when the Split tensile strength is 4.93 N/mm^2.
- The optimal replacement percentage of cement with dolomite powder 10% and sand with m-sand 40%, when the Flexural strength is 9.69 N/mm^2.

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