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A Preparation of High Performance Concrete Using Dolomite Wastes of Hirri Mines

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ABSTRACT- This paper reviews the preparation of High Performance Concrete using dolomite wastes of Hirri mines for building construction in the field of civil engineering. It comprises of the important analysis of mechanical properties and results corresponding to those properties. As we know, cement is essential component of concrete, but during the manufacturing process a large amount of greenhouse gases is released into the atmosphere.. It is estimated that the production of one ton of cement results in the emission of 0.8 ton of CO2. Hence in this report cement is partially replaced by dolomite powder as percentages of 5%, 10%, 15%, 20% and 25% in M_{20} grade of concrete. The replacement of cement not only reduces the cost of construction, but also the emission of greenhouse gases. Dolomite powder is a waste by-product of dolomite mining and has similar properties to that of cement. In this report, the compressive, split tensile and flexural strengths of concrete with partial dolomite replacement are compared to the reference specimens and results are obtained.

Keywords: Dolomite, High performance concrete, Dolomite Powder, Dolomite Wastes, Concrete

I. INTRODUCTION

The constituent materials of concrete are cement, fin aggregate, coarse aggregate and water. Out of these cement is the most important constituent of concrete. But the manufacturing process of cement gives rise to the emission of many green house gasses. One such green house gas is carbon dioxide. It is estimated that manufacturing of cement emits about 0.8 tonne of CO_2 into the atmosphere for each tonne of cement manufactured.

Now a-days, high performance concrete are being used extensively in construction industry. It is known for a variety of properties some of which are high strength, high modulus of elasticity, low permeability, compaction without segregation, etc. In this particular report we will be preparing and testing self compacting concrete, a type of high performance concrete by replacing some portion of cement with dolomite powder in the concrete mix.

Self compacting concrete is able to flow and consolidate under its own weight. This makes SCC particularly useful wherever placing is difficult. Admixtures, particularly High Range water reducers and Viscosity modifying agents are used in SCC to enhance its properties.

Dolomite is a carbonate mineral composed of calcium magnesium carbonate $CaMg(CO_3)_3$. Dolomite powderhas similar properties to cement. It is noted for its wettability and dispersibility and it features a good weathering resistance. It is a popular construction material because of its higher surface hardness an density.

By effective utilization of dolomite powder, effort has been made to explore the possibility as a replacement for cement. Dolomite powder was choosen for experiment because of the fact that it's kind of a waste and hence, inexpensive and available. The material used in this work was waste dolomite powder which is a by-product in the process of mechanical dedusting of dolomite aggregates at Hirri Mines.

The concrete specimens were off-grade M20 and were made by replacing 5,10,15,20 and 25% of cement by dolomite powder these test specimens then checked for compressive, split tensile and flexular strength at 7^{th} and 28^{th} days. Then the optimal percentage of replacement of dolomite was decided based on the test results.

II. LITERATURE REVIEW

Kamal M.M, et al (2012) evaluated the bond strength of self-compacting concrete mixes containing dolomite powder. Silica flume or ash was used alongside dolomite powder to extend the bond strength considerably. He proportionedSseven mixes and test was carried out. The variation of the bond strength for different mixes was evaluated.

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The result showed that the bond strength increased as the replacement of hydraulic cement with dolomite powder increased. The availability of this sort of concrete provided great opportunities for faster construction. They reported that the shear strength of RC beams were better than that of the conventional SCC without dolomite powder.

Deepa Balakrishnan S and Paulose K.C (2013) carried out an investigation on the workability and strength characteristics of self-compacting concrete containing fly ash and dolomite powder. They made high volume fly ash self-compacting concrete with 12.5 percent, 18.75 percent, 25 percent and 37.5 percent of the cement (by mass) replaced by fly ash and 6.25 percent, 12.5 percent and 25 percent of the cement replaced by dolomite powder. The test results for acceptance characteristics of self-compacting concrete such as slump flow test, J-ring test, V-funnel test and L-box test were presented. The mixes were then tested for other mechanical properties like, cube compressive strength at 7th day, 28th day and 90th day, cylinder compressive strength at 28th day, split tensile strength, and flexural strength at 28th day. For all levels of cement replacement, concrete achieved superior performance within the fresh and hardened states in comparison with the reference mixture.

Salim Barbhuiya (2011) administered an investigation to explore the chances of using dolomite powder for the assembly of SCC. Test results indicated that it's possible to manufacture SCC using ash and dolomite powder. The mix containing fly ash and dolomite powder in the ratio 3:1 was found to satisfy the requirements suggested by the European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC) guidelines for making SCC. Compressive strengths of SCC with 75% fly ash and 25% dolomite powder was found to be satisfactory for structural applications.

III. EXPERIMENTAL INVESTIGATION

A. Materials Used

Mixture proportions for SCC differ from those of ordinary concrete, therein the previous has more powder content and fewer coarse aggregate. The materials used in this work were cement, coarse aggregates, fine aggregates, water. No admixtures were used for this work. The details of the materials used are as follows:

1) Cement:

Cement is a binder material, when mixed with water sets and hardens. It also binds other materials together. There are many types of cement available in the market. The most commonly used cement is Ordinary Portland Cement. OPC is a basic ingredient of concrete, mortar and plaster. It consists of a mix of oxides of calcium, silicon and aluminium. Indian standards IS: 12269-2013 outlines the specification for OPC 53 Grade cement. Portland cement of 53 Grade was used for this particular investigation. The density of cement was 3.15.

2) Coarse Aggregates:

Coarse aggregate should be a chemically stable material. It is also the largest component of any concrete mixture. Generally, coarse aggregates are about any rocks that do not pass through 4.75mm sieve. The presence of coarse aggregate helps in reducing the drying shrinkage. The size of coarse aggregate used in this investigation was approximately 10-15mm. It's specific gravity was found to be 2.68.

3) Fine Aggregates:

The fine aggregate assists the cement paste to carry the coarse aggregate particle in suspension. This action promotes plasticity within the mixture and prevents the possible segregation of paste and coarse aggregate.It's important function is to produce workability and form a uniform mixture. It should be clean and be free from any organic matters. It should not contain harmful impurities such as alkalis, salt, coal, decayed vegetation etc.Arpa river sand was used as fine aggregate. The specific gravity of sand was found to be 2.56.

4) Water:

Water is an crucial ingredient of concrete as it actively participates within the reaction with cement. The water which should be used for making concrete should be clean and free from harmful impurities like oil, acids, etc. normally if water is fit for drinking it is considered suitable for making concrete.Water for making concrete should have pH between 6 and 8. Normal tap water was used in this project.

5) Dolomite: Dolomite is a carbonate mineral composed of calcium magnesium carbonate $CaMg(CO_3)_3$. Dolomite powder has similar properties to cement. It is noted for its wettability and dispersibility and it features a good weathering resistance. It is a popular construction material because of its higher surface hardness an density. It has good weathering resistance and properties that are almost similar to that of cement. The dolomite powder was whitish-gray in colour. It's

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specific gravity was 2.85. it's moisture content was found to be nil.

B. Details of Concrete Mix

In the present investigation, M20 mix was designed as per the guidelines given in IS 10262:2009. The water cement ratio adopted was 0.5. The quantities of:

- Cement = 394.32 kg
- Fine aggregate = 669.527 kg
- Coarse aggregate = 1156.61 kg

Now for this mixed proportion for M20 grade of concrete partial replacement of cement was done with dolomite powder by 5,10,15,20 and 25% and each batch was tested for compressive strength, split tensile strength and flexural strength.

B. Results And Discussions

Compressive Strength

The cubical compressive strength of concrete was determined by conducting test on 150mm x 150mm x 150mm cube specimens at 7 days, 28 days of curing. After curing, three cubical specimens were tested on a compression machine. The specimens were tested in the compression testing machine of 2000kN capacity. After keeping the specimens on the compression testing machine, the load was applied at a uniform rate of 140kg/cm2/min until the failure of the specimen. The average value of the three results was taken as the compressive strength. The compressive strength of concrete gives an idea about the overall quality of concrete. The compression testing machine used is shown.

Table 4.1: Compressive Strength of M_{20} Concrete at 7^{th} and 28^{th} Days

S. No.	**% replacement of cement with dolomite powder**	**Compressive Strength (N/mm^2)**			
		7^{th} day	**% variation***	**28^{th} day**	**% variation**
1	0	16.32	-	28.35	-
2	5	17.48	7.10	29.16	2.85
3	10	18.13	11.09	31.63	11.5
4	15	17.87	9.49	24.71	-12.83
5	20	15.33	-6.06	23.56	-16.89
6	25	13.20	-19.11	18.40	-35.09

*- negative sign shows reduction in reduction in strength with respect to the reference specimen

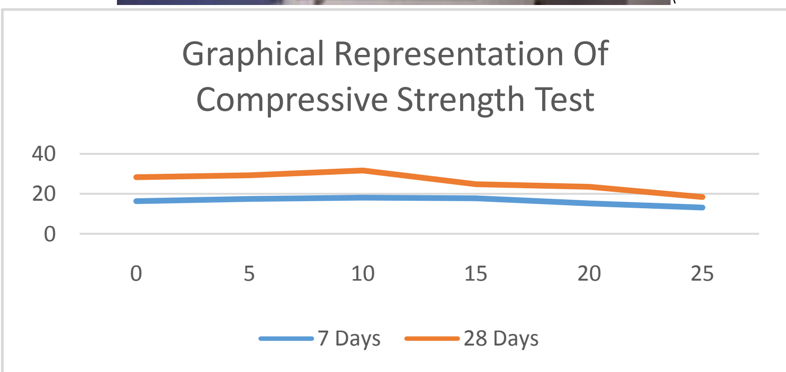

Fig 4.1: Compressive Strength Test

Split Tensile Strength

Tensile strength of concrete ginormous affects the extent and size of cracking in concrete. Tensile strength of concrete is less when compared with its compressive strength. Cylinders of diameter 150 mm and height 300 mm were used to determine the split tensile strength. After curing, the specimens were tested on the compression testing machine of 2000 kN capacity.

Table 4.2: Split Tensile Strength of M_{20} Concrete at 7th and 28th Days

S. No.	**% replacement of cement with dolomite powder**	**Split Tensile Strength (N/mm^2)**			
		7th day	**% variation***	**28th day**	**% variation**
1	0	1.49	-	3.10	-
2	5	1.87	25.5	3.33	7.41
3	10	2.37	59.06	3.62	16.77
4	15	2.55	71.14	4.21	35.8
5	20	2.32	55.70	2.78	-10.32
6	25	1.45	-2.68	1.89	-39.03

*- negative sign shows reduction in reduction in strength with respect to the reference specimen

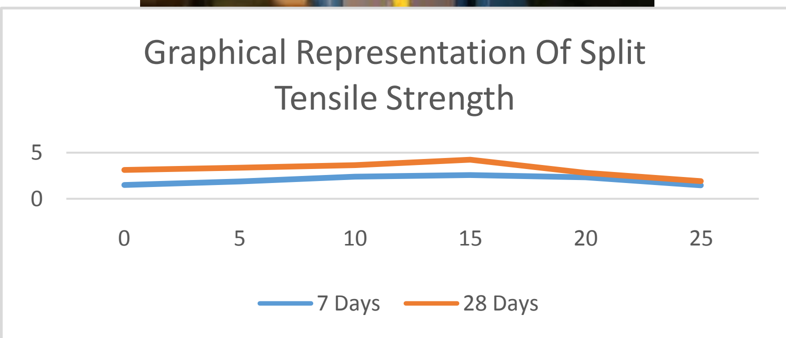

Fig 4.2: Split Tensile Strength Test

Flexural Strength

The determination of flexural tensile strength is essential to estimate the load at which concrete members may crack. The flexural tensile strength at failure is called modulus of rupture. The knowledge of modulus of rupture is useful in the design of pavement slabs, airfield runways, finding deflection and crack width as flexural tension is critical in these cases. Prisms of size 100 mm X 100 mm X 500mm were used to determine the flexural strength. Two point loading was adopted for finding the flexural strength. The specimens were tested in a Universal Testing Machine (UTM) of capacity 1000kN.

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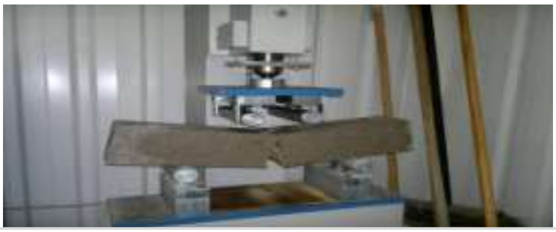
Table 4.3: Flexural Strength of M_{20} Concrete at 7^{th} and 28^{th} Days

S. No.	% replacement of cement with dolomite powder	Compressive Strength (N/mm^2)			
		7^{th} day	% variation*	28^{th} day	% variation
1	0	4.82	-	7.13	-
2	5	5.14	6.63	7.82	9.67
3	10	5.89	22.19	8.36	17.25
4	15	4.74	-1.66	6.56	-7.99
5	20	3.41	-29.25	5.02	-29.59
6	25	2.58	-46.47	4.66	-34.64

*- negative sign shows reduction in reduction in strength with respect to the reference specimen

The values of the compressive, split tensile and the flexural strengths are given in Table 4.1, Table 4.2 and Table 4.3 respectively for M20 grade of concrete.

The variations in the compressive strength, the split tensile strength and the flexural strength of M20 concrete with respect to percentage replacement are shown in Fig 4.1, Fig 4.2 and Fig 4.3 respectively.
From the tables and figures, it can be seen that dolomite powder improves the compressive strength, the split tensile strength and the flexural strength of concrete up to certain replacement percentage. As the percentage replacement of cement with dolomite powder increases, the compressive, the split tensile and the flexural strengths increase, reach a maximum value and then decrease. The maximum compressive and flexural strengths are obtained when the replacement percentage is 10. In case of split tensile strength, the optimal replacement percentage is 15. The maximum compressive strength obtained at 10% replacement was found to be 31.63 N/mm2. The split tensile strength of concrete with dolomite powder increased up to 15% and then it decreased. The maximum split tensile strength at 15% replacement was 4.25 N/mm2.The flexural strength of concrete with dolomite powder increased up to 10% and then it decreased. The maximum flexural strength at 10% replacement was 8.48 N/mm2.



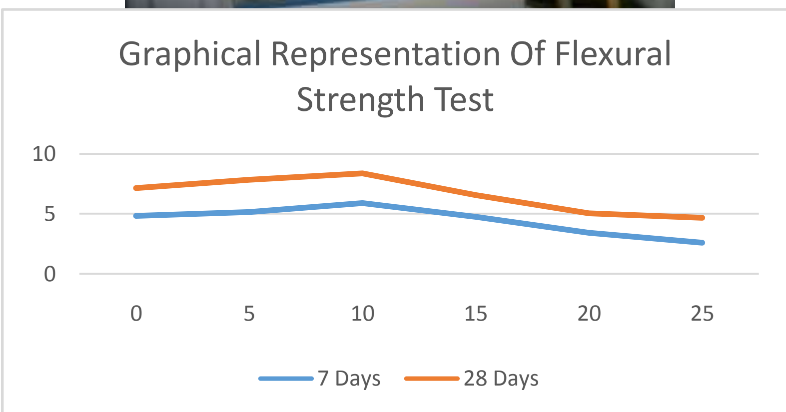


Fig 4.3: Flexural Strength Test

C. Conclusion

- Replacement of cement with dolomite powder is found to improve the strength of concrete upto a certain replacement percentage.
- The optimalreplacement percentage of cement with dolomite powder is found to be 10% and at this replacement level, the maximum increase in the 28th day compression and flexural strength were found to be 11.09% and 17.25% respectively.
- In case of split tensile strength, the optimal replacement is 15% and at this replacement level, the percentage increase in split tensile strength was found to be 35.8%.
- Use of dolomite powder decreases the cost of concrete. Since the cost of dolomite is less than that of cement.
- And as the dolomite powder used is the waste by-product of dolomite mines in at Hirri, is serves a double purpose of waste management.
- The reduction in the consumption of cement will reduce the emission of greenhouse gas.

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