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PARTIAL REPLACEMENT OF CEMENT WITH MARBLE DUST POWDER AND ADDITION OF POLYPROPYLENE FIBRES

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ABSTRACT - To use concrete as a load bearing member it is necessary to increase tensile resistance property of the concrete member. This phenomenon is achieved from hundred year back or more by using primary reinforcement and also by the Application of pre stressing. Both of the two methods provide tensile strength to the structural element but do not increase the inherent tensile strength of concrete matrix itself. The overall performance of reinforced concrete composite material is affected then the individual performance of the concrete itself. This led to the search for new material i.e. two phase composite material in which weak concrete matrix is reinforced with strong fibre to produce composite of superior property and high performance. In two phase composite fibrous material, fibres inhibit the deformation of the concrete matrix and impact to increase the properties of stiffness and strength. The main purpose of adding fiber to concrete is to achieve superior properties of plain concrete.

In this investigation the mechanical properties of fibre reinforced concrete is studied by replacing cement with marble dust powder and addition of polypropylene fibre with different weight fractions with respect to cement.

1. INTRODUCTION

It has been estimated that several million tons of MDP are produced during quarrying worldwide. Hence utilization of marble powder has become an important alternative materials towards the efficient utilization in concrete for improved harden properties of concrete. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance it is white if the limestone is composed solely of calcite (100% CaCO3). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. A large quantity of MDP is generated during the cutting process. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Leaving these waste materials to the environment directly can cause environmental problem. Moreover, there is a limit on the availability of natural aggregate and minerals used for making cement, and it is necessary to reduce energy consumption and emission of carbon dioxide resulting from construction processes, solution to this problem are sought through usage of MDP as partial replacement of cement. In India, MDP is settled by sedimentation and then dumped away which results an environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the MDP in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits.

2. OBJECTIVE OF THIS STUDY

- Study of the effect of using Marble Dust Powder as a replacement and Polypropylene as admixture in concrete and its benefits.
- Improve the overall durability and long-term performance of concrete structures.
- An approach towards the use of the alternative materials as concrete thereby reducing the burden on main ingredients.
- Reducing pollution by using a waste materials like marble dust powder and fibers.
- Comparative cost study between plain cement concrete and concrete having partial cement replacement with MDP and addition of polypropylene Fibers.

3. METHODOLOGY

This experimental scheme comprises of test in compressive strength test and split tensile strength test. For obtaining compressive strength at 7 and 28 days (3+3)= 6 cube specimens of 150mm x 150mm x 150mm size each were casted.(3+3)= 6 cylindrical specimens each with 150mm dia x 300 height were casted to fine split tensile strength.

Trial mixes of concrete 0%, 5 %, 10%, 15% weight of MDP by replacing cement and 0%,0.5 %, 1.0%, 1.5% PPF added by weight of cement are made. Cement used is Ordinary portland (OPC) of grade 43 water – ratio cement of 0.50. Following are the materials that have been used in the present study:

a) Cement
b) Fine Aggregate

c) Coarse Aggregate
d) Water
e) Marble Dust Powder
f) Polypropylene Fibres

4. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength and workability as economically as possible, is termed the 'Concrete Mix Design '.
The compressive strength of hardened concrete which is generally considered to be an index of its other properties depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing, placing and compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variation in the cost of materials arise from the fact that the cement is several time costly then the aggregate, thus the aim is to produce as lean a mix is possible from technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evaluation of high heat of hydration in mass concrete which may cause cracking.

5. MIX CALCULATIONS

A) FOR CUBE:

Volume of Cube of size (150mm×150mm× 150mm) = 0.003375 m^3

1. Determine the amount of cement = (1×1.57×1440×0.003375)/5.5 = 1.39kg

2. Determine the amount of sand = (1.5×1.57×1600×0.003375)/5.5 = 2.31kg

3. Determine the amount of coarse aggregate = (3×1.57×1700×0.003375)/5.5 = 4.91kg

4. Water-cement Ratio = 0.5

5. Water required = 0.5 × 1.39 = 0.695 kg

B) FOR CYLINDER:

Volume of Cylinder of size (300mm× 150mm) = $\pi r^2 h = 3.14 \times 0.075^2 \times 0.3 = 0.0053\ m^3$

1. Determine the amount of cement = (1×1.57×1440×0.0053)/5.5 = 2.179kg

2. Determine the amount of sand = (1.5×1.57×1600×0.0053)/5.5 = 3.631kg

3. Determine the amount of coarse aggregate = (3×1.57×1700×0.0053)/5.5 = 7.716kg

4. Water-cement Ratio = 0.5

5. Water required = 0.5 × 2.1786 = 1.0893 kg

%age of MDP	%age of PPF
0%	0%
	0.5%
	1.0%
	1.5%
5%	0%
	0.5%
	1.0%
	1.5%
10%	0%
	0.5%
	1.0%
	1.5%
15%	0%
	0.5%
	1.0%
	1.5%

COST ANALYSIS

For cube (150x150x150) mm
Cost per kg of cement - Rs 6.5/-
At 10% replacement of cement with marble dust powder, cement obtained = 1.320kg
Therefore cost of 1.320kg cement = Rs 8.58/-
Amount of cement with 0% replacement of marble dust powder = 1.39kg
And cost of cement with 0% replacement of marble dust powder = Rs 9.035/-

From the above observations it is clear that the cost of cement with 10% replacement of Marble dust powder is less as compared to cement with 0% replacement of marble dust powder. Marble dust powder is a waste product and is available free of cost.

6. PREPRATION OF SPECIMENS:

Concrete cube of size 150mm*150mm*150mm were casted for determining the compressive strength of concrete. Cylindrical concrete specimen having dimension 15mm diameter and 300mm height were casted to determine the split tensile strength of concrete.

During the assembly of moulds for use purpose, the joint in between the section of mould with oil and similar coating of mould with oil at contact surface to ensure that no slurry escaped during filling of mould and compaction

of mould. Also, the interior surface of mould coated with mould oil prevent adhesion of concrete and mould during remolding. The test specimens are casted in such a way as produce full compaction of concrete with neither segregation nor bleeding. The compaction is done with tamping rod by filling the mould in three layers. All the specimens were cured by putting them in water for 7 days and 28 days before testing.

7. MIXING, CASTING AND CURING:

The procedures of mixing the concrete involve as following: Firstly, the gravel and sand placed in a concrete mixer and dry mixed for 1 min. Secondly, about half of water is added and mixed for 2 min. As per Indian standard, concrete is fully mixed with uniformly PPF on metal plate and mixed for 3 min. Thirdly the remaining water is added to the mix and mixing is done until good homogeneous and consistence mixture is obtained. If there is any lumping or balling of concrete was found at any stage, it is taken out, crushed and again added manually. Lastly, the concrete mix was cast in mould with proper compaction using tamping rod. The specimens were kept undisturbed for 24 hours in open air to set the concrete.

Total number 32 cubes and 32 cylinders were casted. Marble powder was added in concrete in step of 5% (0%, 5%, 10%, 15%, 20%) and PPF in steps of 0.5% (0%, 0.5%, 1.0%, 1.5%). For each percent of marble powder replacing Cement and polypropylene fiber 2 cubes & 2cylinders were casted for 7 days and 28 days. Final strength of cube & cylinder were tested after 7 & 28 days curing. Compression testing machine is used for testing the compressive strength of cube and split tensile strength of cylinder. The crushing loads were noted and average compressive strength and tensile strength for three specimens is determined for each which is given in tables below.

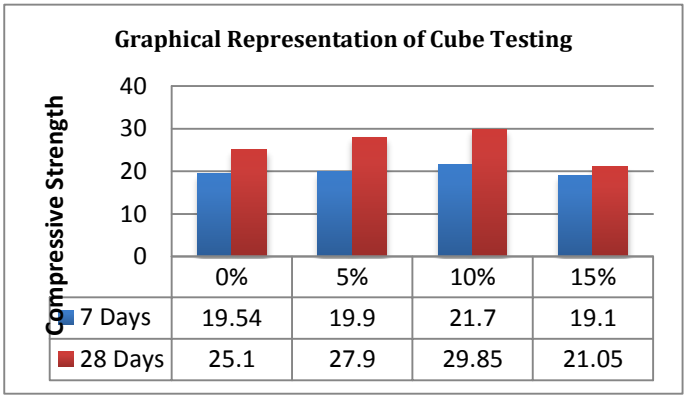
Fig. 1 Mixing of Materials

Fig. 2 Casting of Specimen

8. RESULT ANAYLSIS

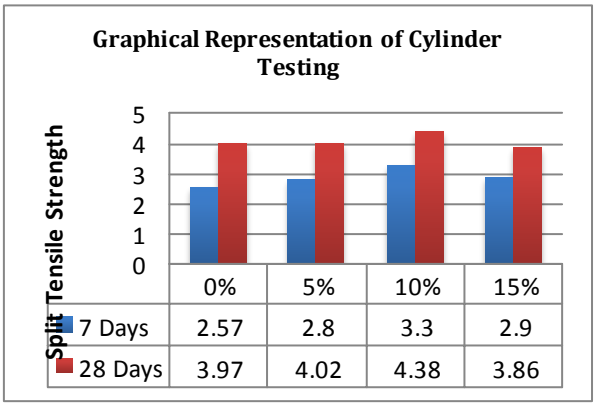
a) TEST RESULT FOR CUBES:

%age of MDP	%age of PPF	Average strength at 7days (N/mm^2)	Average strength at 28days (N/mm^2)
0%	0%	18.36	23.41
	0.5%	19.54	25.10
	1.0%	18.77	24.22
	1.5%	17.95	23.10
5%	0%	18.59	26.95
	0.5%	19.90	27.90
	1.0%	19.05	27.05
	1.5%	18.20	26.70
10%	0%	20.88	28.44
	0.5%	21.70	29.85
	1.0%	20.85	28.70
	1.5%	19.95	28.00
15%	0%	18.07	20.30
	0.5%	19.10	21.05
	1.0%	18.70	20.85
	1.5%	17.80	20.05



b) TEST RESULTS FOR CYLINDERS

%age of MDP	%age of PPF	Average strength at 7days (N/mm^2)	Average strength at 28days (N/mm^2)
0%	0%	2.12	3.30
	0.5%	2.75	3.97
	1.0%	2.54	3.72
	1.5%	2.10	3.28
5%	0%	2.22	3.49
	0.5%	2.80	4.02
	1.0%	2.72	3.82
	1.5%	2.21	3.45
10%	0%	2.92	3.73
	0.5%	3.30	4.38
	1.0%	3.05	3.84
	1.5%	2.82	3.64
15%	0%	2.64	3.49
	0.5%	2.90	3.86
	1.0%	2.70	3.71
	1.5%	2.45	3.29



CUBES:

Compressive strength of concrete is tested on cube at different percentage of marble powder content in concrete. The strength of concrete has been tested on cube at 7 days curing and 28 days. 7 days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the compressive strength test on concrete. At the time of testing the cube is taken out of water and dried and then tested keeping the smooth faces in upper and lower part.

DISCUSSION:

1. With the inclusion of Marble powder the strength of concrete gradually increases up to a certain limit but the gradually decreases.
2. With the inclusion of Marble powder upto 10% and PPF upto 0.5% the initial strength gain in concrete is high.
3. At 10% there is 12% increase in initial compressive strength for 7 days.
4. At 10% there is 17.7% increase in initial compressive strength for 28 days.
5. The initial strength gradually decreases from 15%.

CYLINDER:

Split Tensile strength of concrete is tested on cylinders at different percentage of marble powder content in concrete. The strength of concrete has been tested on cylinder at 7 days curing and 28 days. 7 days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested.

DISCUSSION:

1. With the inclusion of Marble powder the strength of concrete gradually increases up
to a certain limit but the gradually decreases.
2. With the inclusion of Marble powder upto 10% and PPF upto 0.5% the initial strength gain in concrete is high.
3. At 10% there is 27.4% increase in initial Split Tensile strength for 7 days
4. At 10% there is 11.5% increase in initial Split Tensile strength for 28 days.
5. The initial strength gradually decreases from 15%.

9. CONCLUSIONS

- The Compressive strength of Cubes are increased with addition of waste marble powder up to 10% and PPF upto 0.5% replace by weight of cement and further any addition of waste marble powder the compressive strength decreases.
- The Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% and PPF upto 0.5% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases.
- Thus we found out the optimum percentage for replacement of marble powder with cement and it is almost 10% cement and addition PPF is 0.5% for both cubes and cylinders.
- We have put forth a simple step to minimize the costs for construction with usage of marble powder and

PPF which is freely or cheaply available; more importantly.

- We have also stepped into a realm of the environmental pollution by cement production; being our main objective as Civil Engineers.

10. FUTURE SCOPE

- Disposal problem of marble dust powder can be eliminated by effectively using it in concrete.
- Sustainable Development.
- The cost required to produce concrete by using marble dust powder and polypropylene fibres is comparatively less as compared to normal concrete.
- The marble dust powder used in concrete makes the concrete mix more dense by occupying the pores.

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