Volume 8 Issue 4 (2020) 319-323 ISSN 2347 - 3258
International Journal of Advance Research and Innovation

Comparative Studies on Strength of Concrete by Partial Replacement of Cement with Marble Dust and Coconut Fibre

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Article Info
Article history:
Received 29 July 2020
Received in revised form
20 October 2020
Accepted 28 October 2020
Available online 15 December 2020

Keywords: Concrete, marble dust, cement, fibre

Abstract: The cost of building project primarily on the quantity of concrete used during its construction. Cement being the only component manufactured in factories is costly and adds to the cost of a building project. Research work is going on throughout the globe for partial replacement of cement with suitable agriculture waste product such as rice husk ash , fly ash emanating from thermal power plants with the burning of coal, marble powder or coconut coir fiber without hampering the workability as well as strength of concrete. A large amount of coconut fibers is available in coastal region and marble powder exists in Rajasthan .The Feasibility studies on effect of using an admixture of coconut fibers and marble powder on strength of M30 concrete have been conducted . All the instructions, parameters, formulas have been followed according to the bureau of Indian standard. To conduct the test , aggregate consisting of coarse aggregate 20mm and fine sand, 10mm aggregate, marble dust powder, coconut fiber and fresh water have been used. Mix sample of M30 in different variations of ingredients as below have been examined. Four trail mix by varying the percentage of OPC 43 grade of cement, coconut fiber and marble dust powder were prepared and examine for their average compressive strength by the standardized method. It was concluded that M30 mix prepared by 94% of cement with 4% replacement by marble dust powder and adding 2% coconut fiber gives compressive strength of 38.300N/mm^2.

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 color and appearance it is white if the lime stone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marble are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia. Phosphate, leads, zinc, alkalis and sulfides. 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 replacement of Portland slag cement In India 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 now products or can be used as admixtures so that natural resources are used more efficiently and environment is protected from waste deposits. Concrete is the most commonly used construction material, which can be used in construction to have better strength, tougher flexural structure, better workability and durability. Concrete is one of the most extensively used construction materials in the world with two billion tons placed every year. It is attractive in many applications because it offers considerable strength at a relatively low cost. Concrete can generally be produced of locally available constituents and can be cast into a wide variety of structural configuration and requires minimum maintenance during service.

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Table 1 : Replacement of cement with Marble dust powder (Trial - 1)

Trial Mix	% of Cement	% Marble dust powder
Sample 1	100	0%
Sample 2	98	2%
Sample 3	96	4%
Sample 4	94	6%
Sample 5	92	8%
Sample 6	90	10%
Sample 7	88	12%

Table 2: Replacement of cement with Marble dust powder and coconut fiber (Trial – 2)

Trial Mix	% of Cement	% Marble dust powder	%Coconut fiber
Sample 1	100%	0%	0%
Sample 2	97%	2%	1%
Sample 3	94%	4%	2%
Sample 4	91%	6%	3%
Sample 5	88%	8%	4%
Sample 6	85%	10%	5%
Sample 7	82%	12%	6%

2. Materials and Methods

2.1 Marble dust Powder (MDP)

MDP is main wastage produced during cutting shaping and polishing in stone industry. Nearly 20-25% marble dust powder has been produced from marble manufacturing. India being the third (about 10%) top most exporter of marble in the world, every year million tons of marble waste form processing units (Plant) are released. Due to the availability of large quantity of waste produced in the marble factory, this project has been planned and preceded.

2.2 Coconut coir fibers

Coconut fibers also known as coir, comes from the inmost husk of coconut, according to the university of Florida extension, coconuts are the most extensively grown products in the world which contribute significantly to the economy of the many tropical areas.

The short , tough fibers can have varieties of uses from clothing, shelters etc, Unlike man - made fibers, coconut is renewable.There are two types of coconut fibers , brown fibers which is an extraction made from matured coconuts and white fibers which are extracted from immature coconut . Brown fibers are thick, high strength and have high scrapping resistance white fibers appears smooth and fine , but also weaker. Both the brown and white coir are consisting of fibers ranging in the length from 10 cm to 30 cm . Those fibers that approximately 20cm long are called bristle fibers .coconut producing countries especially in India, Tanzania, Burma, Thailand etc.

Fig.1: Marble Powder

Fig. 2: Coconut Coir Fibers

2.3 Concrete mix design

In the present study M30 grade with nominal mix as per Is 456 : 2000 was used. The concrete mix proportion (cement : fine aggregate : coarse aggregate) is design mix by volume and a water cement ratio of 0.45

3.Literature Review

Yalley, P.P. and Kwan, AlanS.K (2009) did an experimental study on concrete by adding coconut fiber in concrete. They found that torsion, toughness, and tensile strength of concrete increased by adding coconut fibred in the concrete. They investigated that the resistance to cracking and resistance to spalling also improve by adding coconut fiber in concrete. They investigated that torsional strength of concrete increased up to 25% and the energy absorbing capacity also enhanced up to 0.5% coconut fiber after that the torsional strength started decreasing. They investigated that similar result also find for the different aspect ratio. Corinaldesi V et al., (2010) Marble as a building material especially in palaces and monuments has been in use for ages. However the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete. The result is that the mass which is 40% of total marble quarried has reached as high as millions of tons. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world.

Saravana Raja Mohan et. al in 2012conduct an experimental study on concrete in which they add fly ash and coconut fibre in concrete. They replaced cement with fly ash 10, 15, 20, 25, and 30% and take coconut fibre as 0.15, 0.30, 0.45, and 0.60% having fibre length 40 mm. They took OPC 43 grade cement with fly ash. The study showed that compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity were increased. After that they add coconut fibre in concrete. They found that mechanical properties of fly ash based coconut fibre concrete were increased. The compressive strength was reduced and addition of coconut fibre did not give better result in case of compressive strength.

Vaidevi (2013) waste of marble can be used in manufacturing the concrete mixtures instead of cement used as a ingredient material in production and this was proposed by vaidevic. The study showed Price of construction can be rerduced when these cementitious materials replaced by different percentage of marble dust . compressive and tensile tests were performed. Only 10% replacement results are found to be good and one bag of cement and their cost can be saved by using marble dust. Sounthararajanet.al (2013) A Study has been conducted on Effect of the Lime Content in marble dust powder for Producing High Strength Concrete. They found that the marble dust powder up to 10% by weight of cement was investigated for hardened concrete properties. Furthermore, the effect of different percentage replacement of marble dust powder on the compressive strength, splitting tensile strength and flexural strength was evaluated. It can be noted that the influence of fine to coarse aggregate ratio and cement-to-total aggregate ratio had a higher influence on the improvement in strength properties' phenomenal increase in the compressive strength of 46.80 Mpa at 7 days for 10% replacement of marble dust powder in cement content was noted and also showed an improved mechanical property compared to controlled concrete study has been conduct by Manju pawar to identify the replacement of cement by waste marble. In this study they found the effect of using marble powder as ingredient material of fine in mortar or concrete by partially reducing quantities of cement has been studied in terms of the relative compressive, tensile as well as flexural strengths. Partial replacement of cement by varying percentage of marble powder reveals that increased waste marble powder (WMP) ratio result in increased strengths of the mortar and concrete Leaving the waste material to the environment directly can cause environmental problems can be caused by directly exposing environmental wastage into environment. The Compressive strength of Concrete are increased with addition of waste marble Powder up to12.5 % replace by weight of cement and further any addition of WMP the compressive strength decreases. The Tensile strength of Concrete are increased with addition of waste marble powder up to 12.5 % replace by weight of cement and further any addition of WMP the Tensile strength decreases Thus they found out the optimum percentage for replacement of MDP with cement and it is almost 12.5 % cement for both compressive & tensile strength.

Ruchi Chandrakar et.al (IRJET-2017), find the requirement for locally manufactured building material has been emphasized in many countries. Environmental problems can be issued due to dumping of waste materials. Waste can be used for production of new products as an admixture so that natural resources are used more efficiently and the environment is protected from waste deposits. The industrial marble stone generate both solid waste and stone slurry. Stone slurry generated from industries up to 15-20% of total final products during processing. There are several reuse and recycling solution for industrial waste. The industrial wastes

are dumped to the ground for improving their fertility property of soil. In this study total 42 cubes were casted. Marble products are mixed in concrete mix M-20 in different percentage (5%, 10%, 15%, 20%, 25%, and 30%) by weight. The cement was replaced by marble powder. After curing (7 and 28 days), cubes were tested. The replacement of cement with 10% of marble powder gives the maximum compressive strength at both 7 days and 28 days curing period. It was found that marble dust available at every processing plant in huge quantity and its cost is very less compared to cement. So with the replacement of cement by marble dust a cost effective concrete can be achieved.

A study in 2018, has been conduct by Piyush Singh Tekaley to identify the replacement of cement by waste marble and addition to used admixture of coconut fiber with different variation of percentage . In this experimental study they found the effect of using marble powder as ingredient material of fine in mortar or concrete by partially reducing quantities of cement has been studied in terms of the relative compressive strengths and workability of concrete . The marble powder is changed with the cement as 5,10,15%and coconut fibers are delivered moreover by weight of cement inside the proportion of 1, 2, 3%. The diameter of coconut fiber is varies among 0.25 to 1cm and period is taken is taken 4cm . The characteristic strength of concrete and target strength of M30 (38.25 N/mm^2)and have low degree of workability .These types of concrete are used for highway engineering. The mass of coir fiber increases, they decrease the strength of concrete because they effect on concrete properties.

4. Objective

Design of the comparative studies on strength of concrete by partial replacement of cement with an admixture of marble dust and coconut fiber. The design M30 grade of concrete according to Indian standard codes IS 456- 2002, 10262- 2009 , 8112- 1989, 516-1959 , 383-1970 , 3025. The material easily available in local market. By using 43grade ordinary Portland cements. The following test was conducted on the respective specimens – material test, compressive strength on cubes. Preliminary test, the test conducting in the lab on trial mix of concrete to verify its strength is termed preliminary test. The test helps in performance of concrete in different proportion to design mix. I will determine the strength of concrete cubes for 7days, 14days, 28days and conduct number of compressive test for strength. I will also conclude the workability of trial mix design by slump test.

4.1 Methodology

I will design the concrete mix fck M30 according to Indian standard codes 456-2000, 10262-2009, 8112- 1989, 516-1959, 383-1970 , 2386 , 9103 -1999 , 3025. A compressive strength test will be taken by the ratio of 2%, 4%, 6%, 8%, 10%, 12% and 1%, 2%, 3%, 4%, 5%, 6% by the weight of cement of concrete marble powder and coconut fiber in the concrete mix. I will determine the effect of coconut fiber and marble powder on compressive strength of concrete with varying percentage of constituents to achieve the required compressive strength and flexural strength. Coconut fibers and marble powder were obtained from the local market. In the method the water cement ratio is selected for the target strength from empirical relation's and the water content is chosen for the required workability for the aggregate in a saturated surface dry condition. In the Indian method and IS guideline, the vol. of dry rodded coarse aggregate in the concrete mix is determine 1st depending on the maximum size of aggregates and the particle distribution of fine aggregates. The following tests were conducted on the respective specimens- material test, compressive strength on cubes. Preliminary tests.The tests conducting in the lab on trial mix of concrete to verify its strength is termed preliminary tests. The test helps in determine the adjustment require in mix design to obtain stipulated performance of concrete. We determine the strength of concrete cubes for 7 days, 14 days, 28 days and conduct numbers of compressive test for strength. We also conclude the workability of trial mix design by slump test. The minimum compressive strength required from structural considerations which in turn is governed by w/c ratio is the basic requirement. The suggest compressive strength required at a unique age , commonly 28 days, determines the nominal water- cement ration of mix.Thus the goal of the mix layout ought to continually be to get concrete combinations of gold standard electricity at minimum cement content and acceptable workability. The degree of workability required depends on three elements. These are the size of the phase to be concrete. The favored workability relies upon at the compacting gadget to be had. Slump is a measure indicating the consistency or workability of clean cement concrete. This test can also be used to decide the water content material to give targeted droop fee.

Fig. 3: Slump Test

Fig.4: Cube Casting

4.2.Materials (ingredients of concrete)

Ordinary Portland cement 43 grade – conforming IS 8112, (2) Coarse aggregate 20mm from Amritsar Conforming IS 383-1970, (3) Fine aggregate 10mm from Amritsar conforming IS 383-1970, (4) Sand conforming IS 383-1970,(5) Fresh Water IS 3025, (6) Marble dust passed from 90 micron sieves.

5. Results and Discussion

5.1 Replacement of cement with marble dust powder

Table 3: Results of compressive Strength after 7, 14, 28 days

Design M30	% of OPC 43 Grade	% of Marble dust powder	Average comp. Strength of Cubes for 7days (N/mm^2)	Average comp. Strength of Cubes for 14days (N/mm^2)	Average comp. Strength of Cubes for 28days (N/mm^2)

Trial Mix 1	100%	0%	24.46	34.04	38.261
Trial Mix 2	98 %	2%	24.56	34.4	38.373
Trial Mix 3	96 %	4%	25.1	35.01	38.65
Trial Mix 4	94 %	6%	25.74	34.75	37.11
Trial Mix 5	92 %	8%	24.16	34.26	36.775
Trial Mix 6	90 %	10%	22.56	32.18	34.155
Trial Mix 7	88 %	12%	21.1	27.01	31.115

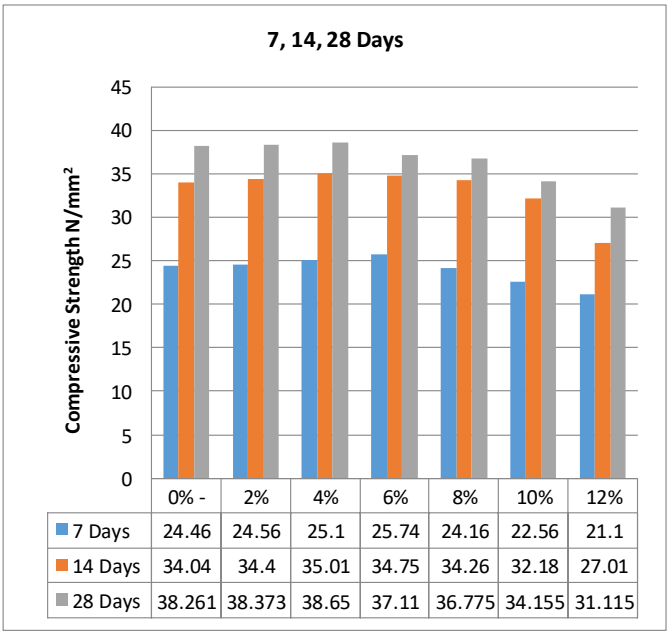

Fig.5: Replacement percentage of Marble dust powder, After 7, 14, 28 days compressive strength

5.2 Replacement of cement with marble dust powder and Coconut fiber

Table 4: Results of compressive Strength after 7, 14, 28 days

Design M30	% of OPC 43 Grade	% of Marble dust powder	% of Coconut Fiber	Average comp. Strength of Cubes for 7days (N/mm^2)	Average comp. Strength of Cubes for 14days (N/mm^2)	Average comp. Strength of Cubes for 28days (N/mm^2)
Trial Mix 1	100%	0%	0%	24.46	34.04	38.261
Trial Mix 2	97%	2%	1%	24.10	33.30	38.115
Trial Mix 3	94%	4%	2%	24.75	34.10	38.300
Trial Mix 4	91%	6%	3%	23.54	33.70	36.340
Trial Mix 5	88%	8%	4%	21.75	31.36	35.750
Trial Mix 6	85%	10%	5%	20.65	30.28	32.115
Trial Mix 7	82%	12%	6%	18.50	25.20	30.135

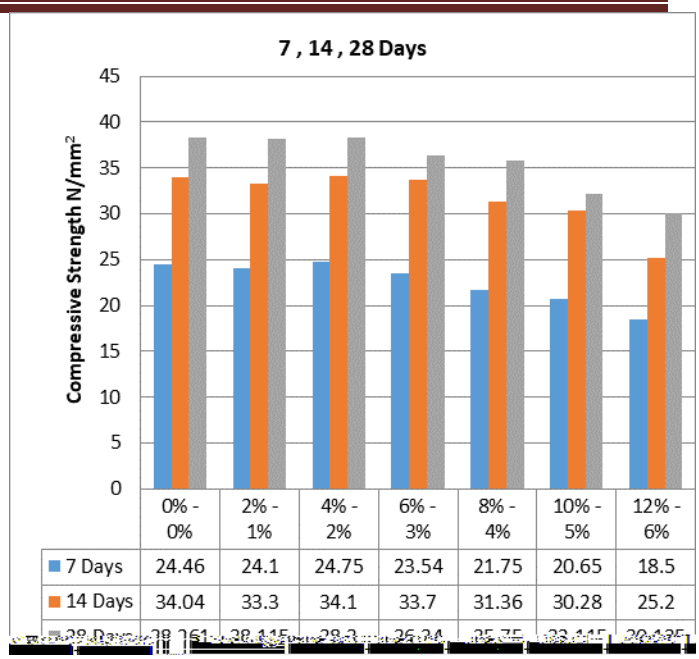

Fig.6: Replacement percentage of cement with marble dust powder and Coconut fiber, After 7, 14, 28 days compressive strength

5.3 Replacement percentage of MDP and Coconut Fiber

Table 5: Shows the workability of the concrete by the Slump test

S. No.	Slump value	Trial Mix 1 0% - 0%	Trial Mix 2 4% - 1%	Trial Mix 3 8% - 2%	Trial Mix 4 12% -3%
1	Slump value 1 (Batch1) mm	60	55	50	48
2	Slump value 2 (Batch2) mm	64	57	52	47
3	Slump value 3 (Batch3) mm	63	52	45	40

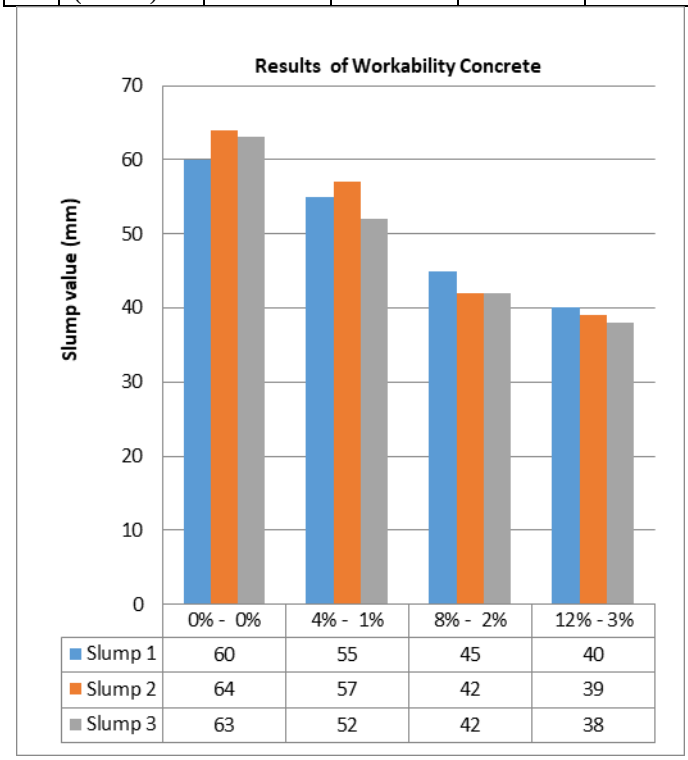

Fig. 7: Shows the slump value of Trial mix different percentage

6.Conclusions

In the study presented above the main aim is replacement of some part of cement in a concrete mix by cheep waste material such as marble dust powder and coconut coir fiber so as to reduced the overall cost of the project. M30 cement concrete has been chosen as the base for the study.Studies have been conducted by preparing three trail mixes by replacing cement 2%, 4%, 6%, 8%, 10%, 12% of the mix by marble dust powder and and 1%, 2%, 3%, 4%, 5%, 6% coconut coir fiber. Workability (slump) test and compressive strength tests were conducted. It has been conclude that;

1) With the addition of coconut coir fiber workability of mix get reduced .
2) Compressive strength of trial mix- 2 replacement of cement by 4% marble dust powder and 2% coconut fiber has been obtained as 38.3 N/mm^2 of the mix M30. Thus the cost of cement concrete per cubic meter shall be reduced considerably.

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