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Experimental Study on Concrete Using Waste Marble Powder and Quarry Dust as Partial Replacement of Cement and Fine Aggregate

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Abstract: **Concrete is the most important component used in the construction industry throughout the world, where the fine aggregate is generally natural sand. The demand for natural sand in the construction industry has consecutively increased which has resulted in the reduction of sources and an increase in price. In such a situation the quarry dust can be an economical alternative to the river sand. As the demand for more and more infrastructures is increasing day by day, the quantity of cement requirements is also increasing. Concrete with the use of waste marble powder as an alternate for cement Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today. The present study is aimed at utilizing Waste marble powder and quarry dust as partial replacement of cement and fine aggregate in concrete and comparing it with conventional concrete. The quarry dust in place of sand is replaced with 25% and waste marble powder in place of cement is replaced partially with various percentages (2.5%, 5%, 7.5%, 10%, 12.5%, and 15%). This paper presents the results of study undertaken to investigate the feasibility of using quarry dust and waste marble powder in concrete. It is found that the studies of concrete made of quarry rock dust and waste marble powder increases at 12.5%. Therefore the quarry dust and waste marble powder should be used in construction works, then the cost of construction would be saved significantly and the natural resources would be used efficiently.**

Keywords: **Marble powder, Quarry dust, Compressive strength, Split tensile strength, Flexural strength.**

1. INTRODUCTION

Innovations are much needed to meet the increasing demand for new and quality materials. Concrete is a widely used construction material consisting of cementing material, fine aggregate, coarse aggregate and required quantity of water, where the fine aggregate is usually natural sand. Cement based material are the most abundant materials in the world. Due to the high in demand of natural resources our engineers & architect has growing interest in sustainable development by choosing the material which is more sustainable that is why the green building concept is emerging in our country. It is very eco-friendly & save the environment by using waste products generated by industries. In India the marble & quarry are the most thriving industries. Presently large amounts of marble dust are generated in natural stone processing plants with an important impact on environment and humans. Marble is one of the most important materials used in buildings since ancient times, especially for decorative purposes. A large quantity of powder 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

The global consumption of natural sand is too high due to its extensive use in concrete. Due to rapid growth in construction industry, the available sources of natural sand are getting exhausted, causing depletion of natural resources resulting increase in scour depth and sometimes flood possibility. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Quarry dust is one such material which can be used to replace sand as fine aggregate.

This project describes the feasibility of using the marble sludge powder in concrete production as partial replacement of cement and quarry dust as partial replacement of fine aggregate.

SCOPE:

- To study the influence of waste marble powder on the mechanical properties of concrete.
- To compare the compressive, flexural and split tensile strength using WMD with the conventional mix.

OBJECTIVE:

The main objective of the project is to study the effects of marble powder and quarry rock dust on properties of fresh and hardened concrete when cement is partially replaced by waste marble powder at 2.5%,5%,7.5%,10%,12.5% and 15% and fine aggregate replaced by quarry dust at 25%.

- And also compare it with the compressive, split tensile and flexural strength of ordinary M_{20} concrete.
- I am also trying to find the percentage of marble powder replaced in concrete that makes the strength of the concrete maximum.

2. METHODOLOGY

This chapter deals with the project work flow methodology of our project.

STEPS INVOLVED IN THE PRESENT WORK:

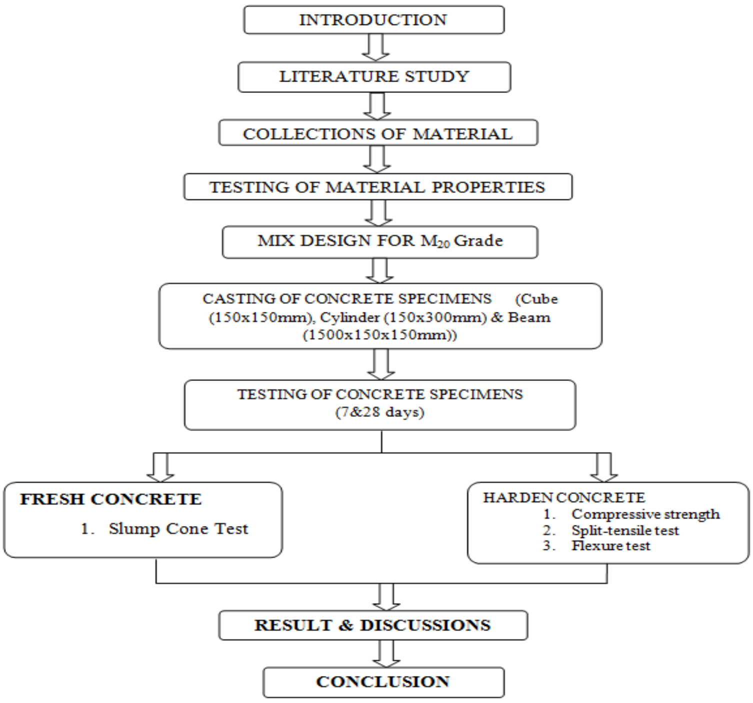

Fig.1: Work Methodology

MATERIALS USED:

CEMENT (OPC):

Cement is a finely ground, usually grey coloured mineral powder. When mix with water, cement acts as a glue to bind together the sand, gravel and crushed stone to form concrete, the most widely used construction material in the world. It was made by grinding of limestone and clay to a fine powder, which can be mixed with water and poured to set as a solid mass or used as an ingredient in making mortar or concrete.

Anhydrous cement compounds when mixed with water, reacts with each other to form hydrated compounds of very low stability. The reaction of cement with water is exothermic and liberates a considerable quality of heat, called heat of hydration. Among the compounds of cement C_3A and C_4AF have high rates of hydration. C_3S has medium rate of hydration while C_3S has the lowest rate of hydration. The reaction of pure C_3A with water is very fast and this may lead to flash setting of cement. To prevent these, gypsum is added as retarded at the time of grinding cement clinker. Therefore the early heat of hydration is mainly contributed from the hydration C_3S. The total quantity of heat generated in complete hydration will depend upon the relative quantities of major compounds presents in the cement.

During the course of reaction of C_3S with water, calcium silicate hydrate (C-S-H) and calcium hydroxide ($Ca(OH_2)$) are formed, C-S-H gel is the significant hydration product which binds the aggregate together, Ca (OH_2) is an unimportant product. For the present investigation, OPC 53grade confirming to BIS : 12269-1987 was used. The cement sample was tested as per procedure given in BIS : 4031-1988 and BIS : 4032-1985. Ordinary Portland Cement 53grade cement confirming to IS: 8112-1939 was used.

FINE AGGREGATE:

The fine aggregate (sand) used was clean dry sand. The sand was sieved to remove all pebbles.

COARSE AGGREGATE:

Hard granite broken stones of 20 mm size were used as coarse aggregate.

MARBLE POWDER:

Marble powder was collected from the dressing and processing unit. It was initially in wet form (i.e. slurry); after that it is dried by exposing in the sun and finally sieved by IS-90 micron sieve before mixing in concrete.

Fig.2: Marble Powder

QUARRY DUST:

Quarry dust as a by-product from crushing process during quarrying activities is one of those materials that have recently gained attention to be used as concreting aggregates, especially as fine aggregate. In concrete production it could be used as a partial or full replacement of natural sand. Besides, the utilization of quarry waste, which itself is a waste material, will reduce the cost of concrete production.

WATER:

Potable tap water available in laboratory with pH value of 7.0 and conforming to the requirement of IS: 456-2000 was used for mixing concrete and curing the specimen as well.

PROPERTIES OF MATERIAL:

CEMENT:

Table.1: Properties of Cement

SI.NO	Characteristics experimental value	Experimental value	As per IS :8112-1939
1	Consistency of cement	33%	-
2	Specific gravity	3.08	3.15
3	Initial setting time	32 min	30 min
4	Final setting time	8 hrs 20 min	Max 10 hrs

PROPERTIES OF MARBLE POWDER:

PHYSICAL PROPERTIES OF MARBEL POWDER:

Table.2: Physical Properties Of Marble Powder

Color	White
Form	Powder
Odor	Odorless
Specific gravity	2.68 gm/cm3

CHEMICAL PROPERTIES OF MARBEL POWDER:

Table.3: Chemical Properties Of Marble Powder

S.No	Materials	Marble Powder (%)
1	Loss of Ignition (LOI)	40.63
2	CaO	32.23
3	Fe_2O_3	1.09
4	Al_2O_3	1.09
5	SiO_2	4.99
6	MgO	18.94
7	SO_3	0.02
8	K_2O	0.91
9	Na_2O	0.63

Source: Chavhan and Bhole (2014)

3. TESTING DETAILS

COMPRESSIVE STRENGTH:

The compressive strength of the concrete was determined by applying axial compression on the cubes of size 150mm x 150mm x 150mm were casted. Three test specimens shall be made from each sample and tested after 7 and 28 days curing. The load is applied to the specimen uniformly. The failure load shows the ultimate compressive load.

The compression strength of the specimen is,

Compressive Strength= $\frac{\text{Ultimate Load(N)}}{\text{Surface Area(mm2)}}$

SPLIT TENSILE STRENGTH:

The split-tensile strength of the concrete was determined by placing cylinder of size 150mm x 300mm horizontally in the compression testing machine. The load is applied gradually till the failure of the specimens and it is recorded. The tensile strength is calculated from the following formula.

The split tensile strength of the specimen is,

The split-tensile strength = $\frac{2P}{\pi DL}$N/mm^2

Where P-Ultimate load

D-Diameter of Cylinder

L-Length of Cylinder

FLEXURAL STRENGTH TEST:

Simply supported RCC beams were subjected to pure flexural failure by subjecting them to two point loading test. The beams used in this study were 150mm x 150mm in cross section and 1500mm in length. Two 10 mm diameter bars were used for flexural reinforcement at bottom and two 8 mm rods were provided for top reinforcement. For each beam, 6 mm diameter mild steel bars are used as stirrups, spaced 200 mm c/c for shear reinforcement. Typical beam reinforcement details are illustrated in Figure 5.1.. All beams were cast by using M20 grade concrete with 20 mm size of CA, locally available sand and OPC 43 grade cement.

EXPERIMENTAL SET UP OF RCC BEAM:

All beams (150mm x 150mm in cross section and 1500mm in length) were tested as simply supported beams under two point loading over an effective span of 1300mm. The loads were applied at a distance of 433mm on either side of the mid span of the beams of 1500mm length, as shown in Figure 5.2. These beams were tested in a loading frame of 500 kN capacity. The loads were monitored through a high accuracy proving ring. For this case, mid span deflection was measured using dial gauges of least count 0.01mm. The parameters such as initial cracking load, ultimate load and the deflected shape of the specimens were noted.

The failure load is noted based on the following formula flexural strength is calculated.

The flexure strength of the specimen is,

Flexure strength = $\frac{PL}{bd2}$N/mm^2 (a is greater than 433.33mm)

Flexure strength = $\frac{3Pa}{bd2}$N/mm^2 (a is less than 433.33mm)

Fig.3: Loading Frame (Flexural Strength)

4. RESULT AND DISCUSSIONS

TEST RESULT FOR FRESH CONCRETE:

Table.4: Slump Values

w/c	Replacement of waste Marble powder material in %	Slump Value in mm
0.5	0%	110
	2.5 %	100
	5%	90
	7.5%	90
	10%	95
	12.5%	100
	15%	120s

TEST RESULT FOR HARDENED CONCRETE:

COMPRESSIVE STRENGTH TEST RESULTS:

The test results are given in tables thus there is a reduction in strength with the increase in replacement value.

Table.5: Compressive Strength Results For 7&28 Days

Replacement of Marble Powder %	COMPRESSIVE STRENGTH	
	7 DAYS	28 DAYS
0%	15.55	21.93
2.5%	15.85	22.22
5%	17.00	23.40
7.5%	17.18	24.44
10%	18.36	26.66
12.5%	16.44	23.70
15%	14.80	19.55

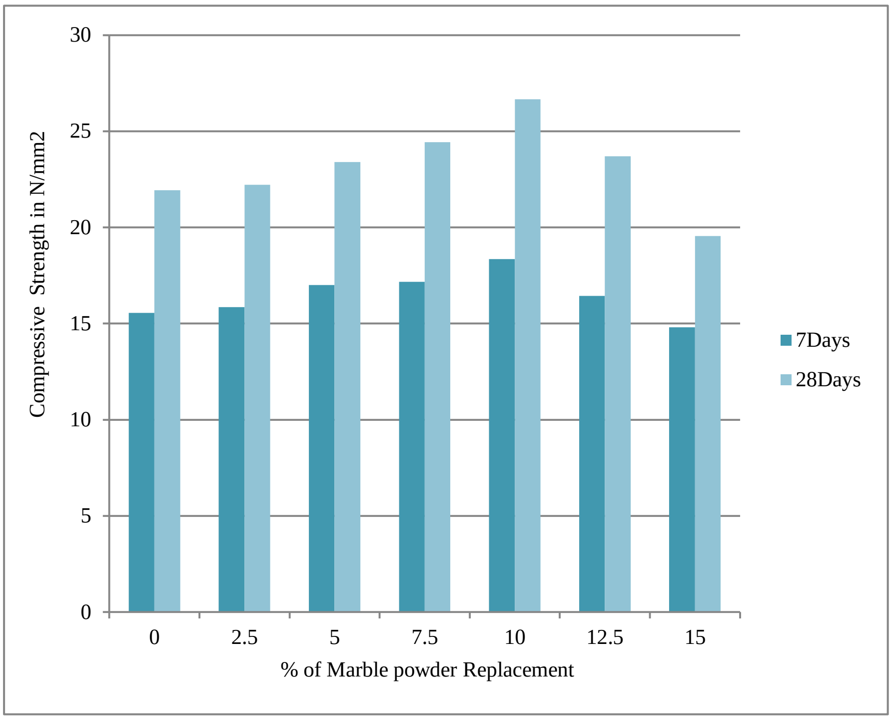

Fig.4: Compressive Strength For 7&28 Days

SPLIT-TENSILE STRENGTH RESULTS:

Table.6: Split-Tensile Strength Results

Replacement of Marble Powder %	Split Tensile Strength	
	7 DAYS	28 DAYS
0%	2.12	2.88
2.5%	2.17	2.97
5%	2.07	3.02
7.5%	2.30	3.11
10%	2.40	3.34
12.5%	2.12	3.06
15%	2.07	2.68

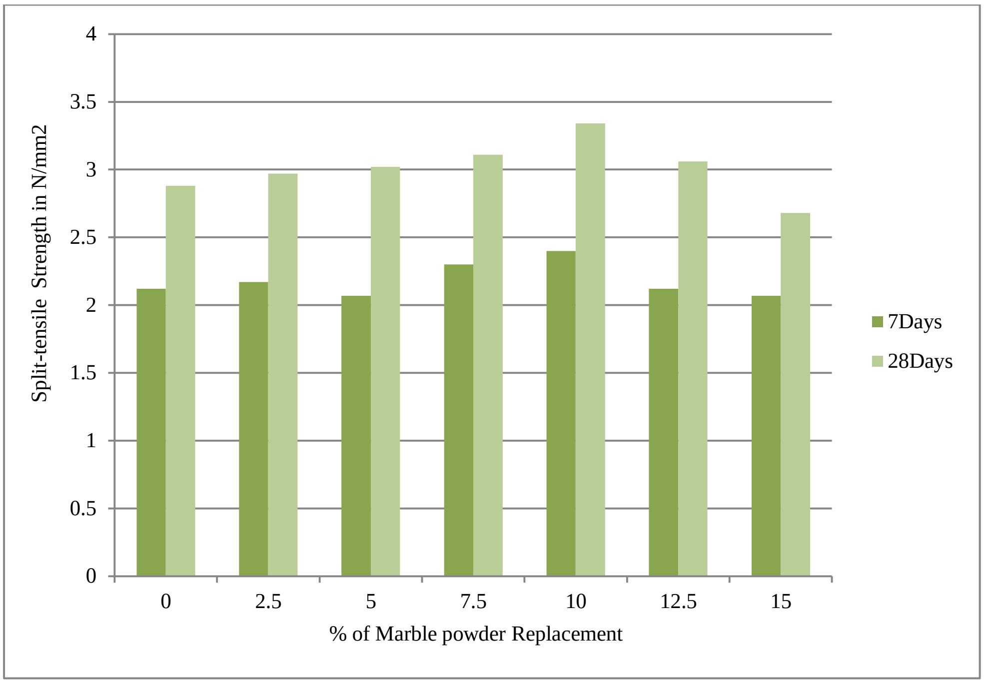

Fig.5: Split-Tensile Results for 7&28days

FLEXURE STRENGTH RESULTS:

Table.7: Flexure Strength Results for 28 Days

Replacement of Marble powder %	28 Days Result		
	Maximum Load(kN)	Maximum Deflection(mm)	Flexural Strength(N/mm^2)
0%	18.5	5.20	5.92
5%	19.74	4.80	6.84
10%	20.93	4.90	7.44
15%	16.74	5.00	5.65

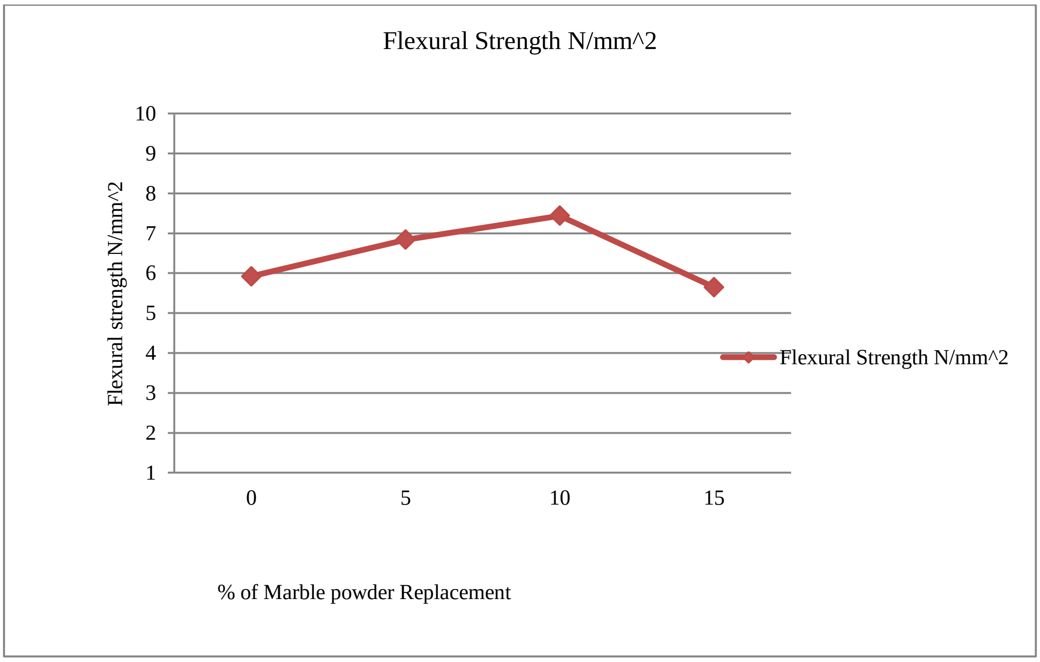

Fig.6: Flexural Strength Results for 28days

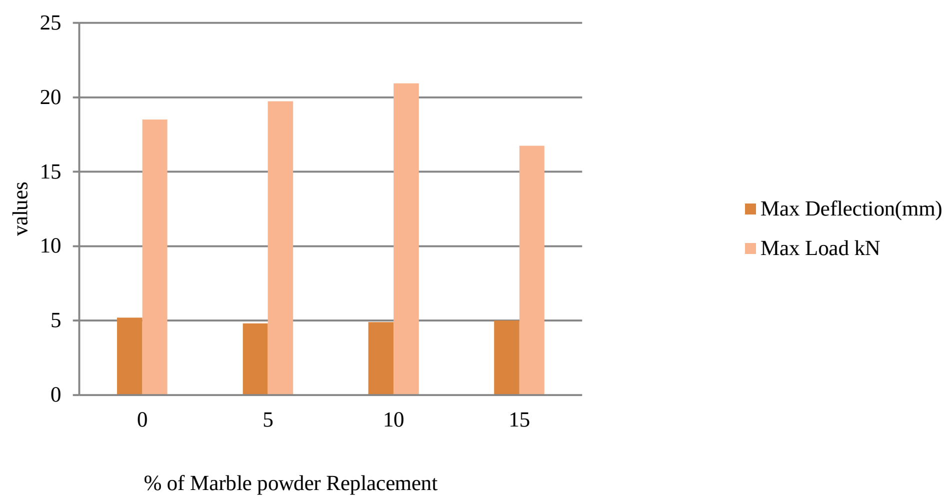

Fig.7: Max Load & Deflection of Beams

5. CONCLUSION

In this experimental investigation, a comparative study on conventional concrete with green concrete quarry dust as fine aggregate replacement of 25% and replacement of marble powder 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by cement have been studied and the results were presented and analyzed in the previous chapter

- Natural river sand, if replaced by twenty five percent Quarry Rock Dust from quarries, better result than the concrete made with Natural Sand, in terms of compressive and flexural strength studies.
- Waste marble powder is a byproduct that can be used in concrete to obtain durability, cost, and environmental benefits.
- The concurrent use of the above two by products, gives an excellent results in strength aspect and quality aspect.
- The compressive strength of concrete is increased with addition of quarry dust and waste marble powder up to 12.5%.
- Also the split-tensile strength of concrete is increased with addition of quarry dust and waste marble powder up to 12.5%.
- Increase the marble powder content by more than 12.5% improves the workability but affects the compressive and split tensile strength of concrete.
- The flexural strength of beams is gradually increased up to 10% with addition of waste marble powder and quarry dust and further any addition of the concurrent products the strength decreases.
- Thus, it concluded that the replacement of natural sand with quarry rock dust, as partial replacement in concrete and also partial replacement of cement with waste marble powder is possible and economical when compared with conventional concrete.

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