Experimental study on partial replacement of cement by Marble Powder & fine aggregate by Quarry Sand

P.P.Shanbhag[1], V.G.Patwari[2]
Department of Civil Engineering
[1]P.G. Student, M.S. Bidve Engineering College, Latur, Maharashtra, India
[2]Assistant Professor,M.S. Bidve Engineering College, Latur, Maharashtra, India

Abstract-*The present study is aimed at utilizing Waste marble powder and quarry sand as partial replacement of cement and fine aggregate in concrete and comparing it with conventional concrete. This experimental investigation is carried out in three phases in 1st phase M20 grade of concrete is produced by replacing cement with 0%, 5%, 10% & 15% of Marble Powder. In 2nd phase concrete is produced by replacing sand with 0%, 30%, 40% & 50% of quarry sand and in 3rd phase concrete is produced by replacing cement and fine aggregate in the percentage of 0%, 5%, 10% & 15% of Marble Powder and 0% , 30%, 40% & 50% of quarry dust respectively. It is found that the studies of concrete made of waste marble powder and quarry sand increases at 10% and 40% respectively. 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 Sand, Compressive Strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

Composite material like concrete which is made up of coarse material mixed in cement which fills between the gaps of aggregate materials & joined them together and create a perfect bond. Cement and concrete production consumes enormous amounts of natural resources and aggregates, thereby causing substantial energy and environmental losses. This production also contributes significantly to the emission of carbon dioxide, a naturally occurring greenhouse gas.

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. The other mineral constituents vary from origin to origin. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO2, limonite, Fe2O3, manganese, 3H2O and FeS2 (pyrite) are the major chemical impurities associated with marble.

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. Quarry dust is one such material which can be used to replace sand as fine aggregate. Quarry sand is a kind of waste material that is generated from the stone crushing industry which is abundantly available to the extent of 200 million tonnes per annum which has landfill disposal problems and health and environmental hazards.

II. MATERIAL PROPERTIES

A. Material Used

1) Cement:

Portland pozzolona cement of ultra tech brand was used and it was conforming to IS 1489-1991. Tests were conducted to find the properties of cement and the results are tabulated in Table 1

Table No.-1 Physical Properties of Cement

Sr. No.	Physical Properties of OPC 53 Grade Cement	Value
1	Specific Gravity	3.15
2	Grade of cement	PPC(53)
3	Fineness Test	340kg/m2
4	Soundness Test	1.00mm
5	Initial Setting Time	112min.
6	Final Setting Time	320 min.

2) Corse Aggregate:

Coarse aggregate was crushed stone which was available locally. Maximum size chosen was 10mm down. Tests are conducted to find the properties of coarse aggregate and the results are tabulated in Table 2

Table No.- 2 Physical Properties of Coarse Aggregate

Sr. No.	Properties	Values
1	Specific Gravity	2.68
2	Size Of Aggregates	10mm down
3	Fineness Modulus	5.96
4	Water absorption	2.0%
5	Impact Test	15.2%
6	Crushing Test	22.5%

3) Fine Aggregate:

Locally available river sand was used as fine aggregate. Tests are conducted to find the properties of fine aggregate and test results are tabulated in table 3

Table No.-3 Physical Properties of Fine Aggregate

Sr.No	Tests	Values
1	Specific gravity	2.63
2	Water absorption	1.5%
3	Sieve Analysis	Zone II

4) Marble Powder:

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 limestone is composed solely of calcite (100% CaCO3). Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. 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. Leaving these waste materials to the environment directly can cause environmental problem.

Table4.1.-Chemical Composition of Marble Powder

Composition of MP	Component mass %
SiO2	13.8
Ca0	43.2
MgO	2.7
Al2O3	2.5
Fe2O3	1.9
SO3	0.07
K2O	0.6
Cl	0.03
Na2O	0.9
LOSS OF IGNITION	43.48

5) Quarry Sand:

Quarry sand is a kind of waste material that is generated from the stone crushing industry which is abundantly available to the extent of 200 million tonnes per annum which has landfill disposal problems and health and environmental hazards. Quarry sand which is a residue tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm.The Quarry sand can be an economic alternative to the river sand since river sand is expensive due to excessive cost of transportation from natural sources and also large scale depletion of these sources creates environmental problems. Crushed sand less than 4.75 mm is produced from hard granite rock using state of crushing plants. Production of quarry fines is a consequence of extraction and processing in a quarry and collected from the near-by quarry. The amount produced depends on the rock type, amount of fragmentation by blasting and type of crushing used. The product is washed to remove excess fines to get sand of excellent shape, gradation free from silt, clay and unwanted contamination. Specific gravity tests were conducted and found as 2.93.

Table no.5.Chemical composition of Quarry sand

Composition of Quarry dust	Component mass %
SiO_2	62.48
CaO	04.83
MgO	02.56
Al_20_3	18.72
Fe_2O_3	06.54
K_2O	03.18
Na_2O	Nil
Loss of Ignition	00.48

6) Water:

The water available in laboratory which satisfies the potable water standards was used casting of concrete specimen and its subsequent curing.

III. METHODOLOGY

The aim of the experiment was to assess the properties of concrete made with Marble powder and Quarry sand and to study the various important aspects such as compressive strength, flexural strength and split tensile strength of concrete prepared by using Marble powder and quarry sand and with different percentage of replacements with cement and Fine aggregate respectively. The studies were carried out for mix design of Grade of concrete-M25 and Design-IS 456:2000 & IS 10262:2009.

Table 3.1: Specimens used

Type of test	Type of Specimen	Dimensions(mm)
Compression test	Cube	150x150x150
Split tensile test	Cylinder	150 diax300 height
Flexural strength test	Beam	750x150x150

According to IS 456:2000 & IS 10262:2009. Mix proportion of M25 Grade becomes

Table 3.2: Mix proportion

Water (Litres)	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)
200	435	664.82	1016
0.46	**1**	**1.529**	**2.337**

IV. TEST RESULTS AND DISCUSSIONS

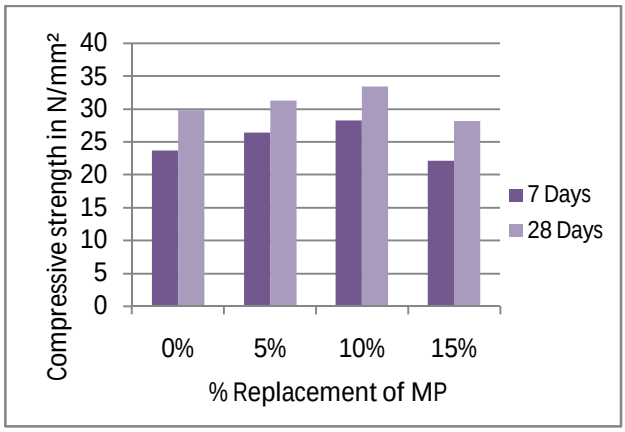
4.1. EXPERIMENT NO.1:Test results for MP Concrete

In this study MP has been partially replaced in the ratio of 0%, 5% 10% and 15%, by weight of cement in concrete. The strength results obtained from the experimental investigations are showed in tables. The results are discussed as follows.

Result tables:

Table 5.1: Compressive strength results for MP Concrete (N/mm²)

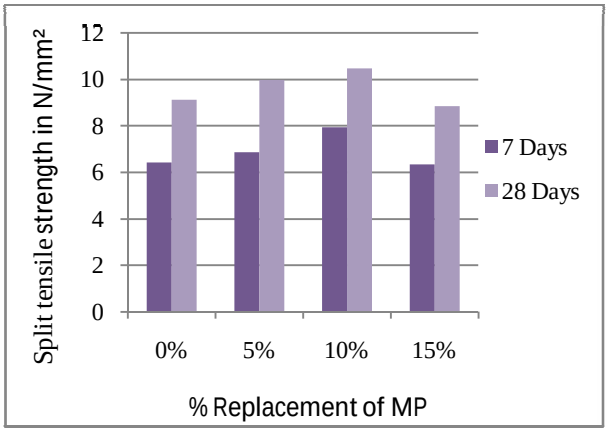
Replacement of cement with MP	7 Days	28 Days	% of increase in compressive strength in 28 days
0%	23.69	29.89	-
5%	26.44	31.28	4.65
10%	28.32	33.43	11.84
15%	22.10	28.20	-5.65



Graph1: % replacement of MP vs Compressive strength (N/mm²)

Table 5.2: Split tensile strength results for MP Concrete (N/mm²)

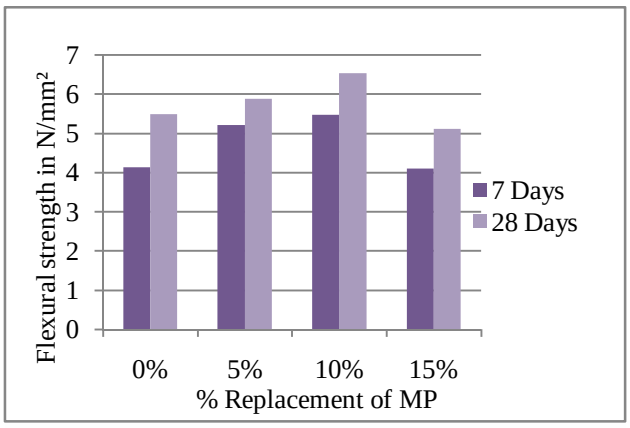
Replacement of cement with MP	7 Days	28 Days	% of increase in Split tensile strength in 28 days
0%	6.41	9.12	-
5%	6.86	9.96	9.21
10%	7.93	10.45	14.58
15%	6.34	8.83	-3.18



Graph 2: % replacement of MP vs Split tensile strength(N/mm²)

Table 5.3: Flexural strength results for MP Concrete (N/mm²)

Replacement of cement with MP	7 Days	28 Days	% of increase in Flexural strength in 28 days
0%	4.13	5.49	-
5%	5.20	5.88	7.10
10%	5.47	6.53	18.94
15%	4.10	5.11	-6.92



Graph 3: % replacement of MP vs Flexural strength(N/mm²)

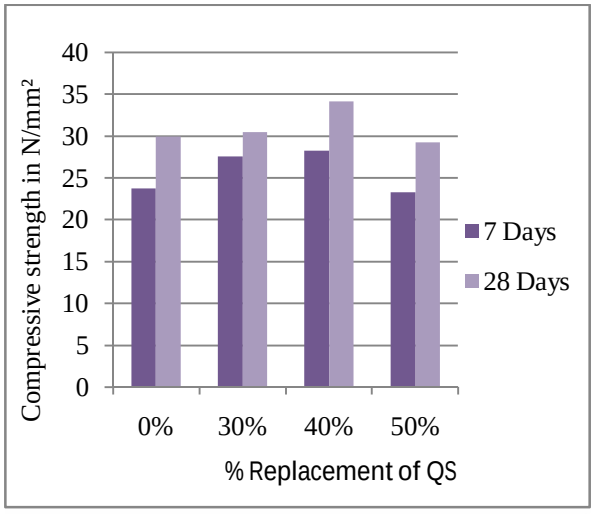
4.2 EXPERIMENT No.2:Test results for QS Concrete

In this study quarry sand has been partially replaced in the ratio of 0%, 30%,40%, And 50%, by weight of Fine aggregate in concrete. The strength results obtained from the experimental investigations are showed in tables..

Result tables:

Table 5.4: Compressive strength results for QS Concrete (N/mm²)

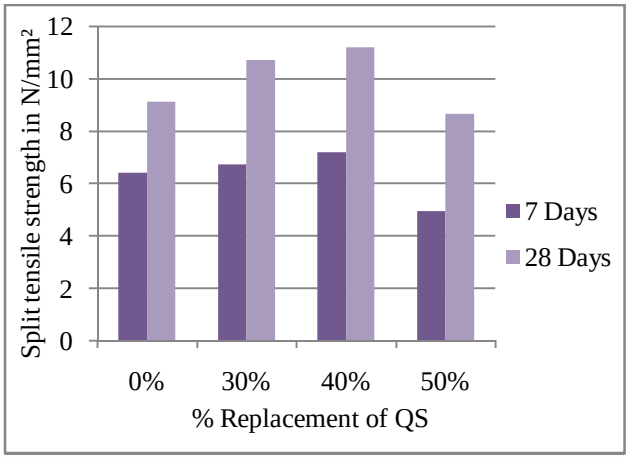
Replacement of Fine aggregate with QS	7 Days	28 Days	% of increase in Compressive strength in 28 days
0%	23.69	29.89	-
30%	27.55	30.44	1.84
40%	28.26	34.10	14.08
50%	23.25	29.23	-2.21



Graph 4: % replacement of QS vs Compressive strength(N/mm²)

Table 5.5: Split tensile strength results for QS Concrete (N/mm²)

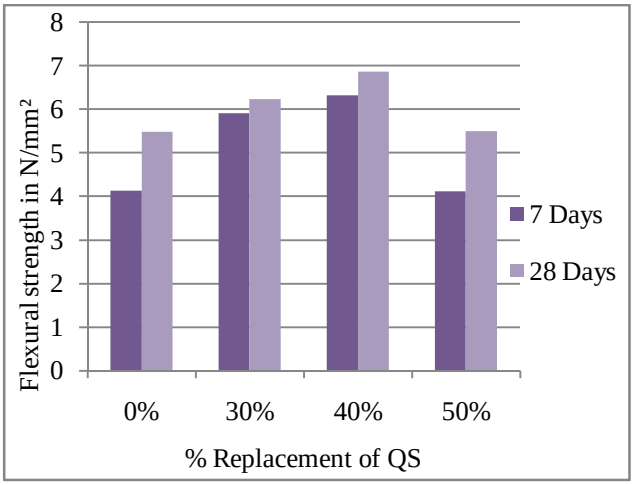
Replacement of Fine aggregate with QS	7 Days	28 Days	% of increase in Split tensile strength in 28 days
0%	6.41	9.12	-
30%	6.73	10.71	17.43
40%	7.20	11.20	22.8
50%	4.95	8.67	-4.93



Graph 5: % replacement of QS vs Split tensile strength(N/mm²)

Table 5.6: Flexural strength results for QS Concrete (N/mm²)

Replacement of Fine aggregate with QS	7 Days	28 Days	% of increase in Flexural strength in 28 days
0%	4.13	5.49	-
30%	5.91	6.24	13.66
40%	6.32	6.87	25.13
50%	4.12	5.50	-0.18



Graph 6: % replacement of QS vs Flexural strength (N/mm²)

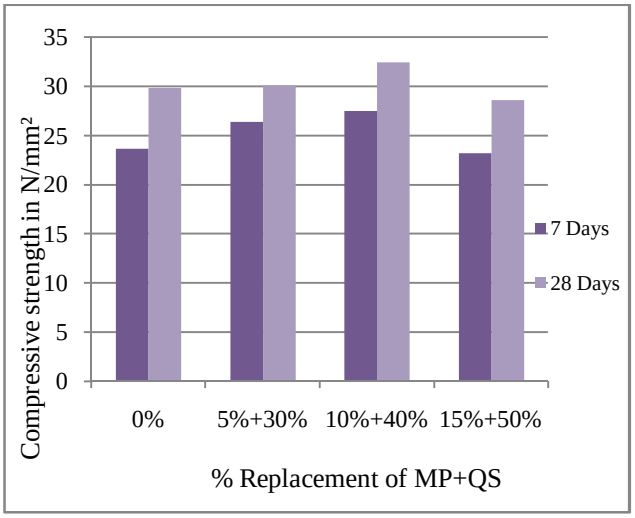
4.2 EXPERIMENT No.3: Test results for MP+QS Concrete

In this study MP has been partially replaced in the ratio of 0%, 5%, 10%, And 15% and quarry dust replaced in the ratio of 0%, 30%,40%, And 50% by weight of Cement and Fine aggregate in concrete respectively. The strength results obtained from the experimental investigations are showed in tables.

Result tables:

Table 5.7:Compressive strength results for MP+ QS Concrete (N/mm²)

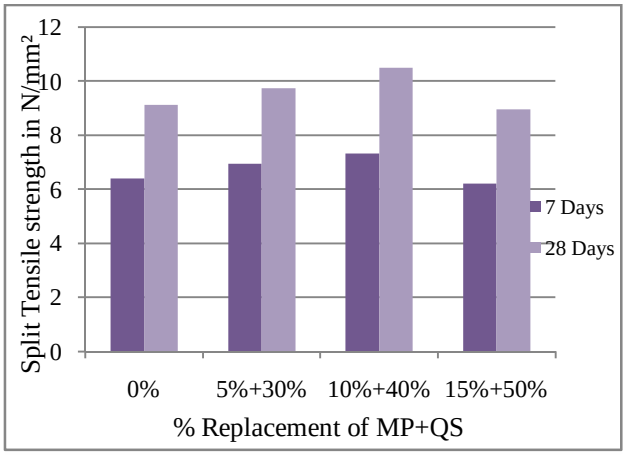
Replacement of Cement with MP and Fine aggregate with QS	7 Days	28 Days	% of increase in Compressive strength in 28 days
0%	23.69	29.89	-
5%+30%	26.41	30.10	0.7
10%+40%	27.53	32.44	8.53
15%+50%	23.22	28.63	-4.21



Graph 7: % replacement of QS vs Compressive strength (N/mm²)

Table 5.8: Split tensile strength results for MP + QS Concrete (N/mm²)

Replacement of Cement with MP and Fine aggregate with QS	7 Days	28 Days	% of increase in Split tensile strength in 28 days
0%	6.41	9.12	-
5%+30%	6.95	9.74	6.79
10%+40%	7.33	10.51	15.24
15%+50%	6.22	8.97	-1.64



Graph 8: % replacement of QS vs Split tensile strength (N/mm²)

Table 5.9: Flexural strength results for MP + QS Concrete (N/mm²)

Replacement of Cement with MP and Fine aggregate with QS	7 Days	28 Days	% of increase in Flexural strength in 28 days
0%	4.13	5.49	-
5%+30%	4.52	5.69	3.64
10%+40%	4.99	6.09	1.92
15%+50%	3.96	5.21	-5.10

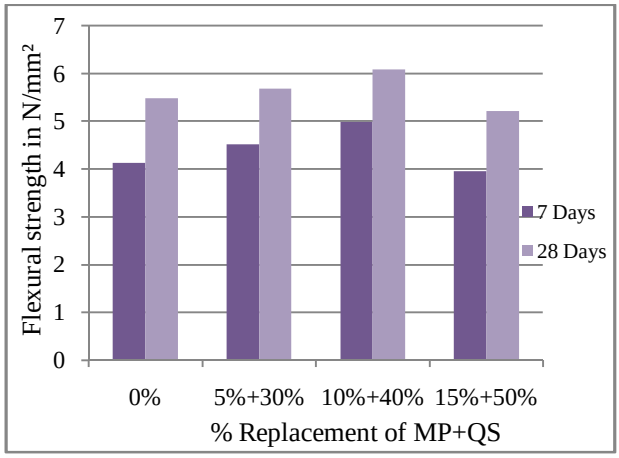


Fig 5.9: Graph % replacement of QS vs Flexural strength (N/mm²)

V. CONCLUSIONS

Based on the results and observation made in this experimental research study. The following conclusions are drawn.

1) It has been observed that the experimental result for the 10% replacement of marble powder to OPC has increase in strength in comparison with 0% and 5% replacement. Beyond 10% replacement of marble powder, the strength was decreased.
2) As the percentage of marble powder increases the compressive strength of concrete tends to increase up to certain percentage and then start's decreasing with the increase of MP content. MP concrete performed better when compared to ordinary concrete up to 10% replacement of marble powder.
3) The results of compression & split-tensile test indicated that the strength of concrete increases with respect to the percentage of Quarry sand added by weight of fine aggregate upto 40% of additions.
4) The optimum level of replacement of Quarry sand was found to be 40% and the results were better than that of control mix.
5) Based on the test results of MP+QS Concrete, it can be concluded that, Marble powder can increase the overall strength of the concrete when used up to a 10% Cement replacement level and Quarry sand can increase the overall strength of the concrete when used upto 40% fine aggregate replacement with w/c ratio of 0.46. Marble powder and Quarry sand are the valuable pozzolanic materials and it can potentially be used as a partial replacement for cement and fine aggregate respectively. This could reduce the environmental problems.

REFERENCES

[1] Babu, K.K., R. Radhakrishnan and E.K.K. Nambiar, 1997. 'Compressive Strength of Brick Masonry with Alternative - Aggregate Mortar'. CE and CR Journal, pp: 25-29.
[2] Veena G. Pathan, Md.GulfamPathan "Feasibility and need of use of Waste marble powder in concrete production", ICAET, pp 23-26.
[3] S.D. Anitha Selva Sofia, R. Gayathri, G. Swathi, and G.Prince arulraj, "Experimental Investigation on Quarry dust concrete with chemical admixture", International Journal of Latest Research in Science and Technology, Vol. 2,Issue. 2,pp. 91-94,March-April 2013.
[4] Venkata Sairam Kumar N, Dr. B. Panduranga Rao, Krishna Sai M.L.N, Experimental study on partial replacement of cement with quarry dust, International Journal of Advanced Engineering Research and Studies E-ISSN:2249–8974.
[5] Noha M. Soliman, Effect of using Marble Powder in Concrete Mixes on the Behavior and Strength of R.C. Slabs, International Journal of Current Engineering and Technology ISSN 2277 - 4106 Vol.3, No.5 (December 2013).

[6] Ramarao Chimata, Venkateswara Rao.J 'Innovative Use of Quartzite Rock Dust and Effect of Glass Fibers in Rigid Pavements' International Journal for Research in Applied Science & Engineering Technology (IJRASET) Vol. 3 Issue IX, September 2015.

[7] MD Mahboob Ali " strength characteristics of concrete with the partial replacement of cement by marble powder dust and sand by stone dust" International journal of engineering research and application ISSN – 2248 – 9622 ,Vol. 4, Issue 9 (version 1), pp. 203 – 209.September 2014.

[8] Sudhir S. Kapgate and S. R. Satone (2013), "Effect of quarry dust as partial replacement of sand in concrete", Indian streams research journal 3(5), 2230-7850.

[9] Sudhir S. Kapgate and S. R. Satone (2013), "Effect of quarry dust as partial replacement of sand in concrete", Indian streams research journal 3(5), 2230-7850.

[10] V Bhikshma, R. Kishore and N. H. M. Raju (2010), "Flexural behavior of high strength Stone dust concrete", Challenges Opportunities and Solutions in Structural Engineering and Construction–Ghafoori (ed.), London, 978-0-415-56809-8.