International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-3, June 2022
https://doi.org/10.55524/ijirem.2022.9.3.3
Article ID IJIR-1207, Pages 15-21
www.ijirem.org

Comparative Study of Mechanical Properties of Concrete Using Marble Dust as Partial Cement Replacement and Addition of Polypropylene Fiber

Mubashir Ajaz[1], and Shakshi Chalotra[2]

[1] M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2] Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Mubashir Ajaz; m.mubi007@gmail.com

ABSTRACT- Ordinary Portland cement (OPC) is used as the primary binder to produce concrete. The amount of the CO_2 released during the manufacture of OPC is in the order of one ton for every ton of OPC produced. Attempts made to reduce the use of OPC in concrete are receiving much attention due to environment related issues. In the present study marble dust is used as a partial replacement for cement. It has been estimated that several million tons of Marble Dust are produced worldwide from extracting to finishing process. Hence its utilization has become an important alternative material because of its cement like properties. Marble dust is also easily available at very less cost. Concrete is characterized by quasi-brittle failure i.e; once failure is initiated; nearly complete loss of loading capacity takes place. By addition of randomly distributed fibers in the concrete matrix concrete can be modified to perform in a more ductile manner which prevent and control initiation, propagation and coalescence of cracks. The fibers prevent surface cracking through bridging action leading to an increased resistance of the concrete. This paper presents results of an experimental program to determine mechanical properties of concrete as cement is replaced with marble dust with known percentages (0%, 5%, 10%, 15%) [5] [6] for the grade of M30 and addition of polypropylene fibers of different percentage (0%, 0.5%, 1%, and 1.5%). The concrete test samples were submitted to compressive strength tests after 7 and 28 days of moist curing, as well as flexure and splitting tensile strength tests. Overall Strength of Concrete (Compressive, Tensile & Flexure) showed a reasonable increase upto a limit of 10% for Marble Dust and 0.5% for PP Fibers [1].

KEYWORDS- Compressive strength, Concrete, Flexural strength, Marble dust, Ordinary Portland cement, Polypropylene Fiber, Split tensile strength etc

I. INTRODUCTION

A. General

Concrete is one of the important materials used in construction other than timber and steel. Its main constituents are cement, fine and coarse aggregates, and water. Most of the aggregates used in the manufacture of concrete come from quarries or alluvial rivers. Nowadays, these sources are in the process of depletion and their extraction has harmful consequences for the environment. For these reasons, it is important to optimize the consumption of natural aggregates as well as to enhance their replacement by other alternative sources [2].

B. Marble Dust

Marble is obtained from the transformation of pure limestone. Marble dust is the waste product, obtained during the process of sawing and shaping of marble from parent marble rock. In India, the amount of Marble Dust produced is very large approximately about 6 million tons from marble industries during marble cutting, grinding, processing and polishing. The particle size of marble dust usually ranges from 10 to 45μm and marble being a natural rock primarily originated from limestone. Hence it can have a good use in construction industry. In this study, we reviewed the waste marble dust obtained from the industry and investigate its effects on the concrete mix and compare the compressive, flexure and split tensile strength [8].

C. Polypropylene Fibers

Polypropylene fibers are synthetic fibers obtained as a by-product from textile industry. Polypropylene fibers help in significant reduction of plastic shrinkage cracking and minimizing of thermal cracking along with reliable and effective improvement of intrinsic tensile and flexural strength of the material. Polypropylene fibers are hydrophobic, i.e; they are water repellent; hence no excess water is required when placed in a concrete matrix. In this study, we reviewed the Polypropylene fibers to investigate its effects on the concrete mix and compare the compressive, flexure and split tensile strength. Mixes with different contents of Polypropylene fibers (0%,0.25%, 0.5%, 0.75%,) as addition is examined. Fig 1 below shows the effect of Fiber on Concrete [7].

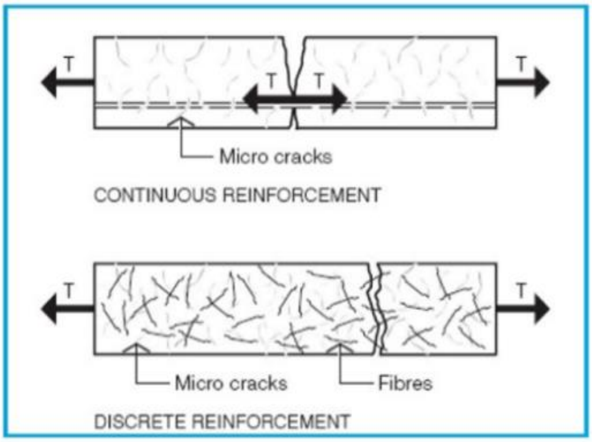

Figure 1: Comparison of Fibrous and Non-Fibrous Concrete

II. LITERATURE REVIEW

Nitisha Sharma and Ravi Kumar 2015 studied the properties using Waste Marble Powder as Partial Replacement in Cement Sand Mix. This was done by replacing cement with different percentages of marble powder. Four basic concrete mixes were considered. Optimum strength of concrete was achieved when cement is replaced with marble powder by 10%.[3]

Patil.V. A 2013 did an experimental investigation on polypropylene fiber reinforced concrete. The primary aim of this investigation is to study the effect of Polypropylene fiber mix by varying PPF content in percentages of 0%, 0.5%, 1% & 1.5% in order to find the optimum Polypropylene fiber content. The study reveals that on addition of 0.5% of polypropylene fiber maximum compressive and tensile strength are achieved.[4]

III. MATERIAL TESTING

A. Cement

Cement is an important constituent in concrete. The cement used for the experimental studies was 53 grade OPC ULTRATECH Cement conforming to the specifications of Indian Standard Code IS: 12269-1987. It was fresh and without any lumps.Test results for OPC obtained are given below in Table 1.

3.1.1 Tests on cement: Experiments were done as per IS-4031.

a) Sieve Analysis
b) Standard Consistency
c) Initial and Final setting time
d) Soundness
e) Specific Gravity

Table 1: Test results for OPC

PROPERTIES	RESULTS
Fineness of Cement (%)	2.7
Standard Consistency (%)	28
Initial setting time (min)	35
Final setting time (min)	370
Soundness Test (mm)	1.3
Specific Gravity	3.16

B. Fine Aggregates

Fine aggregates play an important role in formation of cement sand paste. These should be free from lumps of soil and without any unwanted matter for better performance. Ordinary sand from local riverbed has been used. Standard sieves used for sieve analysis of F.A are 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ.

3.2.1 Tests on F.A: Experiments were done as per IS-2386. The test results obtained are stated in Table 2.

a) Sieve Analysis
b) Specific Gravity
c) Water Absorption

Table 2: Test results for F.A

PROPERTIES	RESULTS
Fineness Modulus	2.77
Water Absorption	1.25 %
Specific Gravity	2.62
Grading	Zone II

C. Coarse Aggregates

Coarse aggregates refer to irregular and granular materials such as sand, gravel, or crushed stone, and are used for making concrete. Locally available crushed stone from local market with maximum graded size of 20 mm has been used as coarse aggregate. Standard sieves for sieve analysis of Coarse aggregates (C.A) are 80mm, 40mm, 20mm, 12.5mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ.

3.3.1 Tests on C.A: Test results for C.A are given below in Table 3

a) Sieve Analysis
b) Aggregate crushing value
c) Aggregate impact value
d) Specific gravity
e) Water absorption

Table 3: Test results for C.A

PROPERTIES	RESULTS
Fineness Modulus	7.46
Specific gravity	2.79
Water absorption	0.86%
Aggregate impact value	29%
Aggregate crushing value	24%

D. Marble Dust

Marble dust comes from crushed marble, which is formed by the crystallization of limestone or dolostone. The crystals appear as a calcite material through different atmospheric and temperature changes. Marble Dust for present study was obtained from a local Marble DEALER. Table 4 gives the results for M.D

Table 4: Test results for M.D

Cement (Kg/m³)	401
Fine aggregate (Kg/ m³)	694
Coarse aggregate (Kg/ m³)	1206
Admixture (Kg/ m³)	4.01
Water (lit/ m³)	172.33
Water cement ratio	0.43

E. Polypropylene Fibers

Polypropylene fibers are characterized by low specific gravity and low cost. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. The material for this experiment was obtained from an Online site INDIAMART. Table 5 below shows the properties of Polypropylene Fiber.

Table 5: Properties of PPF

PROPERTIES	RESULTS
Specific Gravity	1.31
Tensile strength (MPa)	537
Density (kg/m³)	0.9
Length (L) mm	6
Diameter (D) mm	0.0445
Aspect Ratio (L/D)	134.83
Colour	White

IV. METHODOLOGY

The methodology of the work consists of:
a) Identifying the specification of material to be selected.
b) Collection of materials.
c) Identifying the properties of collected materials. Various tests were conducted on cement, fine aggregate, coarse aggregate.
d)Selection of concrete grade.
e) Preparation of mix design of M30 grade concrete.
f) Cubes, Cylinder and Beams were casted with control mix using natural aggregate.
g) Preparation of test specimen by adding 0%, 5%, 10% and 15% of Marble dust & 0%, 0.25%, 0.5% and 0.75% of polypropylene fibers in concrete.
h) Workability tests, compressive strength, tensile strength & flexural strength of concrete were conducted.
i) Optimum percentage of Marble dust & PP fiber addition in concrete was determined

A. Design Stipulations

Table 6 states design conditions followed during the experiment.

Table 6: Design Stipulations

Characteristic compressive strength after 28 days	30 N/mm²
Max. size of Aggregate	20 mm
Types of Coarse aggregate	Crushed
Type of Fine aggregate	Uncrushed
Workability (Slump)	100-125 mm
Degree of quality control	Good
Type of exposure	Moderate
Admixture	MULTIPLAST SP122
Type or brand of cement	Ultratech (OPC Grade 53)

B. Mix Proportion

In the present study, M30 grade of concrete was prepared using the provision IS10262:2009. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is **1: 1.73 : 3.01** by volume and a water cement ratio of 0.43. Proportion of materials required per m³ is given in Table 7.

Table 7: M30 Mix Proportioning

Cement (Kg/m³)	401
Fine aggregate (Kg/ m³)	694
Coarse aggregate (Kg/ m³)	1206
Admixture (Kg/ m³)	4.01
Water (lit/ m³)	172.33
Water cement ratio	0.43

4.3 Preparation of Specimen

Concrete test specimens consist of 150x150x150mm cubes, Cylinders of 150mm diameter and 300mm height and 100x100x500 beams. Trial mixes of concrete consisting of 0%, 5 %, 10%, 15% of cement replacement with Marble dust and 0%, 0.25%, 0.5%, 0.75% PPF addition by weight of cement are made.

C. Mixing, Casting and Curing

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 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 64 cubes, 64 cylinders and 64 beams were casted. Marble powder were added in concrete in steps of 5% (0%, 5%, 10%, 15%) and PPF in steps of 0.25% (0%, 0.25%, 0.5%, 0.75%). For each combination 4 cubes, 4 cylinders & 4 beams were casted. Final strength of cubes, cylinders & beams were tested after 7 & 28 days curing.

D. Tests on Concrete

4.5.1 Test on Fresh Concrete
a) Slump Test: It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the way concrete slumps. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of frustum of a cone having the internal dimensions of bottom diameter 20 cm, top diameter 10 cm and a height of 30 cm. For tamping the concrete, a steel tamping rod 16 mm diameter, 0.6 meter along with bullet end is used.
4.5.2 Tests on Hardened Concrete
a) Compressive Strength
b) Flexural Strength
c) Split Tensile Strength
Concrete specimens were tested using Compression testing machine (CTM) of capacity 200 tones and with a constant rate of load is 14 N/min for all specimens and were tested at different curing ages for 7days and 28 days. Split tensile strength was tested on the 200 tones capacity machine and constant rate of a load is 2.4 N/mm²/minute. Flexural strength testing was also conducted by using a 100kN

capacity electrically operated Flexural testing machine FTM) at a displacement rate of 0.05 mm/sec.

V. TEST RESULTS AND DISCUSSION

A. Test on Workability

5.1.1 Slump Values for different % of MD

The result showed that the workability of a concrete mix first increases slightly upto 5% and then decreases due to more addition of Marble Dust but remain within the desired Limits. Slump Values obtained on replacement of cement by different % of MD are given in Table 8 and graphical representation is shown in Fig 2.

Table 8: Slump values for different % of MD

% OF MD	SLUMP (mm)
0	110
5	114
10	106
15	103

5.1.2 Slump values for different % of PPF

Workability of concrete decreases due to more addition of fibers, as there is increase in the amount of entrapped air voids due to the presence of fibers and therefore increase in air content attributes in reducing workability. Slump Values obtained on addition of PPF by different % of wt. of cement are given in Table 9 and graphical representation is shown in Fig 2.

Table 9: Slump values for different % of PPF

% OF PPF	SLUMP (mm)
0	110
0.25	108
0.50	105
0.75	102

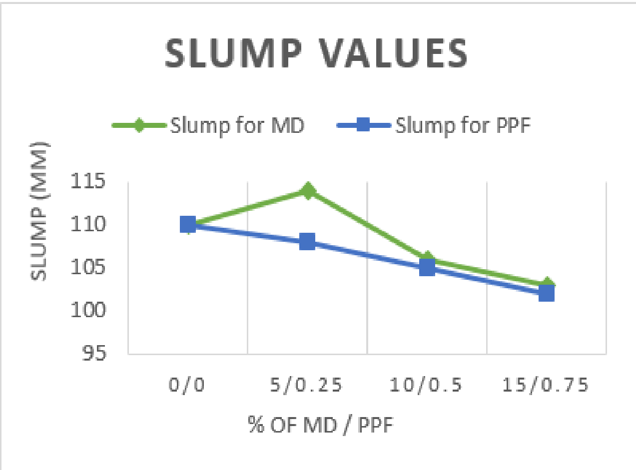

Figure 2: Graph Showing Slump Values for MD & PPF

B. Tests on Strength

The strength of concrete has been tested on cube, cylinder & beam at 7 days and 28 days curing. 7 days test has been conducted to check the gain in initial strength of concrete while 28 days test gives the data of final strength of concrete after 28 days of curing.

5.2.1 Compressive Strength Test

Table 10 shows the results of the compressive strength of concrete for all specimens. It can be noted that when cement is partially replaced by the Marble Dust then the max. compressive strength is obtained at 10% replacement and after that it starts decreasing and the compressive strength of the mix at optimum has increased about 8.7% and when added with PP fiber then again compressive strength is optimum at addition of 0.5% and the resultant compressive strength is found to be increased about 18%.Hence, optimum % of MD & PPF is found to be 10% & 0.5% for the said experiment. Fig 3 & Fig 4 show the graphical representation of Compressive strengths obtained on replacement of cement by different % of MD and addition of different % of PPF after 7 & 28 days

Table 10: Test Results for compressive strength

% of PPF	% of MD	After 7 days (MPa)	After 28 days (MPa)
0	0	21.92	33.72
	5	22.87	35.23
	10	23.75	36.59
	15	23.21	35.76
0.25	0	24.13	37.12
	5	25.19	38.76
	10	26.17	40.25
	15	25.57	39.32
0.50	0	25.85	39.80
	5	27.03	41.57
	10	28.05	43.16
	15	27.44	42.19
0.75	0	24.97	38.44
	5	26.10	40.16
	10	27.12	41.70
	15	26.43	40.73

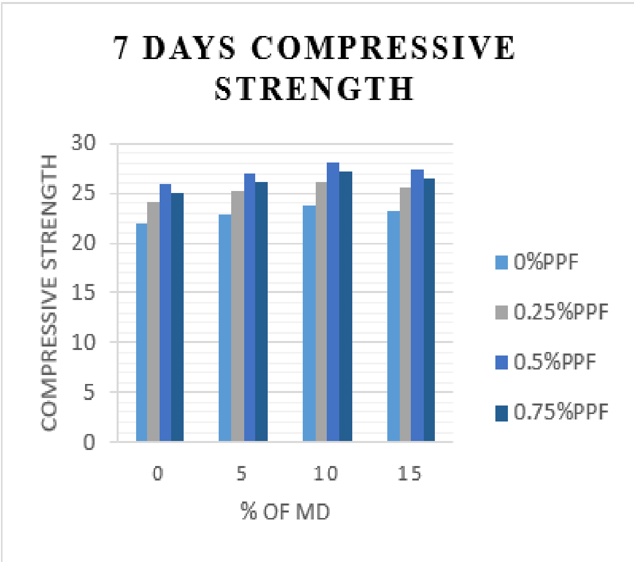

Figure 3: Graph showing Av. Comp. strength after 7 days

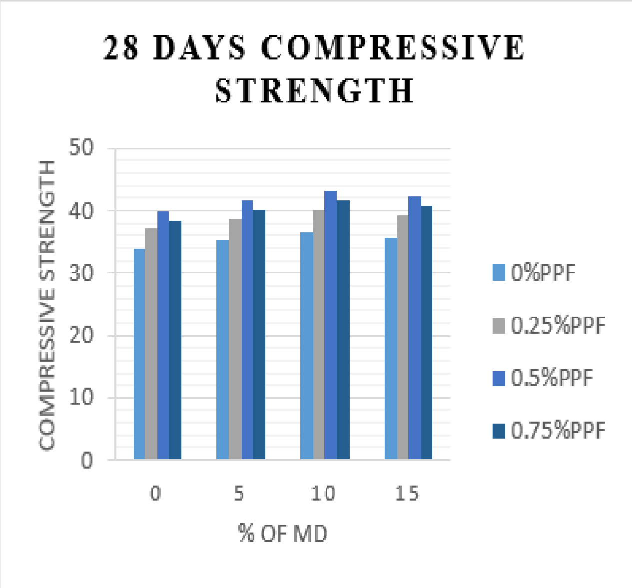

Figure 4: Graph showing Av. Comp. strength after 28 days

5.2.2 Split Tensile Strength Test

Table 11 shows the results of the split tensile strength of concrete for all specimens. It can be noted that when cement is partially replaced by the Marble Dust then the max. split tensile strength is obtained at 10% replacement and after that it starts decreasing and the split tensile strength of the mix at optimum has increased about 9.3% and when added with PP fiber then again split tensile strength is optimum at addition of 0.5% and the resultant strength is found to be increased about 22%.Hence, optimum % of MD & PPF is found to be 10% & 0.5% for the said experiment. Fig 5 & Fig 6 show the graphical representation of Split Tensile strengths obtained on replacement of cement by different % of MD and addition of different % of PPF after 7 & 28 days

Table 11: Test Results for Split Tensile strength

% of PPF	% of MD	After 7 days (MPa)	After 28 days (MPa)
0	0	2.21	3.38
	5	2.32	3.56
	10	2.40	3.69
	15	2.37	3.62
0.25	0	2.48	3.86
	5	2.63	4.04
	10	2.74	4.21
	15	2.69	4.13
0.50	0	2.63	4.13
	5	2.86	4.35
	10	2.94	4.52
	15	2.88	4.43
0.75	0	2.61	4.02
	5	2.72	4.21
	10	2.84	4.40
	15	2.81	4.31

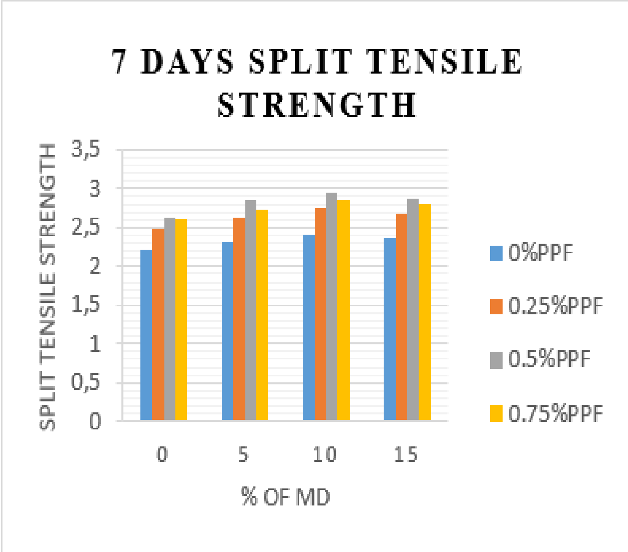

Figure 5: Graph showing Av. Split Tensile strength after 7 days

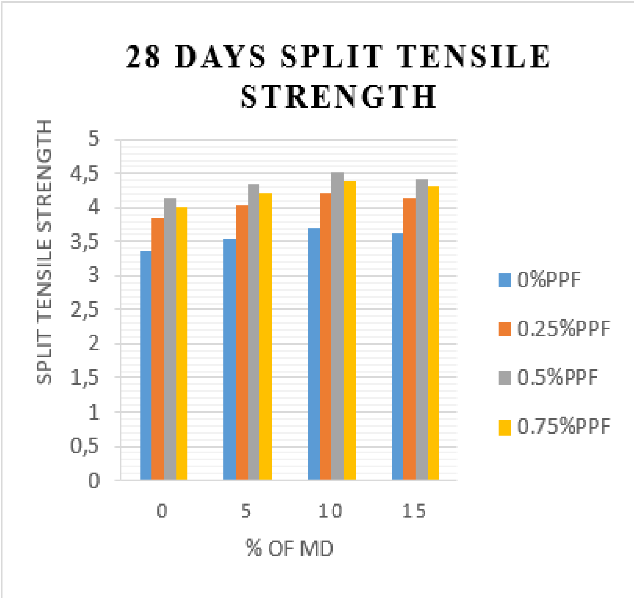

Figure 6: Graph showing Av. Split Tensile strength after 28 days

5.2.3 Flexural Strength Test

Table 12 shows the results of the flexural strength of concrete for all specimens. It can be noted that when cement is partially replaced by the Marble Dust then the max. flexural strength is obtained at 10% replacement and after that it starts decreasing and the flexural strength of the mix at optimum has increased about 9.2% and when added with PP fiber then again split tensile strength is optimum at addition of 0.5% and the resultant strength is found to be increased about 26%. Hence, optimum % of MD & PPF is found to be 10% & 0.5% for the said experiment. Fig 7 & Fig 8 show the graphical representation of Flexural strengths obtained on replacement of cement by different % of MD and addition of different % of PPF after 7 & 28 days.

Table 12: Test Results for Flexural strength

% of PPF	% of MD	After 7 days (MPa)	After 28 days (MPa)
0	0	2.63	4.07
	5	2.75	4.23
	10	2.87	4.45
	15	2.82	4.37
0.25	0	3.09	4.72
	5	3.18	4.91
	10	3.34	5.17
	15	2.27	5.07
0.50	0	3.31	5.13
	5	3.46	5.33
	10	3.62	5.61
	15	3.58	5.50
0.75	0	3.20	4.92
	5	3.33	5.12
	10	3.51	5.39
	15	3.43	5.28

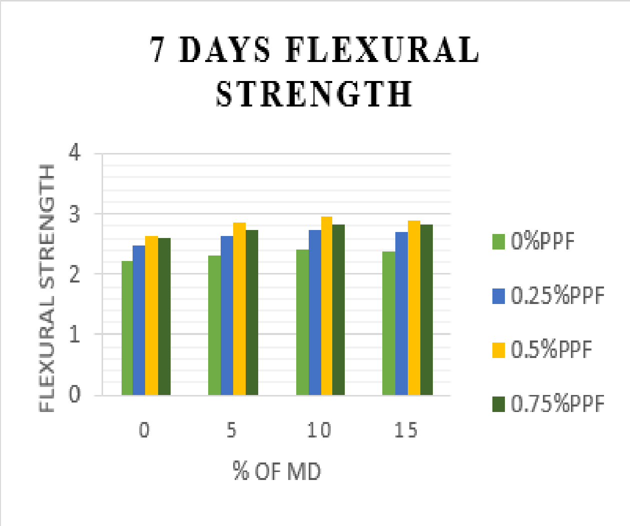

Figure 7: Graph showing Av. Flexural strength after 7 days

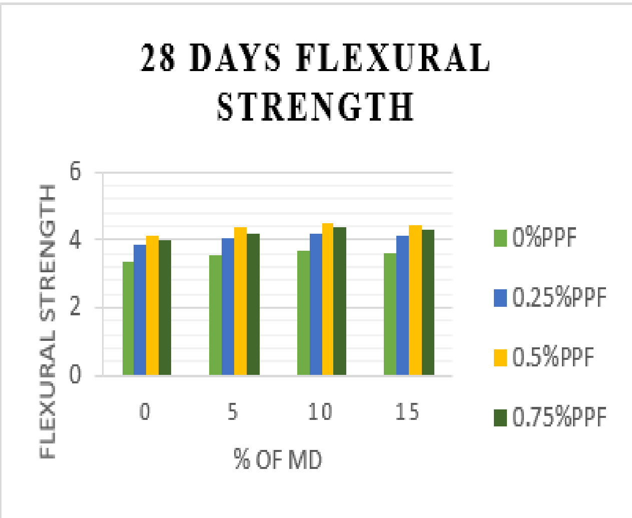

Figure 8: Graph showing Av. Flexural strength after 28 days

VI. CONCLUSION AND FUTURE SCOPE

After performing different tests on the prepared specimen and analyzing their results, the following conclusions drawn have been stated as under:

a) The results achieved from the present study show that both marble dust and PP Fiber have great potential for the utilization in concrete.

b) Due to the high fineness of marble dust, it proved to be effective in providing good cohesiveness to concrete, provided that water to cement ratio is just adequate.

c) Increase of strengths shown at optimum values of MD and PPF are shown in table 13.

Table 13: Comparative result between MD & PPF

Strength	At optimum % of MD	At optimum % of PPF
Compressive Strength	8.7%	18%
Split Tensile Strength	9.3%	22%
Flexural Strength	9.2%	26%

d) Producing Eco-friendly/Green Concrete by replacing cement, in-turn reducing CO_2.

e) We have put forth a simple step to minimize the costs for construction with usage of Marble Dust and PPF which is freely or cheaply available.

f) Reducing environmental pollution by making use of industrial waste material.

A. *Future Scope*

In current research, Marble Dust and PPF was used to prepare the M30 mixture. In future more materials like Nano Silica, Titanium Oxide, Zinc oxide, Metakaolin etc. and different fibers can be used individually or in combination with various proportions to prepare the concrete mixtures in order to increase the quality and strength of the mixtures thereby reducing pollution and dependence on naturally available materials.

REFERENCES

[1]Alhozaimy, A., P. Soroushian, et al. (1996)."Mechanical properties of polypropylene fiber reinforced concrete and the effects of pozzolanic materials". Cement and Concrete Composites 18(2): 85-92

[2]Kore. D. S, Vyas. A. K "study of impact of marble waste as coarse aggregate on properties of lean cement concrete". Department of civil engineering, Malviya institute of technology, Jaipur, Rajasthan 302017, India. Case study in construction materials 4 (2016) 85-92.

[3]Nitisha Sharma, Ravi Kumar "Use of Waste Marble Powder as Partial Replacement in Cement Sand Mix", International Journal of Engineering Research and Technology, Vol-4 Issue -5, May-2015.

[4]Patil. V. A, Sathe. A. P "study of experimental investigation on polypropylene fiber reinforced concrete with artificial sand.1) ME civil engineering department, NBNSCE, Solapur, Maharashtra, India. 2) Assistant professor, ME civil engineering department, NBNSCE, Solapur, Maharashtra, India International journal of science and research (IJSR) ISSN (online):2319-7064 Index Copernicus value (2013): 6.14. Impact factor (2013):4.438. Volume 4 Issue 6, June 2015 www.ijsr.net

[5]Pooja J.Chavhan*, Prof. S. D. Bhole "To Study the Behavior of

Marble Powder as Supplementary Cementitious Material in Concrete". International Journal of Engineering Research and Technology Vol. 4, Issue 4, April 2014.

[6]Prof. P.A. Shirule, Ata ur Rehman, Rakesh D. Gupta, "Partial replacement of Cement with Marble dust powder", IJAERS, Volume I, Issue III, April June 2012, 175-77.

[7]Thirumurugan, S. and A. Sivakumar (2013). "Compressive Strength Index of Crimped Polypropylene Fibers in High Strength Cementitious Matrix". World Applied Sciences Journal 24(6): 698-702.

[8]V. M. Sounthararajan and A. Sivakumar "Effect of The Lime Content in Marble Powder for Producing High Strength Concrete" VOL. 8, NO.4, APRIL 2013 ISSN 1819-6608 ARPN Journal of Engineering and Applied Sciences.