International Journal of Recent Research and Review, Vol. XV, Issue 4, December 2022
ISSN 2277 – 8322

AN EXPERIMENTAL STUDY OF USING WASTE MATERIAL IN RIGID PAVEMENT

Vinod Kumar Yadav[1] & Deepak Mathur[2]
Department of Civil Engineering, Kautilya Institute of Technology & Engineering, Jaipur
[1]vinodyadavnituk@gmail.com, [2]mathurdeepak1507@gmail.com

Abstract: In today world concrete became the base of construction of any type of infrastructure. It consumes natural material rapidly. Now present days the focus on development of green concrete for this utilizing of the waste material produced from industries as much. Waste materials are suitable alternate of cement, fine aggregate and course aggregate etc. Generally Concrete is prepared by mixing of Cement, Sand (Fine Aggregate), Gravels (Coarse Aggregate), Water, Admixtures and Additives. In this study cement is partially replaced by Marble Dust at fixed percentage (15%) and with various percentages ratios of polypropylene fiber (0%, 1%, 2%,3% & 4%). It can be concluded that with partial replacement of cement with 15% marble dust, the mechanical properties like: compressive, split, tensile and flexural strength of M30 remains unaltered. Further the addition of polypropylene fibers up to 3% of cement enhances mechanical properties such as compressive strength and split tensile strength but at 1% flexural strength enhances. The durability study of M30 with 15% marble dust replacing cement with additional polypropylene fibers reveals that there was a little loss of weight from original weight.

***Key Words**: FRC (Fiber Reinforced Concrete), MDP (Marble Dust Powder), Polypropylene Fiber, Green concrete, Durability etc.*

I. INTRODUCTION

Concrete is prepared using cement, water, coarse aggregate, fine aggregate (sand). According to standard requirement of construction, sometimes concrete also uses admixtures and minerals. It is the construction material used widely and is being in existence since development of modern cement. Concrete having great mechanical properties with good durability properties in general environment is most economical as compared to other materials to fulfill needs of construction industry.

The marble dust percentage as a partial replacer has been kept constant that is 10% after investigating the properties by varying percentage of marble dust from 5% up to 25% by weight and Polypropylene fiber proportion are being used in different percentage of 0%, 1%, 2%, 3% and 4%.

For this study marble dust procured from Marble Industry, Kishangarh, Rajasthan having properties like specific gravity 2.77, Fineness 84.4%, pH of 8.89 and polypropylene fibers of aspect ratio 250 and specific gravity of 0.954 are used.

Objectives of This Study

The main purpose of this study is to assess the optimum use of marble dust as a cement replacer.

This study carried out on following:

- To reduce the carbon emission by partially replacing cement with marble dust (an industrial waste), thus making green concrete.
- To compare & analyze the difference in workability of fresh concrete using MDP and PPF.
- To develop economical concrete mix.
- To check the flexural, compressive and tensile strength of concrete.
- To adjudge the durability properties by undertaking alkali test.

II. LITERATURE SURVEY

A literature survey has been done to be aware with the area in which research is to be done along with the issues in particular area where some solutions can be provided for the better enhancement of the society. The literature survey provides clear way to tackle any study proposed.

S. Anandaraj et.al (2022) [1] on Luffa Fiber Reinforced Concrete. Adding Luffa strands at different rates like 0.5%, 1%, 1.5%& 2% to the solid. Concrete’s mechanical properties are being test. The substitution is done halfway and completely in the different extents like 0%, 20%, 40%, 60% and 80% and its impact on cement properties was examined.

Omrane Benjeddou and Nuha Mashaan (2022) [2] on recycling the marble waste usability as an aggregate for construction of road. Experimental tests carried out on coarse and fine marble aggregates samples: Atomic Absorption Spectrometry, seieve analysis, calcium carbonate content, scanning electron microscope (SEM), X-Ray diffraction (XRD), density, water absorption limits and equivalent of sand, Los Angeles, Micro Deval, flakiness index and shape index.

G. Anusha et.al (2021) [3] on concrete paver blocks properties with partially replacement of cement by granite powder waste. Results shows the compressive strength and flexural strength are increased upto 10 % replacement of cement with granite powder. The compressive strength is 14 percent and flexural strength 8.60 percent higher than conventional concrete paver's flexural strength and compressive strength.

Candra Aditya et.al (2021) [4] creates innovation in rigid pavement construction. The maximum compressive strength of 34.67 N/mm² occurs at 60% replacement level of aggregate by marble sand content. Calculation of marble sand’s optimum level yielded 48.90% by regression method with average value of compressive strength of 32.37 N/mm².

Gaurav Rajotia et.al. (2020) [5] use of waste generated from road demolition as recycle materials in the construction of pavement. The water absorption percentage for modified/ amended G.S.B. aggregates obtained as 0.68% which is under the maximum limit of 2% specified by IS Code 2386 (Part 3):1963. **Vineet Kumar et.al. (2020) [6]** Strenth and durability properties of concrete with partial replacement of Cement with metakaolin and marble dust. The concrete’s compressive strength is higher for replacement by 10%+10% marble dust and meta-kaoline. Marble dust and metakaoline is being replaced with cement for predetermined percentages such as 0%, 5%+ 5%, 7.5%+ 7.5%, 10%+ 10%, 12.5%+ 12.5%, 15%+ 15% for the grade of M30.

III. MATERIAL USED AND EXPERIMENTS CONDUCTED

Locally available material has been used except cement and polypropylene fibers. The ordinary Portland cement of 43 grade ambuja plant and polypropylene fibers from dolphin floats pvt ltd, India procured from local vendor. Marble dust collected from marble industry available in Jaipur. Details and properties of material used in this study are elaborated as under:-

Cement

Cement(OPC) 43 grade of Ambuja brand is used.

Sand

Sand is a granular material which occurs naturally. Natural river sand having properties of specific gravity 2.66 and water absorption 1% were use for this research which was collected from Kuber Building Material store, Pratap Nagar, Jaipur.

Polypropylene Fiber

PPF is generally available in various forms for example- mono filament, microfilaments or fibrillated bundles. The fibrillated PPF are created from plastic film’s expansion, which splits into strips and then cuts.

Marble Dust

Marble is result of metamorphism mechanism of geology that is when limestone is subjected to the very high temperature and pressures. It is composed primarily of mineral calcite ($CaCO_3$) and other minerals like: clay minerals, quartz, iron oxides, and graphite. Marble waste was obtained from Marble polishing industries. Marble powder from Marble suppliers, Jaipur, Rajasthan having specific gravity 2.77 and Fineness 84.4%, water absorption of 1% and PH of 8.89 used for this research which was collected from Kuber Building Material store, Pratap Nagar, Jaipur.

Mix Design for M30

Design method adopted for this study is as per guidelines under IS 10262: 2009. The mix proportioning for concrete of M30 grade containing polypropylene fiber and marble dust as a partial replacement material for cement is designed and mentioned as per the guidelines of IS 10262: 2009.

Mix Proportioning of M-30 Concrete

The trial mix of M30 as per mix design made and compressive strength after 28 days being tested after satisfying the calculated target mean strength, the trial mix was adopted accordingly, the experiment was carried out for marble dust and polypropylene fiber. The mix proportions considered for each addition of polypropylene fiber by 0%, 1%, 2%, 3% & 4% volume of concrete and a fixed 15% replacement of cement with marble dust in M-30 Grade Concrete.

Quantity of marble dust: Partially replaced the cement by marble dust in an adequate quantity by weight of cement. From the literature reviews and with varying % of marble dust in cement from 5% to 25%, it was seen that the optimum strength of concrete got by replacing the cement 15% by weight of cement.

M30 Grade Concrete:

The quantity of marble dust = 425.73*15/100 = 63.85 kg/m^3. Now the quantity of cement decreases by 15%

So, cement's quantity after partially being replaced by marble dust

= 425.73 – 63.85 = 361.88 kg/m^3

Quantity of PPF: The quantity of polypropylene fiber varies at various percentages from 1% to 4% by weight of cement and the variation of PPF is by weight of cement and PPF have been added to concrete.

M30 Grade Concrete:

At 1 % = 1*361.88/100 = 3.62 kg/m3

At 2% = 2*361.88/100 = 7.24 kg/m3

At 3 % = 3*361.88/100 = 10.86 kg/m3

At 4% = 4*361.88/100 = 14.48 kg/m3

Materials Preparation

Raw materials were brought at room temperature, preferably 27º ± 3 ºC before experimenting. Aggregate samples for each batch were of the desired grading and were in an air-dried condition.

A. Weighing: Determination of quantities of cement, aggregate and water for each batch was done by weight, with an accuracy of 0.1% of the total weight of the batch. Marble dust and PPF were taken by weight of cement.

B. Mixing: The mixture of cement and fine aggregate was thoroughly blended in the dry state after that coarse aggregates were added and properly mixed it with the fine aggregate and cement until coarse aggregate uniformly got distributed throughout the batch, then adequate water was added, continuous mixing was done until the concrete appeared to be homogenous. The water was added to maintain the consistency.

Preparation of Specimen

A. Compressive Strength: Cube: Just after the mixing, sample cube of mixed concrete mould was poured. The concrete was fully compacted in layers as per standards so that no air void remains trapped. No signs of segregation of the aggregates and cement paste were allowed. Dimensions of used cubes for sample were 150×150×150 mm.

B. Split Tensile Strength: Cylinder: After sample prepared, the cylindrical mould was filled immediately and full compaction of concrete was done. All precautions were taken so that over compaction does not happen. Cylinder dimensions for sample were 150 mm (dia.) and 300mm (length).

C. Flexure Strength: Beam: After the sample was prepared, immediately the beam mould was filled. The concrete was fully and evenly homogenous compacted. Beams dimensions were 500×100×100 mm.

Experimental Program

Fineness Test:

Table No.3.1 Fineness Modulus of Fine Sample

S.No	Material	Sieve size	Fineness Modulus
1	Cement	90 micron sieve	94%
2	Sand	>4.75mm to 0.15mm	26.5%
3	Marble Dust	90 micron sieve	82.2%,

Specific Gravity Test:

A. Fine Aggregates (Sand, Cement and Marble Dust)

- Dry weight of the pycnometer with its cap (W_1)
- Weight of 200gm to 300gm of oven dried

material passing through 4.75mm sieve in pycnometer (W_2)

- Weight of pycnometer with water (W_3).
- Weight of the pycnometer after drying it on the outside thoroughly (W_4).

Coarse Aggregates:

- Weight of the basket and the sample while suspended in water (W_1) g.
- Weight of the empty basket in water (W_2) g.
- Weight of the surface dried aggregate (W_3) g.
- Weight of oven dried aggregate (W_4) g.

Water Absorption Test:

- Predetermined amount of sample was taken, put in oven to dry it by maintaining 110^{0}C of temperature for 24 hours
- Now allowed the sample to cool down to room temperature.
- After cooling weight the sample measured as W_a.
- Now emerge the sample in water for 24 hours at 23^{0}C.
- Remove the sample, pat it dry with cotton cloth and weight the sample as $W_{b.}$
- Use below mention formula to calculate the amount of water absorb by the sample.

Calculation:

The Compressive Testing Machine (CTM) used in test was manual, so experimental value compressive strength of specimen has been calculated from: dividing maximum load applied by specimen's cross-sectional area during the test. Compressive strength of specimen can be determined by given formula below:

f = P/A Here, f = compressive strength of the concrete sample

P = Maximum load applied to the sample

A = Specimen's cross sectional are

IV. RESULTS AND DISCUSSIONS

Slump Test

Table No. 4.1 Slump value for Control mix of M30 Grade

S. No.	Control Mix	Slump (mm)
1	M30	95

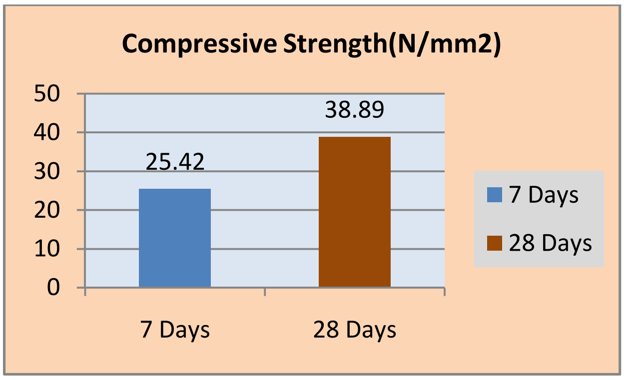
Average Strength for M30:

Compressive Strength Test:

To ascertain the average value of compressive strength of concrete mix M30 three cubes with dimensions 150×150×150 mm were casted and test performed for compressive strength as per code IS: 516- 1959 on compression testing machine. The average strength values of concrete sample is being tabulated in the table below.

Table No. 4.2 Compressive Strength for Control mix of M30 Grade

Sample of cube	Compressive Strength(N/mm^2) M30	
	7 Days	28 Days TMS (38.25)
1	25.17	39.26
2	25.62	38.90
3	25.47	38.52
Average Strength	**25.42**	**38.89**



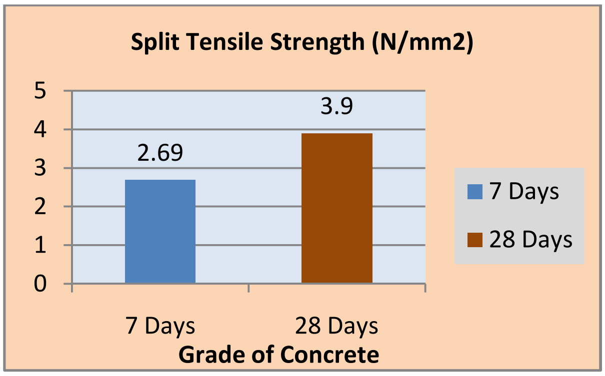
Graph No. 4.1 Comparative average Compressive Strength for M30 Grade

Split Tensile Strength Test:

For determination of the average Split Tensile strength of M30 concrete mix, three sample of cylindrical specimens having dimensions 150mm (dia.) and 300mm (length) were casted and tested as per IS: 5816-199 on universal testing machine. The average strength values of split tensile strength is being tabulated in the table below.

Table No.4.3 Split Tensile Strength for Control mix of M30 Grade

Sample of cube	Split Tensile Strength (N/mm^2)M30	
	7 Days	28 Days
1	2.85	3.85
2	2.77	3.99
3	2.46	3.86
Average Strength	**2.69**	**3.90**

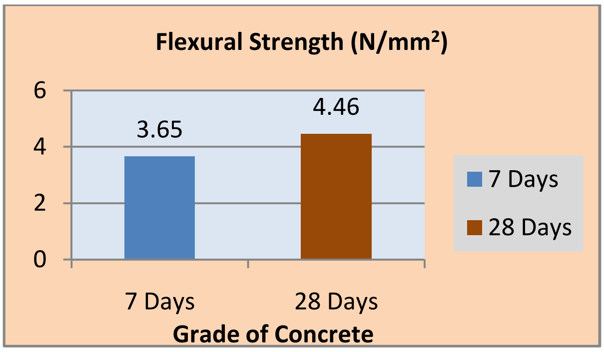


Graph No. 4.2 Comparative average split tensile Strength for M30 Grade

Flexural Strength Test:
To ascertain the average flexural strength of M30 concrete mix, three beams having dimensions 500×100×100 mm were casted and tested with the flexural testing machine as per IS: 516-1959. Pure bending condition was being created on beam sample using two-point loading system. The average flexural strength values is being tabulated in the table below.

Table No. 4.4 Flexural Strength for Control mix of M30 Grade

Sample of cube	Flexural Strength (N/mm^2) M30	
	7 Days	28 Days
1	3.65	4.45
2	3.85	4.56
3	3.47	4.39
Average Strength	**3.65**	**4.46**



Graph No. 4.3 Comparative average Flexure Strength for M30 Grade

The average values for compressive, split tensile and flexure strength for M30 concrete mix.

Workability of Concrete

Table No. 4.5 Slump with 15% MDP and Polypropylene Fiber

S. No.	Polypropylene Fiber %	Slump (mm) M30
1	0	95
2	1	84
3	2	78
4	3	73
5	4	67

Table no.4.5 shows the comparison of slump values for various fiber content percentages. It was observed that with increases of polypropylene fiber content in concrete, slump values of concrete decreases accordingly, hence the workability decreases. So concrete with 0% fiber replacement have the highest workability and concrete specimen with 4% replacement have the lowest workability.

Compressive Strength Test
Minimum compressive strength obtained for 0% addition of polypropylene fiber while optimum compressive strength obtained for 3% addition of polypropylene fiber for 7, 14 and 28 days curing period of cubes. It was observed that optimum increment in percentage value of compressive strength of concrete obtained was 9.80% at 28 days of curing respectively.

Table 4.6 Compressive strength of M30 grade

MDP and Polypropylene Fiber%	Compressive Strength (N/mm^2)	
MDP + PF	7 Days	28 Days
MDP 0% + 0% PF	25.42	38.89
MDP 15% + 0% PF	26.79	40.15
MDP 15% + 1% PF	27.07	40.84

MDP 15% + 2% PF	27.44	41.11
MDP 15% + 3% PF	27.89	41.45
MDP 15% + 4% PF	27.05	41.04

It was observed that minimum value of compressive strength had been obtained at 0% addition of polypropylene fiber while optimum value of compressive strength had been obtained at 3% addition of polypropylene fiber for both 14 days and 28 days of curing period of cubes. It was also observed that optimum increment in compressive strength value in percentage of concrete was 10.51% at 28 days of curing respectively.

Split Tensile Strength of Concrete

Cylinders having dimensions 150mm (dia.) and 300mm (length) were casted and tested as per IS: 5816-199 on universal testing machine.

It was observed that minimum value of split tensile strength had been obtained for addition of 0% polypropylene fiber while optimum value of split tensile strength had been obtained for addition of 3% polypropylene fiber at 14 and 28 days of curing periods of cubes. It was also observed that optimum increment in term of percentage of split tensile strength of concrete obtained was 37.21% at 28 days of curing respectively.

Table 4.7 Splitting Tensile Strength of M30 grade

MDP and Polypropylene Fiber %	Splitting Tensile Strength (N/mm^2)	
	7 Days	28 Days
MDP 0% + 0% PF	2.69	3.9
MDP 15% + 0% PF	3.71	4.97
MDP 15% + 1% PF	3.94	5.09
MDP 15% + 2% PF	4.13	5.27
MDP 15% + 3% PF	4.59	5.53
MDP 15% + 4% PF	3.87	4.87

It was observed that minimum value of split tensile strength had been obtained for addition of 0% polypropylene fiber while optimum value of split tensile strength had been obtained for addition of 3% polypropylene fiber at 14 and 28 days curing of cubes. It was also observed that optimum increment in split tensile strength in term of percentage for concrete sample was 30.73% at 28 days of curing respectively.

Flexural Strength of Concrete

For flexural strength test of beams having dimensions 500×100×100 mm was casted and tested on flexural testing machine as per IS: 516-1959. Pure bending condition was created using two-point loading system. Minimum value of flexural strength had been obtained for addition of 0% while optimum value of flexural strength had been obtained for addition of 3% polypropylene fiber at 7 and 28 curing days respectively.

Table 4.8 Flexural Strength of M30 grade

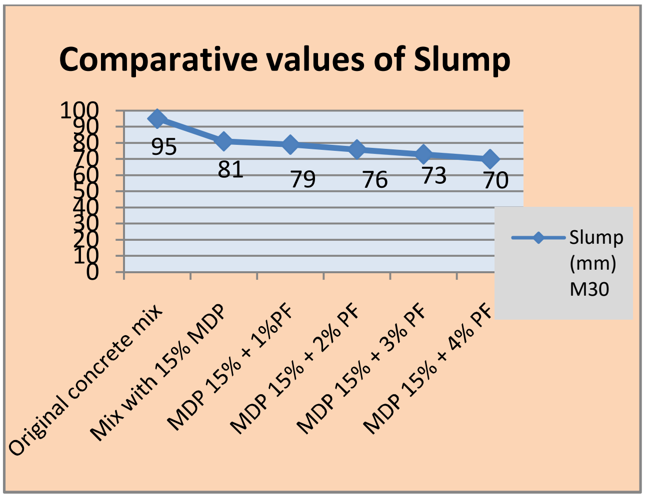
MDP and Polypropylene Fiber %	Flexural Strength (N/mm^2)	
	7 Days	28 Days
MDP 0% + 0% PF	3.65	4.46
MDP 15% + 0% PF	4.27	5.32
MDP 15% + 1% PF	4.53	5.47
MDP 15% + 2% PF	4.87	5.69
MDP 15% + 3% PF	5.11	5.83
MDP 15% + 4% PF	4.14	5.01

SUMMARY OF RESULT

i. Workability

Table No 4.9 Comparative values of slump

S. No.	Type of Mix	Slump (mm) M30
1	Original concrete mix	95
2	Mix with 15% MDP	81
3	MDP 15% + 1% PF	79
4	MDP 15% + 2% PF	76
5	MDP 15% + 3% PF	73
6	MDP 15% + 4% PF	70

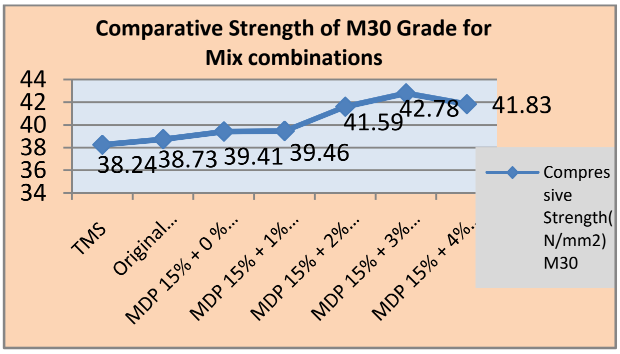


Graph No. 4.4 Comparative values of slump

ii. Compressive strength

Table No. 4.10 Compressive Strength of M30 Grade for Mix combinations

S. No.	Mix Combination	Compressive Strength (N/mm^2) M30
1	TMS	38.24
2	Original concrete mix	38.73
3	MDP 15% + 0 % PF	39.41
4	MDP 15% + 1% PF	39.46
5	MDP 15% + 2% PF	41.59
6	MDP 15% + 3% PF	42.78
7	MDP 15% + 4% PF	41.83

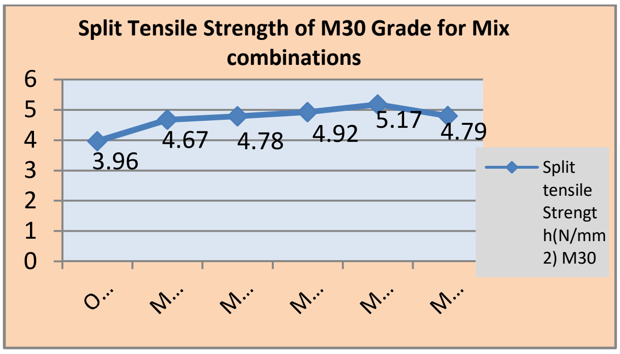


Graph No. 4.5 Compressive Strength of M30 Grade for Mix combinations

iii. Split tensile strength

Table No. 4.11 Split tensile Strength of M30 Grade for Mix combinations

S. No.	Mix Combination	Split tensile Strength (N/mm^2) M30
1	Original concrete mix	3.96
2	MDP 15% + 0 % PF	4.67
3	MDP 15% + 1% PF	4.78
4	MDP 15% + 2% PF	4.92
5	MDP 15% + 3% PF	5.17
6	MDP 15% + 4% PF	4.79

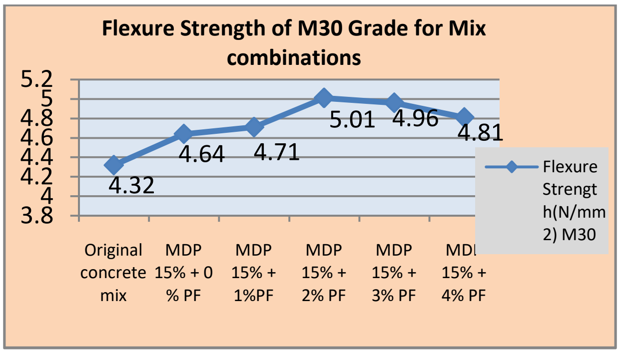


Graph No. 4.6 Split tensile Strength of M30 Grade for Mix combinations

Flexure Strength

Table No. 4.12 Flexure Strength of M30 Grade for Mix combinations

S. No.	Mix Combination	Flexure Strength (N/mm^2) M30
1	Original concrete mix	4.32
2	MDP 15% + 0 % PF	4.64
3	MDP 15% + 1% PF	4.71
4	MDP 15% + 2% PF	5.01
5	MDP 15% + 3% PF	4.96
6	MDP 15% + 4% PF	4.81

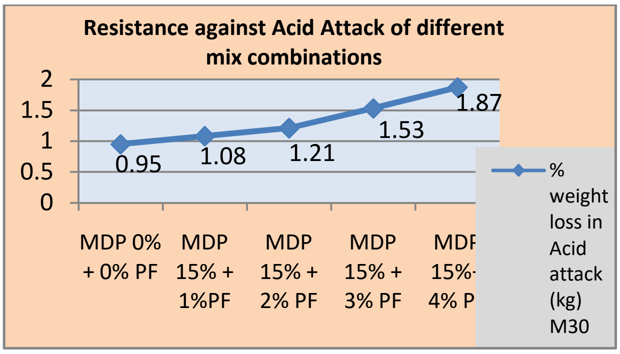


Graph No. 4.7 Flexure Strength of M30 Grade for Mix combinations

iv. Comparative analysis for Resistance against Acid Attack

Table No. 4.13 Resistance against Acid Attack of different mix combinations

S. No.	Mix Combination	% weight loss in Acid attack (kg) M30
1	MDP 0% + 0% PF	0.95
2	MDP 15% + 1% PF	1.08
3	MDP 15% + 2% PF	1.21
4	MDP 15% + 3% PF	1.53
5	MDP 15% + 4% PF	1.87



Graph No. 4.8 Resistance against Acid Attack of different mix combinations

V. RIGID PAVEMENT

Factor in the Design of Rigid Pavement

- The most important factor is thickness that is designed as per requirement.
- Warping stress is due to the variation in temperature of pavement depends on the length and width.
- The load carrying capacity is mainly depends due to rigidity and high elasticity modulus of slab.

Factor Affecting Stability of Pavement

The stability of pavement largely depends on thickness of pavement. The thickness of pavement depends on many variables of different aspects, but with practical application it had been experienced that 'five factors' given below will affect pavement's performance to greater extents:-

1. Traffic Factors
2. Moisture Factors
3. Climatic Factors
4. Soil Factors
5. Stress Distribution Factors

VI. CONCLUSION

The objectives of this study and conclusion drawn are as under:

Firstly, present study's objective was to utilize the waste of marble dust in M30 concrete without compromising its mechanical properties. After experimental investigation it was assessed that 15% of cement can be used as replacement by marble dust in M30.

Secondly, this study's objective was to observe the effect of polypropylene fiber in concrete mix with 15% marble dust which replaces cement by weight. The dosage variation of PPF was 1% to 4% of cement by weight with an increment of 1% of cement quantity by weight. All mechanical properties of concrete mix were determined and compared with original concrete and concrete with 15% of marble dust. After experimental study, it was observed that concrete mix with 15% marble dust replacement of cement and 3% of polypropylene fiber is great comparable with original concrete.

Thirdly, this study's objective was to undertaking durability test with acid test and alkali test. After experimental investigation it was expressed that there is no major losses in weight with respect to the virgin concrete M30.

The detailed conclusion drawn from experimental result wise is as under – FOR M30

1. **Compressive Strength:**
   It was observe that by partially replacement of cement with several different percentages of marble dust, there is satisfactory increase in compressive strength of M30 concrete. Optimum result was obtained at 15% replacement with MDP. The maximum increase in the compressive strength for M30 was 1.80% at 28 days of curing respectively. It was then concluded that optimum percentage increment in compressive strength of concrete was 10.51% at 28 days of curing respectively.

2. **Split Tensile Strength:**

   The results shows that obtained split tensile strength for 0% addition of polypropylene fiber was minimum while obtained value of split tensile strength for 3% addition of polypropylene fiber at 14 and 28 days curing of cubes was optimum. It was also concluded that optimum increment in the value of split tensile strength of concrete in terms of percentages was 30.73% at curing period of 28 days.

3. **Flexure Strength:**
   It is observed that with partial replacement of cement with several different percentages of marble dust there is satisfactory increment in flexure strength of concrete mix M30. Optimum value of flexural strength was

obtained at 15% replacement with MDP. It was finally observed that percentage increment in concrete's flexural strength was optimum 16.16% at curing periods of 28 days.

4. **Durability:**
   It were analyzed that the percent weight loss in cube specimens for acid attack resistance were founded as -
   - For MD 0% and PPF 0% at 90 days - 0.96%
   - For MD 10% and PPF 1-4% at 90 days, loss in weight found increasing - 1.09 to 1.89%

   The results shows that the percent weight loss in cube specimens for alkali attack resistance was founded as -
   - For MD 0% and PPF 0% at 90 days – 0.37%
   - For MD 10% and PPF 1- 4% at 90 days, loss in weight found increasing - 0.48 to 0.77%

Final concluding statement

The concrete mix has become economical and comparatively less harmful for environment with the use of marble dust in replacement of cement at 15% by weight of cement. It has been founded that the concrete mix with marble dust replacement of cement became highly economical than plain concrete mix. For M30 mix, reduction in percentages of cement content by 15 replacements was found to be 42.72 kg/m^3 which is equal to 0.85 bags of cement. Therefore we can save cost by 297Rs/m^3 for M30.

Future Scope of work

1. The PPF be utilized in self-compacting concrete made with marble dust and fly ash can be studied.
2. The PPF be utilized in high strength concrete made with silica fume and marble dust
3. The PPF concrete with blending of marble powder, granite powder and silica fume may be studied.
4. The study PPF concrete with marble dust is reducing the workability so super plasticizer could be used to increase the desired workability.

VII. REFERENCES

[1] S. Anandaraj et.al (2022) An Experimental Investigation of Marble Dust in Luffa Fibre Reinforced Concrete, IOP Conf. Series: Materials Science and Engineering 1145 (2021) (Published 23 February 2022.

[2] Omrane Benjeddou and Nuha Mashaan (2022) Experimental Study of the Usability of Recycling Marble Waste as Aggregate for Road Construction, Sustainability 2022, 14, 3195. https://doi.org/10.3390/su14063195, Published: 9 March 2022.

[3] G. Anusha et.al (2021) Experimental Study on Properties of Concrete Paver Blocks by Partially Replacing Cement with Granite Powder, IOP Conf. Series: Materials Science and Engineering 1145 (2021) 012074, Published 23 February 2022.

[4] Candra Aditya et.al (2021) Implementation of marble waste as aggregate material rigid pavement, (2021), EUREKA: Physics and Engineering, DOI: 10.21303/2461-4262.2021.001932.

[5] Gaurav Rajotia et.al (2020) An Experimental Study on Use of Road Demolition Wastes as Recycled Materials in Pavement Construction, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, p-ISSN: 2395-0072, Volume: 07 Issue: 07 | July 2020, Page 3262.

[6] Vineet Kumar Jadoun & Akash Prakash (2020) Strength and Durability Properties of Concrete with Partial Replacement of Cement with Metakaolin and Marble Dust, Journal of Interdisciplinary Cycle Research, Volume XII, Issue VII, July/2020, ISSN NO: 0022-1945, Page No:1465.