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Partial Replacement of Cement to Concrete by Marble Dust Powder

Vijaya Kumar YM[1] | Shruti D[2] | Tharan SN[3] | Sanjay SR[4] | Sricharan PM[5]

[1]Dept of Civil Engineering, Adichunchanagiri Institute Of Technology, Chikmagalur, Karnataka, India
[2]Dept of Civil Engineering, Adichunchanagiri Institute Of Technology, Chikmagalur, Karnataka, India
[3]Dept of Civil Engineering, Adichunchanagiri Institute Of Technology, Chikmagalur, Karnataka, India
[4]Dept of Civil Engineering, Adichunchanagiri Institute Of Technology, Chikmagalur, Karnataka, India
[5]Dept of Civil Engineering, Adichunchanagiri Institute Of Technology, Chikmagalur, Karnataka, India

ABSTRACT

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Partial replacement of cement by varying percentage of marble dust Powder powder reveals that increased waste marble dust powder ratio result in increased workability and compressive strengths of the concrete Marble Dust Powder is settled by sedimentation and then dumped away, which results in environmental contamination, in addition to forming dust in summer and threatening both agriculture and public wellness.. In this research work, Marble Dust Powder has replaced the (OPC & PPC) cement accordingly in the reach of 0%, 5%, 10%, 15% 20%, & 25% by weight of M-20 grade concrete. Concrete mixtures were developed, tested and compared in terms of compressive strength to the conventional concrete. The purpose of the investigation is to analyze the behavior of concrete while replacing the Marble Dust Powder with Different proportions in concrete.

KEYWORDS: *Cement, Concrete, Compressive Strength, Marble Dust Powder, Partial Replacement, Tensile Strength.*

I. Introduction

The purity of the marble is responsible for its color and appearance it is white if the limestone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration; marble is durable, has a noble appearance, and consequently in great demand Marble Dust Powder is an industrial waste produced from cutting of marble stone. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Marble as a building material especially in places 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 sizin g industry generally unattended for use in the bui lding industry itself as filler or plasticizer in morta r or concrete. One of the logical means for reduction of the waste marble masses calls for utilizing them in building industry itself. Marble powder is not available in all the places. Despite this fact, concrete production is one of the concerns worldwide that impact the environment with major impact being global warming due to CO_2 emission during production of cement. Waste Marble dust can be used to improve the mechanical and physical properties of the conventional concrete. Now-a-days the cost of material is increasing so if we use the waste material in the production of the concrete so we decrease the price. If the waste is disposed on soils, the porosity and permeability of topsoil will be reduced, the fine marble dust reduces the fertility of the soil by increasing its alkalinity. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans. In India, marble dust is settled by sedimentation and then dumped away which results n environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits.

II. LITRATURE REVIEW

1 Valeria (2005):He observed that marble dust powder had very high Balinen fineness value of about 1.5m2/g, with 90% of particles passing through 50 micron sieve and 50% through 7micron sieve. It was observed that marble powder had a high specific surface area.

2 Hanifi Binici (2007):It was found that marble dust powder have higher compressive strength than corresponding lime stone dust concrete having equal w/c and mix proportion.

3 Baboo Rai (2011):Baboo Rai have done their research on Influence of Marble dust powder/granules in Concrete mix. Partial replacement of cement and usual fine aggregates by varying percentage of marble powder reveals that increased waste marble powder result in increased workability and compressive strengths of the mortar and concrete.

4 Vaidevi C (2013):Vaidevi C found that the use of this waste was proposed in different percentages both as an addition to and instead of cement, for the production of concrete mixtures. The study showed the cost of these cementitious material decreases cost of construction when replaced by different percentages of MD. Compressive test and tensile tests were conducted. 10% replacement gives the best result and for every 10 bags of cement, the addition of 10% of marble dust saves 1bag of cement and 1 bag cost.

5 V.M.Sounthararajan (2013):By partial replacement of cement by MDP compressive strength, splitting tensile strength and flexural strength was evaluated. Fine to coarse aggregate ratio and cement to total aggregate had a higher influence on the improvement in strength properties. A phenomenal increase in the compressive strength of 46.80 MPa at 7 days for 10% replacement of marble powder in cement content.

6 Manju Pawar (2014):They found that the effect of using marble dust powder as constituents of fines 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. They found out the optimum percentage for replacement of marble dust powder with cement and it is almost 12.5 % cement for both cubes and cylinders further increase in % MDP compressive strength decreases.

OBJECTIVES

- To study the influence of partial replacement of cement to concrete with marble dust powder, and to determine the compressive strength and tensile strength of concrete

- To compare the results of normal concrete and partial replacement of cement by marble dust powder.

III. METHODOLOGY

3.1. General

This chapter deals with various studies that were carried out on plain concrete and concrete with CSA. Compression test is conducted on cubes of standard dimensions respectively. Based on the result of the tests conducted in the laboratory, conclusions are drawn.

3.2. Compressive Strength Test

3.2.1. General

Compressive strength test is carried out as per Indian Standard code IS 516: 1959 on plain concrete and concrete with CSA and results are tabulated and conclusions are drawn.

3.2.2. Specimen Preparation

3.2.2.1. Weighing of materials

Concrete is prepared for M_{20} mix, designed for plain concrete and concrete with CSA. Materials such as cement, fine aggregate, coarse aggregate and CSA are free from impurities are weighed with an accuracy of 5%, 10%, 15% and 20% of weight of cement.

3.2.2.2. Mixing of Materials

Concrete is mixed in a non absorbent clean platform i.e., in a mixing tray with a trowel. Initially fine aggregate is put into the platform following cement and fine aggregates for plain concrete. For concrete with CSA, initially fine aggregate is put into the mixing tray followed by mixture of cement and slag and then coarse aggregates are mixed properly.

At last required quantity of water as per water – cement ratio is added and mixed well within 2 minutes.

3.2.2.3. Mould Preparation

Mould is cleaned properly and greased with mould oil. Concrete is placed in the mould of dimension 150mm x 150mm x 150mm in 3 layers each layer of height approximately 50mm. After the placement of first layer of concrete it is compacted by a tamping rod of 16mm diameter, 0.6m long and bullet pointes at the lower end. The stroke of the bar is uniformly distributed over the cross section of the mould. Each layer is compacted with 25 strokes and next scoop of concrete is placed followed by same manner of compaction and top layer is finished.

3.2.3. Curing of Specimen

The test specimens are stored in place free from vibration, in moist air of at least 90% relative humidity and at a temperature of $27^0 \pm 2^0$ C for 24 hours from the time of addition of water to the dry ingredients. After this period, the specimens are marked and removed from the moulds and immediately submerged in cleaned fresh water and kept there until taken out just prior to test. The water in which the specimens are submerged, are renewed every seven days and maintained at a temperature of $27^0 \pm 2^0$ C. The specimens are not allowed to become dry at any time until they have been tested.

3.2.4. Method of Testing

Specimens are tested at the ages of 7 and 28 days. The specimens to be tested are taken out from water and wiped to remove excess water and grit present on the surface. 3 specimens are tested for each type of mix at specific age. Cubes are placed on the compression testing machine of 200 tons capacity such that the marked face faces the observer and load is applied on the specimen and increased at the rate of 140kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no freater load can be sustained. Maximum load applied to the specimen was recorded and compressive strength of the concrete is found out using the relation,

$$\text{Compressive strength} = \frac{P}{B \times D}$$

3.3. Materials Used and test on Materials

3.3.1. General

The chapter deals with the materials collection, which were used in the investigation. It also explains the various experimental investigations carried out for physical and chemical properties to understand the behavior.

3.3.2. Cement: Cement is a fine powder, which when mixed with water and allowed to set and harden, is capable of uniting fragments or masses of solid matter together to produce a mechanically strong material. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cement i.e. Portland cement harden because of hydration. The most common cement used is ordinary Portland cement. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. Many tests were conducted to cement, some of them are consistency tests, setting tests, soundness tests, etc.

Composition of Ordinary Portland Cement

Oxides	OPC
SiO_2	20.98%
Al_2O_3	5.42%
Fe_2O_3	3.92%
CaO	62.85%
MgO	1.76%
Na_2	0.28%
K_2O	0.53%
SO_3	2.36%
Loss of ignition	1.90%

3.3.3. Tests on cement paste

3.3.3.1. Fineness

Fineness or particle size of Portland cement affects hydration rate and thus the rate of strength gain. The smaller the particle size greater will be the surface area-to-volume ratio and thus more area available for water-cement interaction per unit volume.

3.3.3.1.(A) By Hand Sieving

Weigh accurately 100gms of cement and take it on a standard IS sieve 90µ. Break down the air set lumps with fingers. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes. Weigh the residue left in the sieve. Determine the fineness of cement by using the relation W_2/W_1X100.

Where,

W_1 = Initial weight of the cement sample.

W_2 = Weight of residue left on the sieve.

3.3.3.1.(B) By Mechanical Sieving

Weigh accurately 100gms of cement and take it on a standard IS sieve 90µ. Break down the air set lumps with fingers. Place a pan at the bottom and cover the top of sieve by a lid. Fix the setup to a mechanical sieve shakes. Continuously sieve the sample for a period of 15 minutes.

Table 1: Fineness of cement by hand sieving

Hand Sieving	1	2
Weight of cement taken (W_1) in gms	100	100
Weight of residue retained on 90µ sieve (W_2) in gms	8.87	8.73
Percentage fineness of Cement=(W_2/W_1)X100	8.87	8.73

Table 2: Fineness of cement by Mechanical Sieving

Mechanical Sieving	1	2
Weight of cement taken (W_1) in gms	100	100
Weight of residue retained on 90µ sieve (W_2) in gms	8	8
Percentage fineness of Cement=(W_2/W_1)X100	8	8

3.3.3.2. Specific gravity of cement

AIM: To determine the specific gravity of cement by using density bottle.

APPARATUS REQUIRED: Density bottle, Distilled water, weighing balance and cement.

PROCEDURE:

1. Weigh the clean empty dry Density bottle along with cap and note down it as W_1 gms.
2. Fill the Density bottle 1/3rd of height by cement and note down the weight as W_2 gms.
3. Fill the remaining by kerosene completely and note down the weight as W_3 gms.
4. Empty the Density bottle, clean it. Fill completely with kerosene and note down the weight as W_4 gms.
5. Empty the Density bottle, clean it. Fill completely with water and note down the weight as W_5 gms.
6. Specific gravity can be calculated by using the formula.

Table3: Specific gravity of cement

Particulars	1	2	3
Weight of empty bottle (W_1) gms	27	27	27
Weight of empty bottle + 1/3rd of cement (W_2) gms	47.11	42.95	43.19
Weight of bottle + cement + Kerosene (W_3) gms	81	82	82
Weight of bottle + kerosene (W_4) gms	66	66	66
Weight of bottle + water (W_5) gms	76	76	76
Specific gravity of kerosene, $G_k = \frac{(W_4-W_1)}{(W_5-W_1)}$	0.799	0.799	0.799
Specific gravity of cement wrt kerosene $G_{ck} = \frac{(W_2-W_1)}{(W_4-W_1)-(W_3-W_2)}$	3.92	3.90	3.93
Specific gravity of cement $G = G_k \times G_{ck}$	3.13	3.12	3.14
Average Specific gravity of cement = 3.13			

The Specific gravity of cement = 3.13

3.3.3.3. Standard consistency of cement paste

The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point of 7mm from the bottom of the Vicat mould, when the cement paste is tested in a standard manner as explained below.

1. Type of cement: Ultra-tech cement
2. Grade of cement: Ordinary Portland cement 43 grade.
3. Type of cement: consistency test.

Table4: Standard consistency of a cement paste

Trail No	Weight of cement taken (gms)	Percentage of water added	Quantity of water in (ml)	Penetration in (mm)
1	400	25	100	0
2	400	26	104	7
3	400	27	108	9
4	400	28	112	13
5	400	29	116	28
6	400	30	120	37

Percentage of water required to make cement paste = 30%

3.3.3.4. Setting time

Cement paste setting time is affected by a number of items including cement fineness, water-cement ratio, chemical content and admixtures. Setting tests are used to characterize how a particular cement paste sets. For construction purposes, the initial set must not be too soon and the final set must not be too late. Additionally, setting times can give some indication of whether or not cement is undergoing normal hydration. Normally, two setting times are defined.

1. Initial set: Occurs when the paste begins to stiffen considerably.
2. Final set: Occurs when the cement has hardened to the point at which it can sustain some load.
   Initial setting time = 50 minutes

Final setting time = 370 minutes

3.3.3.5. Strength

Cement paste strength is typically defined in three ways: Compressive, tensile and flexural. The strengths can be affected by a number of items including water-cement ratio, cement-fine aggregate ratio, type and grading of fine aggregate, manner of mixing and moulding specimens, curing conditions, size and shape of specimens, moisture content at time of test, loading conditions and age. Since cement gains strength over time, the time at which strength test is to be conducted must be specified. Typically times are 7 days, 14 days, and 28 days when considering cement paste strength tests.

3.3.4. Coarse aggregate

The coarse aggregates can be classified into six groups of shapes namely cubically and angular for high quality aggregates while irregular, flaky and elongated are classified as low quality aggregate. As far as coarse aggregate is concerned, equidimensional shape of particle is preferred because particles which significantly depart from such a shape have larger surface area and pack in an anisotropic manner. Two types of particles which depart from equidimensional shapes are elongated and flaky. The latter type can also affect adversely the durability of concrete because; flaky particles tend to be oriented in one plane, with bleeding water and air voids forming underneath.

3.3.5. Tests on coarse aggregate

3.3.5.1. Specific gravity of coarse aggregate

AIM: To determine the specific gravity of coarse aggregate by using Pycnometer.

APPARATUS REQUIRED: Pycnometer, Distilled water, weighing balance and coarse aggregate.

PROCEDURE:

1. Weigh the clean empty dry Pycnometer along with its conical cap and note down it as W_1 gms.
2. Fill the Pycnometer 1/3rd of height by coarse aggregate and note down the weight as W_2 gms.
3. Now add some amount of water into the Pycnometer and shake well to remove the entrapped air.
4. Fill the remaining by water completely up to brim level and note down the weight as W_3 gms.
5. Empty the Pycnometer, clean it. Fill completely with water and note down the weight as W_4 gms.
6. Specific gravity can be calculated by using the formula.

Table5: Specific gravity of coarse aggregate

Particulars	1	2	3
Weight of empty Pycnometer (W_1) gms	620	620	620
Weight of empty Pycnometer + 1/3rd of coarse aggregate (W_2) gms	1030	1110	1070
Weight of Pycnometer + coarse aggregate + Water (W_3) gms	1740	1770	1770
Weight of Pycnometer + Water (W_4) gms	1490	1490	1490
Specific gravity of coarse aggregate, $G = \frac{(W_2-W_1)}{(W_4-W_1)-(W_3-W_2)}$	2.56	2.33	2.64

The Specific gravity of coarse aggregate = 2.51

3.3.5.2. Sieve analysis of coarse aggregate

AIM: To determine the fineness modulus of coarse aggregate.

APPARATUS REQUIRED: IS sieve 40mm, 20mm, 16mm, 12.5mm, 10mm, 8mm, 6.3mm empty pan, weighing balance with weights.

PROCEDURE:

1. Take 5kgs of mixed coarse aggregate and remove the organic particles.
2. Take the sieves IS 40mm, 20mm, 16mm, 12.5mm, 10mm, 8mm, 6.3mm and arrange them in descending order. Keep the pan below and cover the top.

3. Fix the sieves in sieve shaking machine with pan at bottom and cover at top. Place the coarse aggregate in top sieve before fixing to sieve shaking machine.
4. Carry out sieving in set of sieves as arranged for a period not less than 15 min.
5. Find out the weight of retained materials on each sieve and pan.
6. Finally calculate fineness modules of coarse aggregate.

Table 6: Sieve Analysis of coarse aggregate

Sl.no	IS Sieves (mm)	Weight retained (W) gms	% weight retained (W/5000)X100	Cumulative % retained (C)	% Finer N = (100 – C)
1	20	330	6.6	6.6	93.4
2	12.5	4285	85.70	92.3	7.7
3	10	355	7.1	99.4	0.6
4	4.25	20	0.4	99.8	0.2
5	Pan	10	0.2	100	0

$\sum n = 398.1$

Fineness modulus of coarse aggregate $S_C = \frac{\text{Cummulative percentage weight retained}}{100}$

$= 398.1/100 = 3.98$

3.3.5.3. Water absorption of coarse aggregate

AIM: To determine the percentage of water absorption of coarse aggregate.

APPARATUS REQUIRED: Weighing balance, pan, clean and dry cloth.

PROCEDURE:

1. Take a representative sample of 1kg dried in oven for 24 hours.
2. Clean the aggregate thoroughly in a dry trowel. This eliminates major problem of the very fine materials.
3. Weigh the sample and take it as W_1 grams.
4. Place the weighed sample in a pan and pour cover completely with water for 24 hours.
5. Drain the water from sample using dry cloth and weigh it as W_2 grams.

Table 7: Water absorption of coarse aggregate

Sl.No	Particulars	Weight in gms
1.	Weight of oven dried coarse aggregate ,W1	500
2.	Weight of coarse aggregate after 24hrs covered in water , W2	502.5
3.	Water absorption, $W=\frac{(W2-W1)}{W1}X100$	0.5%

Table 8: Free moisture

Sl.No,	Particulars	Weight in gms
1	Empty wt of cup , W1	378
2	Weight of saturated FA , W2	1003
3	Wt after oven drying	993.13

% FA=1%

3.3.6. Fine aggregate

Locally available free of debris and nearly riverbed sand is used as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to Zone II as per the Indian standards. Those fractions from 4.75mm to 150µ are termed as fine aggregate.

3.3.7. Tests on fine aggregate

3.3.7.1. Specific gravity of fine aggregate

AIM: Determine the specific gravity of fine aggregate by using Pycnometer.

APPARATUS REQUIRED: Pycnometer, Distilled water, weighing balance and fine aggregate.

PROCEDURE:

1. Weigh the clean empty dry Pycnometer along with its conical cap and note down it as W_1 gms.
2. Fill the Pycnometer 1/3rd of height by fine aggregate and note down the weight as W_2 gms.
3. Now add some amount of water into the Pycnometer and shake well to remove the entrapped air.
4. Fill the remaining by water completely up to brim level and note down the weight as W_3 gms.
5. Empty the Pycnometer, clean it. Fill completely with water and note down the weight as W_4 gms.

6. Specific gravity can be calculated by using the formula.

Table 9: Specific gravity of fine aggregate

Particulars	1	2	3
Weight of empty Pycnometer (W_1) gms	620	620	620
Weight of empty Pycnometer + 1/3rd of fine aggregate (W_2) gms	1030	1110	1070
Weight of Pycnometer + fine aggregate + Water (W_3) gms	1770	1770	1770
Weight of Pycnometer + Water (W_4) gms	1490	1490	1490
Specific gravity of fine aggregate, $G = \frac{(W_2-W_1)}{(W_4-W_1)-(W_3-W_2)}$	2.56	2.33	2.64

The Specific gravity of fine aggregate = 2.51

3.3.7.2. Sieve analysis of fine aggregate

AIM: Determine the fineness modulus of fine aggregate.

APPARATUS REQUIRED: IS sieve 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ and empty pan, weighing balance with weights.

PROCEDURE:

1. Take 2kgs of mixed fine aggregate and remove the organic particles.
2. Take the sieves 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ and arrange them in descending order. Keep the pan below and cover the top.
3. Fix the sieves in sieve shaking machine with pan at bottom and cover at top. Place the fine aggregate in top sieve before fixing to sieve shaking machine.
4. Carry out sieving in set of sieves as arranged for a period not less than 15 min.
5. Find out the weight of retained materials on each sieve and pan.
6. Finally calculate fineness modules of fine aggregate.

Table 10: Sieve Analysis of fine aggregate

Sl. no	**IS Sieves (mm)**	**Weight retained (W) gms**	**% weight retained (W/5000)X100**	**Cumulative % retained (C)**	**% Finer N = (100 – C)**
1	4.75	10	1	1	99
2	2.36	32	3.2	4.2	95.8
3	1.18	273	27.3	31.5	68.5
4	60µ	365	36.5	68	32
5	300µ	264	28.4	96.4	3.6
6	150µ	34	3.4	99.8	0.2
7	Pan	2	0.2	100	0

$\sum n = 400.9$

Fineness modulus of fine aggregate $S_C = \frac{\text{Cummulative percentage weight retained}}{100}$

= 400.9/100

= 4.009

3.3.7.3. Water absorption of fine aggregate

AIM: To determine the percentage of water absorption of fine aggregate.

APPARATUS REQUIRED: Weighing balance, pan, clean and dry cloth.

PROCEDURE:

1. Take a representative sample of 1kg dried in oven for 24 hours.
2. Clean the aggregate thoroughly in a dry trowel. This eliminates major problem of the very fine materials.
3. Weigh the sample and take it as W_1 grams.
4. Place the weighed sample in a pan and pour cover completely with water for 24 hours.
5. Drain the water from sample using dry cloth and weigh it as W_2 grams.

Table 11: Water absorption of fine aggregate

Sl.No	**Particulars**	**Weight in gms**
1.	**Weight of oven dried fine aggregate ,W1**	500
2.	**Weight of fine aggregate after 24hrs covered in water , W2**	505.45
3.	**Water absorption, $W=\frac{(W2-W1)}{W1}X100$**	1%

Table 12: Free Moisture

Sl.No	**Particulars**	**Weight in gms**
1	**Empty wt of cup , W1**	**276**
2	**Wt of saturated FA , W2**	**776**
3	**Wt after oven drying**	**765.10**

FM=1.4%

4.3.8.Marble dust powder

Marble powder: Marble powder was collected from the dressing and processing unit in Hassan. It was sieved by IS-90 micron sieve before mixing in concrete.

IV. RESULTS AND DISCUSSIONS

Ratio = 1: 1.88 : 2.86

4.1. Quantity of materials required for cube

Volume of cube = (0.15 X 0.15 X 0.15) X 6

= 20.25×10^{-3} m^3

Mass of concrete = Density X Volume

= $2400 \times 20.25 \times 10^{-3}$

= 48.6 kg

Add 20% extra dry material = 48.6 X 1.2

= 58.32 kg

4.1.1. For normal concrete

Amount of cement = $\frac{1}{5.74}$ X 58.32

= 10.16 kg

Amount of fine aggregate = $\frac{1.67}{5.74}$ X 58.32

= 16.96 kg

Amount of coarse aggregate = $\frac{2.99}{5.74}$ X 58.32

= 30.37 kg

Water content = 0.5 X 10.30 = 5080 ml

4.1.2. For 5% replacement

MDP = $\frac{5}{100}$ X 10.16 = 508g

Cement = 10.16 – 0.508 = 9.652 kg

Fine aggregate = 16.96 kg

Coarse aggregate = 30.37 kg

4.1.3. For 10% replacement

MDP = $\frac{10}{100}$ X 10.16 = 1.016 kg

Cement = 10.16 – 1.016 = 9.144 kg

Fine aggregate = 16.96 kg

Coarse aggregate = 30.37 kg

4.1.4. For 15% replacement

MDP = $\frac{15}{100}$ X 10.16 = 1.524 kg

Cement = 10.16 – 1.524 = 8.636 kg

Fine aggregate = 16.96 kg

Coarse aggregate = 30.37 kg

4.2. Quantity of materials required for cylinder

Volume of cube = (Area of circle X height) X 6

= $\left(\frac{\Pi \times 100^2}{4}\right)$ 220 X 6

= 10.36×10^{-3} m^3

Mass of concrete = Density X Volume

= $2400 \times 10.36 \times 10^{-3}$

= 24.864 kg

Add 20% extra dry material = 24.864 X 1.2

= 29.83 k

4.2.1.For normal concrete

Amount of cement = $\frac{1}{5.74}$ X 29.83 = 5.19 kg

Amount of fine aggregate = $\frac{1.67}{5.74}$ X 29.83 = 8.67 kg

Amount of coarse aggregate = $\frac{2.99}{5.74}$ X 29.83 = 15.53 kg

Water content = 0.5 X 5.19 = 2595 ml

4.2.2. For 5% replacement

MDP = $\frac{5}{100}$ X 5.19 = 259.5 g

Cement = 5.19– 0.259 = 4.931 kg

Fine aggregate = 8.67 kg

Coarse aggregate = 15.53 kg

4.2.3. For 10% replacement

MDP = $\frac{10}{100}$ X 5.19 = 519 g

Cement = 5.19 – 0.519 = 4.671 kg

Fine aggregate = 8.67 kg

Coarse aggregate = 15.53 kg

4.2.4. For 15% replacement

MDP = $\frac{15}{100}$ X 5.19 = 778.5 g

Cement = 5.19 – 0.778 = 4.412 kg

Fine aggregate = 8.67 kg

Coarse aggregate = 15.53 kg

4.3. Compressive strength

4.3.1. Normal concrete

Compressive strength of normal concrete

Sl. No	No of Days	Weight of Specimen(g)	Density kN/m^3	Failure load kN	Compressive strength MPa
1	7	8840	2619.20	370	15.62
		8670	2568.8	350	
		8730	2586.6	335	
2	28	8270	2450.3	560	24.51
		8530	2527.4	545	
		8700	2577.7	550	

4.3.2. Concrete with 5% replacement of cement by MDP

Compressive strength of concrete with 5% replacement of cement by MDP

Sl. No	No of Days	Weight of Specimen (g)	Density KN/m³	Failure load KN	Compressive strength Mpa
1	7	8550	2533.33	340	16.59
		8580	2542.22	415	
		8650	2562.96	365	
2	28	8490	2515.5	640	26.81
		8680	2517.8	570	
		8710	2580.7	600	

4.3.3. Concrete with 10% replacement of cement by MDP

Compressive strength of concrete with 10% replacement of cement by MDP

Sl. No	No of Days	Weight of Specimen(g)	Density KN/m³	Failure load KN	Compressive strength Mpa
1	7	8550	2533.33	380	18.66
		8580	2542.22	450	
		8650	2562.96	430	
2	28	8490	2515.5	650	28.88
		8680	2517.8	640	
		8710	2580.7	660	

4.3.4. Concrete with 15% replacement of cement by MDP

Compressive strength of concrete with 15% replacement of cement by MDP

Sl. No	No of Days	Weight of Specimen(g)	Density KN/m³	Failure load KN	Compressive strength Mpa
1	7	8550	2533.33	260	13.32
		8580	2542.22	350	
		8650	2562.96	290	
2	28	8490	2515.5	480	20.07
		8680	2517.8	435	
		8710	2580.7	440	

4.4. Split tensile strength

4.4.1. Normal concrete

Tensile strength of normal concrete

Sl. No	No of Days	Weight of specimen	Density KN/m³	Failure load KN	Tensile strength Mpa
1	7	4357	2773.75	40	1.19
		4250	2707.00	45	
		4367	2781.52	39	
2	28	4300	2737.47	80	2.36
		4350	2769.29	75	
		4400	2801.13	90	

4.4.2. Concrete with 5% replacement of cement by MDP

Tensile strength of concrete with 5% replacement of cement by MDP

Sl. No	No of Days	Weight of specimen	Density KN/m³	Failure load KN	Tensile strength Mpa
1	7	4390	2796.76	50	1.64
		4410	2808.91	60	
		4455	2837.57	55	
2	28	4390	2796.76	90	2.55
		4450	2832.96	90	
		4490	2858.42	85	

4.4.3. Concrete with 10% replacement of cement by MDP

Tensile strength of concrete with 10% replacement of cement by MDP

Sl. No	No of Days	Weight of specimen	Density KN/m³	Failure load KN	Tensile strength Mpa
1	7	4225	2691.08	65	1.95
		4286	2729.93	46	
		4360	2777.07	92	
2	28	4290	2731.09	100	2.69
		4350	2769.2	95	
		4460	2839.3	85	

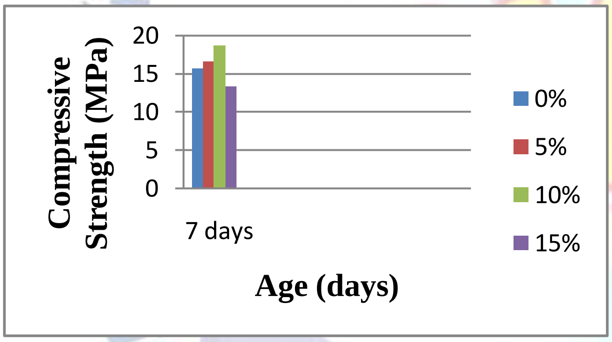
4.4.4. Concrete with 15% replacement of cement by MDP

Tensile strength of concrete with 15% replacement of cement by MDP

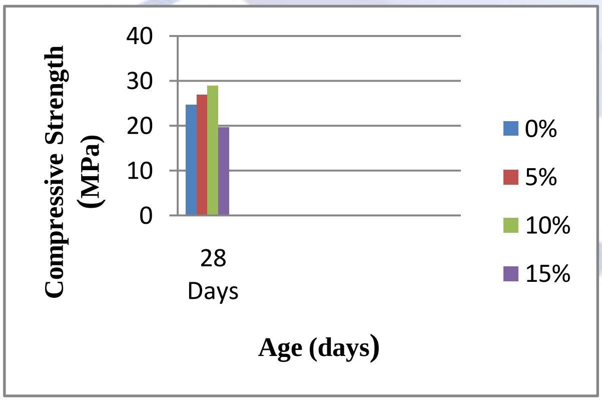
Sl. No	No of Days	Weight of specimen	Density KN/m³	Failure load KN	Tensile strength Mpa
1	7	4010	2554.14	39	1.05
		4190	2668.78	35	
		4280	2726.11	35	
2	28	4120	2622.8	70	2.07
		4240	2699.2	65	
		4360	2775.6	80	

4.5. Graphs

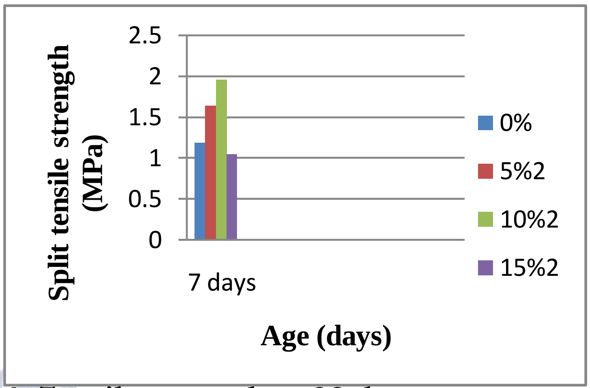
4.5.1. Compressive strength at 7 days



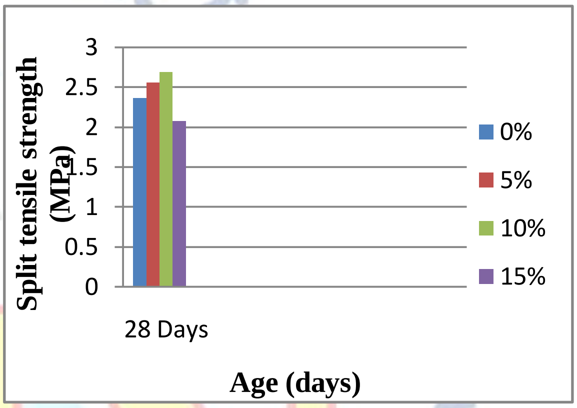
4.5.2. Compressive strength at 28 days



4.5.3. Tensile strength at 7 days



4.5.4. Tensile strength at 28 days



APPENDIX

DESIGN STIPULATION FOR PROPORTIONING OF M20

The design of concrete mix is done as per guidelines of IS 10262:2009.

Grade Designation	:	M20
Type of Cement	:	Ordinary Portland Cement 43 grade
Maximum nominal size of aggregate	:	20mm down size
Minimum cement content	:	300 kg/m³
Degree of supervision	:	Good
Workability	:	25 – 50 mm (Slump)
Exposure Condition	:	Moderate
Type of Aggregate	:	Crushed Angular aggregate
Maximum cement content	:	450 kg/m³
Chemical admixture	:	Not recommended

Test data of materials

- Cement used : OPC 43 grade confirming of IS 8112
- Specific Gravity
  - Cement : 3.11
  - Coarse aggregate : 2.51
  - Fine aggregate : 2.59
- Water absorption
  - Coarse aggregate : 0.2%
  - Fine aggregate : 0.5%
- Free (surface) moisture
  - Coarse aggregate : 1% Nil (absorbed moisture full)
  - Fine aggregate : 1.4%Nil
- Sieve analysis
  - Coarse aggregate : Confirming to Table-2 of IS 383
  - Fine aggregate : Confirming to Zone-I of IS 383

Target strength for mix proportioning

f'ck = fck + 1.65 S

Where,

f'ck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days,

S= Standard deviation From Table 1 standard deviation, s = 5 N/mm²,

Therefore, target strength = 20 + 1.65 x 4 = 26.6 N/mm²

Selection of water cement ratio

From Table 5 of IS:456-2000

Maximum water cement ratio = 0.50

Hence ok

Selection of water content

From Table-2 of IS:456-2000

Maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates)

Calculation of cement content

Water-cement ratio = 0.5

$$\text{Cement content} = \frac{\text{Maximum water content}}{\text{Water -cement ratio}}$$

$$= \frac{186}{0.5}$$

$$= 372 \text{ kg/m}^3 > 300 \text{ kg/m}^3$$

Hence Ok.

Proportion of volume of coarse aggregate and fine aggregate

Fine aggregate = Zone I

Coarse aggregate = 20mm (down size)

W/C = 0.5

For every decrease of 0.05 w/c, CA raised by 0.01 for 0.5 w/c

Volume of coarse aggregate = 0.6+0.01
= 0.61

Volume of fine aggregate = 1-0.61
=0.39

Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m³

b) Volume of cement = (Mass of cement/Specific gravity of cement)x(1/1000)

$$= \frac{372}{3.11} \times \frac{1}{1000}$$

= 0.119 m³

c) Volume of water = (Mass of water/specific gravity of water)x(1/1000)

$$= \frac{186}{1} \times \frac{1}{1000}$$

0.816 m³

d) Volume of all in aggregates = [a-(b+c)]
= [1-(0.119+0.186)]
= 0.695 m³

e) Mass of coarse aggregate = d x Volume of coarse aggregate x Specific gravity of coarse aggregate x 1000
= 0.695 x 0.610 x 2.51 x 1000
= 1064.11 kg

f) Mass of fine aggregate = d x Volume of fine aggregate x Specific gravity of fine aggregate x 1000
= 0.695 x 0.39 x 2.59 x 1000
= 702.01 kg

Mix proportion / m³

Cement = 372 kg/m³

Water = 186 kg/m³
Fine aggregate = 702.01 kg/m³
Coarse aggregate = 1064.11 kg/m³
Water – cement ratio = 0.5

Ratio = 1 : 1.88 : 2.86

Adjustment of water content

$$= 186 + \left(\frac{0.2\times1064.11}{100} + \frac{0.5\times702.01}{100}\right) - \left(\frac{1\times1064.11}{100} + \frac{1.4\times702.01}{100}\right)$$

= 171.16

Adjustments for water absorption

For CA = 1.0%

$= \frac{1.0}{100}$ X 1124.65

= 11.25 kg/m³

For FA = 2.0%

$= \frac{2.0}{100}$ X 633.84

= 12.68 kg/m³

Water content = 186 + 11.25 + 12.68 = 209.93 kg/m³

Coarse aggregate = 1124.65 – 11.25 = 1113.4 kg/m³

Fine aggregate = 633.84 – 12.68 = 621.16 kg/m³

Final mix proportion

Cement	**Fine Aggregate**	**Coarse Aggregate**	**Water**
327 kg/m³	702.01 kg/m³	1064.11 kg/m³	171.13 kg/m³
1	**1.88**	**2.86**	**0.523**

Ratio = 1: 1.88 : 2.86

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[4] Shirule, Ataur Rahman , Rakesh D. Gupta PARTIAL REPLACEMENT OF CEMENT WITH MARBLE DUST POWDER Prof. P.A. Address for Correspondence a*bc Dept. Of Civil Engineering, SSBT's COET, Bambhori, Jalgaon, Maharashtra – 425001