EFFECT OF SUPPLEMENTARY CEMENTITIOUS MATERIALS AS PARTIAL CEMENT REPLACEMENTS ON CONCRETE PROPERTIES

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ABSTRACT

Ordinary Portland cement is the highest produced cement type in the world, however its production is high energy consumption means expensive, huge natural resource consumptive, and creating high environmental pollution. Hence many researchers studied to reduce the effect of ordinary Portland cement by substituting artificial and natural supplementary cementitious materials (SCMs) commonly in a concrete/mortar mixture. However, the comprehensive effect of different SCMs on various properties of cement composite materials are not well known. So the present study sought to review the effect of different natural and artificial SCMs on the durability and mechanical properties of cement composites, especially due to their doses, types, chemical composition, and physical properties. Hence the review shows that many SCMs used by literatures from different places satisfy ASTM replacement standard based on their chemical compositions. Also, the review indicated as adding 5–20% of different SCMs positively affect mechanical properties, durability, and microstructures of the cement composite materials, specifically as most researchers found isolately adding of 15% SCMs such as bentonite, kaolin, and biomass, 20% addition of volcanic ash and 10% employment of fly ash, silica fume, and zeolite to the cement composites achieves the most optimum compressive and split tensile strength. These observations reveal that most natural pozzolana can more replace cement to give optimum strength, hence can more reduce energy consumption, production cost, and environmental pollution comes due to cement production. Furthermore, most researchers found employing different SCMs generally improves durability, however there is a limited study on the effect of silica fume on water absorption and acidic attack resistance of cementitious materials. Therefore, it is recommended that future research should also focus more to know the effect of silica fume on the durability of cement composites.

I. INTRODUCTION

1.1 General

In construction Industry, consumption of cement is increasing day by day as well as cost is also increasing so to reduce the consumption of cement, partial replacement with Metakaolin and Marble powder was done in this study. Metakaolin is a calcinied clay and easily available in Gujarat, Maharashtra & Bombay etc. It is a Dehydroxylated form of the clay mineral Kaolinite. Stone having higher percentage of Kaolinite are known as china clay or kaolin was traditionally used in the manufacture of porcelain i.e. ceramic material. The particle size of Metakaolin is smaller than cement particles. Marble dust is obtained from cutting and manufacturing industries of marble. In India near about 3500 metric tons of marble dust slurry per day is generated. So, Marble dust is very easily available with very less cost. Some of industries used to wash out this marble powder with water in natural streams which cause water pollution and is harmful for our environment. So, it is advisory to use marble dust as partial replacement with cement as it has properties similar to cement and one of good pozzolanas. Similarly use of Metakaolin leads to Green concrete, because during production of Metakaolin concrete there is no emission of carbon dioxide Since there is large emission of carbon dioxide in manufacturing of cement and clinker, results in 3-5% increase in greenhouse gasses and global warming.

1.1.1 Marble dust

It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that sparkle in rock surfaces. The crushed marble powder used in the experiments is in a form of white powdered, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to 45µm

Figure-2: Marble dust waste from construction Industry.

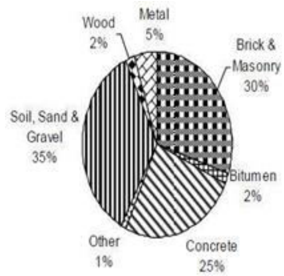


Figure-3: Different constituents of C&D waste.

1.2 Scope of the Work

The aim of the present study is to use naturally available and low cost metakaoline and marble dust as a partial replacement to cement in concrete and to recycle the Construction waste materials so that to reduce environmental pollution.

1.3 Objectives of the Research

Objectives of the study as follows:

- To study mechanical properties such as compressive strength at the end of 7, 14 and 28 days of curing by partially replacing cement with metakaoline and marble powder under normal curing.
- To reduce environmental Pollution
- To study the properties of fresh pollution by utilizing waste material in concrete.
- To make Eco-friendly concrete
- concrete this is cast by using metakaolin and marble dust
- To study the properties of fresh concrete this is cast by using metakaoline and marble dust.

II. LITERATURE REVIEW

Abdullah Anwar et.al (2014) : In this paper the authors represented that Marble Dust Powder has replaced the (OPC&PPC) cement of 0%, 5%, 10%, 15% 20%, & 25% by weight & M-20 grade concrete was used. Concrete is M30. 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. The result obtained for 28-day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10% for (PPC) and (OPC). This will post less on the production of carbon dioxide and solving the environmental pollution by cement production there by enhances the urban surroundings.

Sanjay N. Patil et,al (2014) : The paper deals with the use of Metakaolin which is having good pozzolanic activity and is a good material for the production of high strength concrete. Use of MK is getting popularity because of its positive effect on various properties of concrete. Literature Review shows that optimal performance is achieved by replacing 7% to 15% of the cement with Metakaolin and when use of MK is less than 10% , then the benefits are not fully realized so at least 10% Metakaolin should be used. Values of compressive strength of concrete with Metakaolin after 28 days can be higher by 20%. Dosage of 15% of Metakaolin causes decrease of workability. So increasing amount of perceptual proportion of Metakaolin in concrete mix seems to require higher dosage of super plasticizer to ensure longer period of workability.

J.M. Khatib et.al(2012) : In the paper author studied the compressive strength, density and ultrasonic pulse velocity of mortar containing high volume of Metakaolin (MK) as partial substitution of cement. In this paper up to 50% of MK was used to replace cement in increment of 10. After De-molding, specimens were cured in water at 20°C for a total period of 28 days. The density seems to reduce with the increase of MK content especially at MK content above 30%.The strength increases as the MK content increases up to about 40% MK with a maximum strength occurring at 20% where the strength is 47% higher. At 50% the strength start reducing, 10% and the 30% MK mixes exhibit an increase in strength of around 37%.

Prof. P.A. Shirule et.al (2012) : The paper described the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. The Compressive strength of Cubes & Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replaced by weight and it was also observed that 10% replacement gave optimum percentage of strength

B.B.Sabir et.al (2001) : The paper described the partial replacement of cement with the Metakaolin in concrete and mortar, which causes great improvement in the pore structure and hence resistance of concrete to harmful solutions. The paper also demonstrated clearly that MK is very effective pozzolanas and result enhanced early strength with no detriment to, and some improvement in the long term strength. Mortar and concrete were observed as great improvement in resistance to the transportation of water and diffusion ions which lead to degradation of matrix.

A. ManjuPawar et.al (2014): A Study has been conducted on Periodic Research, The Significance of Partial replacement of Cement with Waste Marble Powder. They found that the effect of using marble 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. Partial replacement of cement by varying percentage of marble powder reveals that increased waste marble powder (WMP) ratio result in increased strengths of the mortar and concrete .Leaving the waste materials to the environment directly can cause environmental problem. Hence the result, The Compressive strength of Concrete are increased with addition of waste marble Powder up to12.5 % replace by weight of cement and further any addition of WMP the compressive strength decreases. The Tensile strength of Concrete are increased with addition of waste marble powder up to 12.5 % replace by weight of cement and further any addition of WMP the Tensile strength decreases. Thus they found out the optimum percentage for replacement of MDP with cement and it is almost 12.5 % cement for both compressive & tensile strength.

III. TESTS ON MATERIALS

3.1. Materials

3.1.1. Cement: cement is a binding material invented by Joseph Aspdin in 1824. It is manufactured from calcareous materials, such as limestone or chalk, and argillaceous material such as shale and clay.

3.1.2. Coarse Aggregate: I f the size of aggregate is bigger than 4. 75 mm, then the

aggregate is considered as coarse aggre gate.
Eg: Stone, ballast, gravel, brick ballast.

3.1.3. Fine Aggregate: According to IS 383, most of the aggregate which will pass through 4. 75 mm IS sieve and entirely retained on 75 μ sieve is considered as fine aggregate.
Eg: Sand crushed stone, ash or cinder and surkhi.

3.1.4. Water: water is the main ingredient used to mix all t he contents. Potable water is used as usage of any other water may contain salts and cause decrease in strength of concrete.

3.1.5 Metakaolin

Metakaoline is a pozzolanic probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC.

Figure 3.1: Metakaoline powder

3.1.6 Marble dust powder: It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that sparkle in rock surfaces. The crushed marble powder used in the experiments is in a form of white powdered marble flour, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to 45µm

One of the major wastes produced in the stone industry during cutting, shaping, and polishing of marbles is the MDP. During this process, about 20-25% of the process marble is turn into the powder form. India being the third (about 10%) top most exporter of marble in the world, every year million tons of marble waste form processing plants are released. Due to the availability of large quantity of waste produced in the marble factory, this project has been planned and preceded.

Figure 3.2: marble dust powder

3.2 Tests on Cement

3.2.1 Specific Gravity of Cement

Specific gravity of the cement is calculated by using density bottle method.
Cement specific gravity: 3.12
The following is the procedure to find specific gravity of cement.
Aim: To determine the specific gravity of cement
Required Materials & Apparatus:

- Ordinary Portland Cement

- Kerosene
- Specific Gravity Bottle (100 ml)
- Weighing balance with 0.1 gm accurate

Calculation

Specific Gravity of cement

$$S_g = \left(\frac{W2 - W1}{(W2 - W1) - (W3 - W4) \times 0.79} \right)$$

Specific gravity of kerosene is **0.79 g/cc**

$$= \frac{(293.30 - 243.30)}{(293.30 - 243.30) - (365.35 - 322.30) * 0.79}$$

= 3.12

NOTE: All weights are in grams

Results

Specific gravity of cement with respect to water = 3.12.

3.2.2 Fineness test on cement:

The following procedure is used to find Fineness test on cement.

Aim: To determine the fineness of the given sample of cement by sieving.

Apparatus: IS-90 micron sieve conforming to IS: 460-1965, standard balance, weights, and brush.

Fig- 3.3 Sieve used for find fineness of cement

Observations:

S.No	Weight Of Sample Taken(G) W1	Weight Of Residue(G) W2	Residue (%) = (W2/W1)X100
1	100	2.15	2.15
2	100	2.16	2.16
3	100	2.16	2.16
Average percentage of residue = 2.16			

Table-3.1 – Observations of Fineness test on cement

Average fineness of cement =100 - 2.16 = 97.84%.

Result:

Fineness of test cement: 97.84%.

3.2.3 Standard consistency test

The standard consistency trial of cement is characterized as the consistency which allows vicat's plunger of distance across 10mm and 50mm length to penetrate to a profundity of 33 to 35mm from the highest point of the form. The fundamental point is to discover the amount of water content required to deliver a concrete glue of standard consistency according to the IS: 4031(Part 4) – 1988.

Standard consistency of bond: 32%

Aim: To determine the quantity of water required for produce a standard consistency of cement paste.

Apparatus:
Vicat's apparatus (conforming to IS: 5513 – 1976) with plunger (10 mm in diameter)
Balance, Gauging trowel

Fig 3.4-Vicat's Apparatus used for finding standard Consistency and initial and final Setting Times of Cement

Observations:

S. No	Weight of cement taken in gms (a)	Weight of water taken in gms (b)	Plunger penetration from bottom (mm)	Time Taken (mins)	Consistency of cement in % by weight b/a * 100
1	300	96	5	4	32
2	300	99	7	5	33
3	300	97	5	5	32.33

Table –3.2: Observations of standard consistency of cement

Average of standard consistency: 32%

Result: Normal consistency for the given sample of cement is 32%.

3.2.4 Initial and final setting time on cement

Initial and final setting time on cement is obtained by vicat`s apparatus, for the initial setting time of the cement vicat`s needle should penetrate to a depth of 33 to 35mm from the top, for final setting time the vicat`s needle should pierce through the paste more than 0.5mm. The initial and final setting time as per IS: 4031(Part 5)-1988.

Aim: To determine the initial and final setting times for the given sample of cement.

Determination of Initial Setting Time

1. Place and take a look at blocks restrained in the mildew and relaxation it on the non-porous plate, under the rod bearing preliminary putting needle, decrease the needle lightly in touch with the surface of the check block and quick launch, allowing it to penetrate into the check block.
2. Within the beginning, the needle will absolutely pierce the test block.
3. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block to a point 5 to 7 mm measured from the bottom of the mould

shall be the initial setting time.

Determination of Final Setting Time

1. Replace the needle of the Vicat apparatus by the needle with an annular attachment.
2. The time shall be considered as final setting time, when we dropped the needle gently on to mould, the needle makes an impression there on, while the attachment fails to do so.

Observations:

Time in minutes	38	480
Height fails to penetrate in mm	6	0

Table – 3.3: Observations of initial and final setting times of cement

Results:

- Initial setting time for the given sample of cement = 38 min
- Final setting time for the given sample of cement = 480 min

3.3 TEST CONDUCTED ON METAKAOLIN

Metakaoline is a pozzolanic probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC.

3.3.1 Specific Gravity of Metakaolin

Specific gravity of the metakaolin is calculated by using density bottle method. The following is the procedure to find specific gravity of metakaolin.

Aim: To determine the specific gravity of Metakaolin

Required Materials & Apparatus:

- Metakaolin
- Kerosene
- Specific Gravity Bottle (100 ml)
- Weighing balance with 0.1 gm accurate

Tabulation:

4. Weigh of the empty flask(W1) = 245.30
5. Weigh of the flask with metakaolin (W2) = 296.30
6. Weigh of the flask with metakaolin and kerosene (W3) = 375.35
10. Weigh of the flask with full of kerosene up to top (W4) = 332.30

Calculation

Specific Gravity of cement

$$S_g = \left(\frac{W2 - W1}{(W2 - W1) - (W3 - W4) \times 0.79} \right)$$

Specific gravity of kerosene is **0.79 g/cc**

$$= \frac{(296.30 - 245.30)}{(296.30 - 245.30) - (375.35 - 332.30) * 0.79}$$

= 3.28

NOTE: All weights are in grams

Results

Specific gravity of metakaolin with respect to water = 3.28

Table3.4. Properties of Metakaoline

Properties	metakaoline
Specific gravity	3.28
Bulk density	1005kg/m3
Percentage of Void	41.83%
Fineness modulus	2.84

3.4 TEST CONDUCTED ON MARBLE DUST

3.4.1 Specific Gravity of Marble dust

One of the major wastes produced in the stone industry during cutting, shaping, and polishing of marbles is the MDP. During this process, about 20-25% of the process marble is turn into the powder form. India being the third (about 10%) top most exporter of marble in the world, every year million tons of marble waste form processing plants are released. Due to the availability of large quantity of waste produced in the marble factory, this project has been planned and preceded. Specific gravity of the marble dust is calculated by using density bottle method. The following is the procedure to find specific gravity of marble dust.

Aim: To determine the specific gravity of marble dust

Required Materials & Apparatus:

- Marble dust
- Kerosene
- Specific Gravity Bottle (100 ml)
- Weighing balance with 0.1 gm accurate

IV. EXPERIMENTAL METHODOLOGY

Tests on Fresh Concrete 4.1

Workability tests

4.1.1 Slump test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete.

The apparatus for conducting the slump test ess entially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions bottom diameter 20 cm, top diameter 10 cm, height 30cm. The thickness of metal sheet for the mould should not be thinner than 1. 6 mm. the internal surfa ce of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test.

The mould is then filled in four layers, each approximately1/4 of the height of the mould.

Each layer is tamped 25 t imes by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as SLUMP of concrete.

The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured and is taken as the slump of concrete. ASTM measures the center of the slumped concrete as the difference in height.

I f the concrete slumps evenly, it is called t rue slump. I f one half of the cone slides down, it is called shear slump. IS 456 - 2000 suggests that in the very low category of workability where strict control is necessary, measurement of workabilit y by determination of compaction factor will be more appropriate than slump.

Fig. 4. 1. Apparatus to determine the workabilit y of concrete (slump test)

4.1.2. Compaction factor test

The compaction factor test is designed primarily for use in t he laboratory. It is more precise and sensitive than the slump test and is mostly useful for very low workability concrete mixes.

Principle: To determine the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. Compaction factor is the ratio of the density actually achieved in the test to densit y of same concrete fully compacted.

The apparatus consists of upper hopper, lower hopper and cylinder. Upper and lower hoppers having, top internal diameter 25. 4 cm, bottom internal diameter 12. 7 cm, internal height 27. 9 cm. dimensions of cylinder are internal diameter 15. 2 cm, internal height 30. 5 cm. the sample of concrete to be tested is placed in the upper hopper up to the brim. The t rap door is opened so that the concrete falls in to the lower hopper. Then the t rap door of the lower hopper is opened so that the concrete falls in to t he cylinder. The excess concrete remaining above the top level of the cylinder is then cutoff and is the cylinder with concrete is weighed. It is considered as the Weight of Partially Compacted Concrete. The cylinder is emptied and then refilled with the same sample in 5 layers each layer is given 25 blows with a tamping rod for the sake of fully compaction. It is taken as the Weight of Fully Compacted Concrete.

Compaction Factor = weight of partially compacted concrete /weight of fully compacted concrete.

Fig. 4. 2 Apparatus for compaction factor test

4.2 Tests on Hardened Concrete 4.2.1.
Compression Test

Compression test is the most common test conducted on hardened concrete because most of t he desirable characteristic properties are qualitatively related to it s compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. The cube specimen is of the size 150 × 150 × 150 mm. The test is conducted on Universal Testing Machine.

The specimens are taken out from t he water tank and kept aside for sometime such that the specimens get dried up. The specimens need to get the measurements before the test ing. The platens of the testing machine were cleaned with a clean rag. Clean the surface of the specimen and place the specimen in t he test ing machine. The platen was lowered until the uniform bearing was obtained. The force was applied and increased continuously at a rate equivalent to 20MPa compressive stress per minute until the specimen failed. Record the maximum force from the test ing machine.

Fig. 4. 3 Setup for Compression Test

AIM: To determine the compressive strength of concrete specimens.

Apparatus:

- Compression testing machine (2000 KN)
- Curing tank.

- Balance (0-10 Kg)

Calculation:

Compressive strength is calculate using the following formula

Compressive strength (kg/cm2) = Wf / Ap

Where, Wf = Maximum applied load just before load, (N) Ap = Plan area of cube mould, (mm2)

4.2.2 Split Tensile Strength of concrete

This test method consists of applying a diametric compressive force along the length of a cylindrical concrete specimen at a rate that is within a prescribed range until failure occurs. This loading induces tensile stresses on the plane containing the applied load and relatively high compressive stresses in the area immediately around the applied load. Tensile failure occurs rather than compressive failure because the areas of load application are in a state of t r iaxial compression, thereby allowing them to withstand much higher compressive stresses t han would be indicated by a uniaxial compressive strength test result. The s ize of the specimen will be 150 mm diameter and 300 mm long.

AIM: To determine of the splitting tensile strength of cylindrical concrete specimens.

Apparatus:

Testing Machine – The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not more than ± 2 percent of the maximum load. Cylinders –The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982. Weights and weighing device, Tools and containers for mixing, Tamper (square in cross section) etc.

Fig. 4. 4 Setup for split tensile strength test

4.2.3 FLEXURAL STRENGTH TEST OF CONCRETE (IS: 516-1959):

AIM: TO determining the flexural strength of moulded concrete flexure test specimens. APPARATUS:

Testing Machine - The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not greater than ± 2 percent of the maximum load.

Beam Moulds - The beam moulds shall conform to IS: 10086-1982. The size shall be 10 × 10 × 50 cm may be used. Weights and weighing device, Tools and containers for mixing, Tamper (square in cross section) etc.

Fig 4.5 : Concrete Beam Specimen for Flexural Strength Test

V. RESULTS AND DISCUSSIONS

5.1 Introduction

Series of test was carried out on the concrete cylinder to obtain the strength characteristics concrete for potential application in high strength structural Concrete. This chapter discuss on the result that obtained from the testing. The results are such as slump test, compacting factor test, compression test, indirect tensile test and modulus of e last icit y.

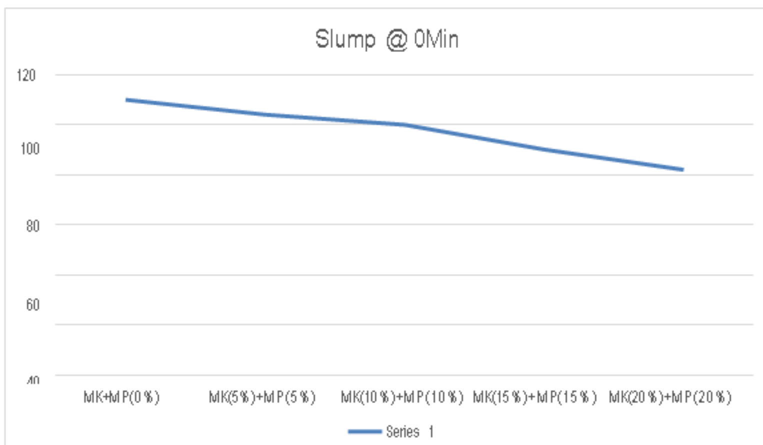
5.2 Slump Test Result and Analysis

The slump test indicates a decreasing t rend of workability when the percentage of metakaolin and marble dust increased. Table shows the average slump recorded during the test. Figure 5. 1 below shows a graphical repres entation of slump height. According to the result, the highest slump obtained was 110 mm and the lowest slump was 82 mm. the average slum for each batch of mix was 96 mm. therefore, target slump had been achieved, where the range is from 50 mm to 120 mm. The workability was good and can be sat isfactorily handle for 0% metakaolin and marble dust to 20% . The slump from 0% metakaolin and marble dust to 20% were considered moderate due to the drop in the range of 5 mm to 9mm.

Figure 5. 1 **:** Slump results at MK+ MP 0%, MK+ MP 5%, MK+ MP 10%, , MK+MP 15%, MK+ MP 20%

Table 5. 1 slump values

	MK+ MP 0%	MK+ MP 5%	MK+ MP 10%	MK+ MP 15%	MK+ MP 20%
Slump @ 0Min	110 mm	104 mm	100 mm	90 mm	82 mm
Slump @ 30Min	98 mm	98 mm	94 mm	88 mm	75 mm



Graph 5. 1 : slump@ 0 min

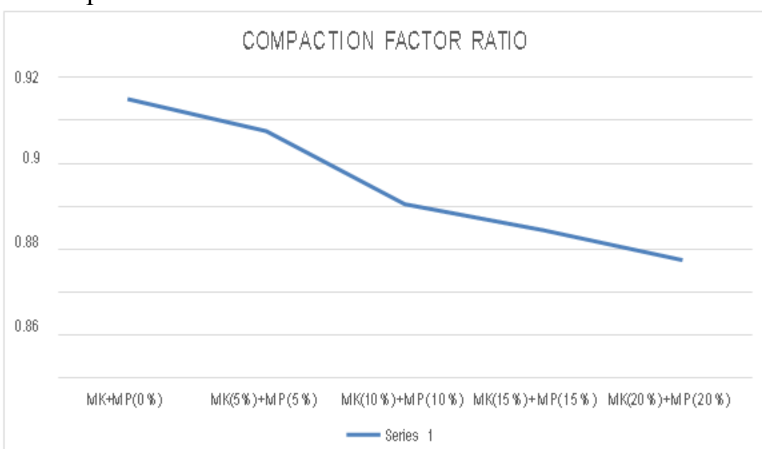
5.3 Compacting Factor Test Result and Analysis

The compacting factor indicates a moderate decreasing t rend of workability when the Percentage of mk and mp increased. Table 5. 2 below show the compacting factor ratio recorded during the test. Figure 5. 2 below sh ows a graphical representation of compacting factor ratio.

Table 5. 2: The Compacting Factor Ratio for Each Of Mix Concrete

METAKAOLIN AND MARBLE DUST	0%	5%	10%	15%	20%
Compaction factor	0. 91	0. 895	0. 861	0. 849	0. 835

Figure 5. 2 shown that the compacting factor rat io is decreasing as the percentage of metakaolin and marble powder increased. The result is very similar to the result of slump test. The highest compacting factor ratio is 0. 91 and the lowest is 0. 835. The average of compacting factor ratio for 0% mk and mp to 20% . is 0. 87. There is no problem in handle and compact the fresh concrete in these batches. From the result obtained, we can say that the workability is getting lower due to the increasing of metakaolin and marble powder used.



Graph 5. 2 : Compaction factor ratio

5.4 4 COMPRESSIVE STRENGTH RESULTS AND ANALYSIS

After the curing period the specimen is taken out for the test.The test is carried out on 150x150x150 mm size cubes, as per IS: 516-1959. A 1000KN capacity Compression Testing Machine (CTM) is used to conduct the test. The specimen is placed between the steel plates of the CTM and load is applied at the rate of 140 Kg/Cm^2/min and the failure load in KN is observed from the load indicator of the CTM and the failure load in KN is observed from the load indicator of the CTM.

Compressive strength = Load / Area

Nominal concrete (NC) = Cement + Sand + CA

Compressive strength of metakaolin and marble dust replaced concrete Following are the mixes considered for the study

- 5% Metakaolin + 5% Marble dust + 90% Cement
- 10% Metakaolin + 10% Marble dust + 80% cement
- 15% Metakaolin + 15% Marble dust + 70% cement

- 20% Metakaolin + 20% Marble dust + 60% cement
- Compressive strength of cubes of size 15x15x15cm is tested after 7,14,28 days Table 5.3 : Compressive strength of concrete cubes for 7,14,28 days

S NO	No. of Days	Conventional concrete	MK(5%)+ MP(5%)	MK(10%)+ MP(10%)	MK(15%)+ MP(15%)	MK(20%)+ MP(20%)
1	7	21.26	22.63	25.83	23.31	19.27
2	14	30.89	32.08	37.16	32.74	24.04
3	28	33.67	35.34	41.28	34.52	26.19

Fig 5. 2 compressive failure

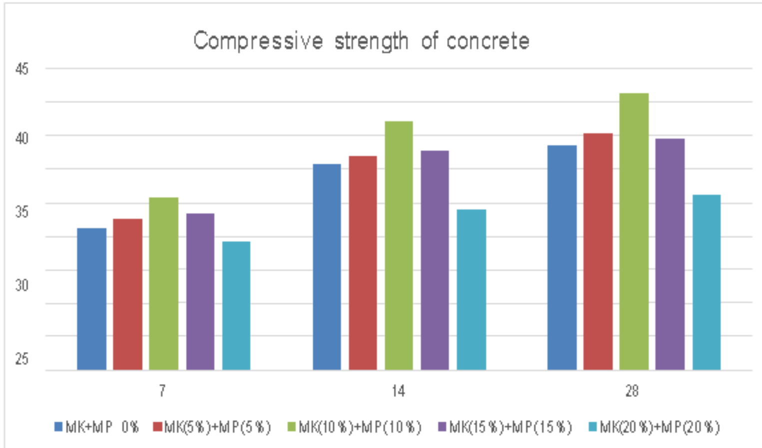


Figure 5.3 : Graph the concrete replaced with Metakaoline and Marble dust 10%+10% has given more strength

Result: It is seen that from the Graph that the concrete replaced with Metakaoline and Marble dust at 10% + 10 % has given Maximum strength which is 41.28 KN/M2

5.5 SPLIT TENSILE STRENGTH RESULTS AND ANALYSIS

The split tensile strength of concrete for cylinder was determined based on 5816-1999. The load shall be applied nominal rate within the range 1.2 N/ (mm^2/min) to 2.4/ (mm^2/min). The test was carried out on diameter of 150mm and length of 300mm size cylinder

$$\text{Split tensile strength} = \frac{2P}{\pi LD}$$

Where,

P = Compressive Load in N L = Length in mm D = Diameter in mm

- Split Tensile Test of Cylinders of Size 15x30 cm after 7 14, 28 days

Table 5.4 : Split tensile test results of concrete cylinders for 7,14, 28 days

S NO	No. of Days	Conventional concrete	MK(5%)+ MP(5%)	MK(10%)+ MP(10%)	MK(15%)+ MP(15%)	MK(20%)+ MP(20%)
1	7	2.36	2.84	3.42	2.77	2.14
2	14	2.97	3.49	4.26	3.32	2.58
3	28	3.35	3.82	4.73	3.59	2.93

Fig 5. 3 tensile failure

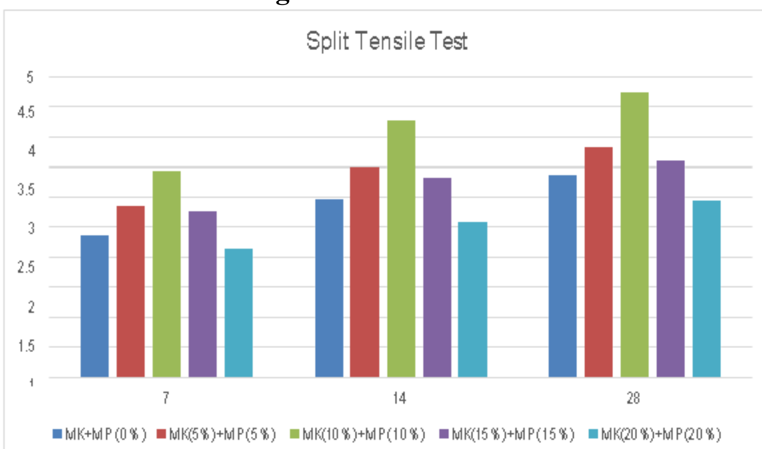


Figure 5.4 : Graph the concrete replaced with Metakaoline and Marble dust 10%+10% has given more strength

Result: It is seen that from the Graph that the concrete replaced with Metakaoline and Marble dust 10% + 10 % has given Maximum strength which is 4.73 KN/M2

VI. CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSIONS

The present experimental investigation was aimed to design a high grade concrete with partial replacement of Metakaolin and Marble dust to cement analysing the same on various parameters to obtain replacement percentage of metakaolin in production of concrete. Some of the broad conclusions

The following conclusions may be drawn based on the experimentations conducted on the behavior of concrete with partial replacement of cement by Metakaolin and Marble dust The addition of Metakaolin along with cement has increased the compressive strength of the concrete when compared to the conventional concrete.

- From the Test results we find that metakaoline and marble dust can be use for partial replacement in concrete.
- The compressive strength of concrete is more at 10%+10% replacement of metakaoline and marble dust. Has give maximum strength is 41.28 KN/M2
- The Split tensile strength of concrete Cylinder strength of concrete is more at 10%+10% replacement of metakaoline and marble dust. Has give maximum strength is 4.73 KN/M2

- Flexural strength of concrete replaced with Metakaoline and Marble dust 10% + 10 % has given Maximum strength which is 4.73 KN/M2
- Workability of concrete is also reducing due o increase in percentage of metakaoline and marble dust.
- Strength and durability of concrete is increase
- Eco-friendly by reducing of CO2

By replacing the cement and sand with Metakaolin and Marble powder the reduction in the consumption of cement can be achieved. By reducing the consumption of cement. the ecology of the earth can be improved enormously and the air pollution due to the production of cement can also be reduced. Comparative analysis for beam is done.

6.2 FUTURE SCOPE

The present experimental investigation was confined to the strength evaluation of concrete using Metakaolin and Marble dust combination with the cement. The invistigationcan be extended in future to incorporate some of the following aspects which have not been covered in the present study :

1. Tests for mix design of higher grade of concrete can be considered
2. Permeability tests of the above combinations may be undertaken
3. Metakaolin replacement accelerates the rate of gain of strength in concrete and is predominant at early age

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