INFLUENCE OF MARBLE WASTE POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

STRUCTURAL ENGINEERING

SUBMITTED BY: -

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UNDER THE SUPERVISION OF

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CANDIDATE'S DECLARATION

I, SAGAR UPADHYAY, Roll No. 2K17/STE/17 student of M.Tech (Structural Engineering), hereby declare that the Major project II titled " **INFLUENCE OF MARBLE WASTE POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE**" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title of recognition.

Place: Delhi SAGAR UPADHYAY

Date: 2020

DEPARTMENT OF CIVIL ENGINEERING

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CERTIFICATE

I hereby certify that the Major project II titled "**INFLUENCE OF MARBLE WASTE POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE**" which is submitted by SAGAR UPADHYAY 2K17/STE/17, Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi — Dr. Ritu Raj

Date: 2020 — (M.TECH SUPERVISIOR)

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ABSTRACT

Construction industry uses Portland cement which is known to be a heavy contributor to the CO_2 emissions and environmental damage. Incorporation of industrial wastes like silica fume (SF) and fly ash (FA), marble powder as supplementary cementing materials (SCMs) could result in a substantial reduction of the overall CO_2 footprint of the final concrete product .With increasing industrialization, the industrial byproducts (wastes) are being accumulated to a large extent, leading to environmental and economic concerns related to their disposal (land filling). Cement is an energy extensive industrial commodity and leads to the emission of a vast amount of greenhouse gases, forcing researchers to look for an alternative, such as a sustainable building practice. The present work is directed towards developing a better understanding on strengths characteristics of concrete using marble dust powder as a partial replacement of cement. Not much of the work has been carried out on the split tensile strength and flexural strength concrete using marble powder as partial replacement of cement so this Dissertation work is carried out with M40 grade concrete for which the cement is replaced by marble powder by 0%, 5%, 10%, 15%, 20% by weight of cement. For all the mixes compressive, split tensile strengths are determined at different days of curing. Only 3 cubes were casted for various percentage cement with marble powder for 28 days. The results of the present investigation indicate that marble dusts incorporation results in significant improvements in the compressive and split tensile strengths of concrete upto 10% of replacement.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 Introduction to Marble

Transformation of a pure limestone creates metamorphic rock called marble. Limestone is composed solely of calcite (100% CaCo3) is purely white in appearance. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. Cutting process of stone generated a large amount of marble dust lot of environmental related problems can be generated as we leave this dust in the environment. The advancement in concrete technology can lessen the burden of pollutants on the environment and reduce the consumption of natural resources. A lot of mineral admixtures are used in the concrete production like blast furnace slag, silica fume, fly ash to minimize their hazards. These wastes have beneficial effect on concrete properties include mechanical and durability aspects. Marble and granite grains and dust are considered waste materials during production of marble and granite products. Marble and granite are used as coarse aggregate and fine aggregate to produce concrete mixes with different grades.Annually billion tons of cement manufactured around the world consumes enormous amount of energy.

For better environment the demand is to decrease because cement manufacturing is largest contributor of carbon dioxide in the atmosphere. Various mineral additives like silica fume, fly ash and blast furnace slag have been used in concrete production, whereas marble dust can be used as replacement of sand as well as replacement of cement content in concrete. It has been seen that the usage of byproducts of marble as hundred percent substitutes for natural sand in concrete has displayed an enhancing effect on the compressive strength and split tensile strength of concrete. The durability as well as workability has increased to large extent by use of marble dust as replacement of fine aggregate and coarse aggregate. The effect on properties of concrete were investigated and aim is to find the optimum percentage for replacement of cement with marble powder in concrete. on the other hand, the effect of using marble powder and granules as constituents of fines in mortar or concrete by partially reducing quantities of cement as well as other conventional fines has been found better in terms of the relative workability & compressive as well as flexural strengths.

Waste marble dust has been used as an additive material in blended cement for cement manufacturing. Most of the studies have focused on the replacement of marble dust with cement in the cement mortar. optimum percentage of marble dust in concrete was not defined. Studies have shown that marble dust can be used as filler material in production of self compacting concrete.

This study was planned to investigate various properties of concrete namely workability, compressive strength, as well as study of micro structure of concrete with replacement of marble dust for different percentage with cement by scanning electron microscope test. The amount of replacement of cement with marble dust varies from 0-20 percent by weight of cement.

1.1.1 Origin

Marble dust comes from crushed marble, which is formed by the crystallization of limestone or dolostone. The crystals appear as a calcite material through different atmospheric and temperature changes. The pressure present in the formation of marble destroys any other objects in the rock creating a dense, smooth rock. Colored marble is produced when different amounts of silt, clay and other objects are mixed with the limestone.

1.1.2 Identification

Marble dust is characterized by its fine powdery texture, similar to that of crushed limestone. Since marble is a harder, crystallized rock, the dust is not comprised of soft particles. The dust also has a slight shimmer to it because of the crystallized particles, and it can also be discolored with brown, grey, yellow, pink or even greenish particles due to impurities in the original marble.

1.1.3 Types

The different types of marble dust often are named for the country it originates from. Carrara marble dust comes from Italy, and is the kind used in many Roman sculptures. Pentelicus dust comes from Greece, and was used for many Greek sculptures and buildings. Another kind of marble dust originates from Proconnesus, a quarry in Turkey.

1.1.4 Uses

Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects. Marble dust give an iridescent feel to the object because of the crystallized particles present in the dust from the marble. These cultured marble objects are often seen in luxury settings. Synthetic marble objects made with marble dust are more commonly used than 100 percent solid marble objects. Marble dust is also used to make paint primer for canvas paintings, and as a paint filler.

1.1.5 Significance

Individuals who cannot afford solid marble to use in furniture, buildings, floors and other objects will often turn to objects that include marble dust instead. Not only can it look like the real thing, it's easier to transport than solid marble.

1.2 Objective

Use of industrial wastes and by products as an aggregate or raw material is of great practical significance developing building material components as substitutes for materials and providing an alternative or supplementary materials to the housing industry in a cost effective manner and the conservation of natural resources.

Because of the environmental threats associated with the WMP (waste marble powder), their proper disposal has attracted a lot of attention of the environmentalists in the last years. In order to properly dispose of these hundreds to thousands of tonnes of powder, the use of innovative techniques to recycle them is important. Without the proper disposal of this powder material, the resulting stockpiles would cause major health risks for the public and the environment. Therefore, the objective of this paper is to study the possibility to incorporate marble sawing powder wastes as a filler in concrete with no major sacrifice of the properties of the final product and thereby reducing the ill effects of Marble dust.

The objectives of this experimental and research project study are

1. This project refers to the feasibility study of using the marble waste in concrete production as partial replacement of cement.

2. The main objective and goal of our project is to through study the influence and effect of partial replacement of cement or binder in concrete with waste marble powder.

1.3 Problem Statement

The ordinary Portland cement is acknowledged to be the most widely used construction material throughout the world. The cement production is known to be one of the most environmental unfriendly processes because it releases of Co2 gases to the atmosphere. Studies suggest that one ton of cement clinker production releases one ton of Co2. 7% of world carbon dioxide coming up from Portland cements industry.So the objective was to study the strength characteristcs of concrete using marble which is from rajasthan Hence the present research focuses on making concrete with marble dust powder as partial replacement of cement.

Besides the negative environmental impacts of cement, it is the most expensive constituent of concrete. The raw materials which are used in the production of cement like lime are being depleted in large amount. on the other hand, the raw marble stone is cut seasoned and dressed in large quantity which upon dressing produce 25% of waste marble powder. The disposal of this waste marble powder is a big problem which causes environmental pollution. Thus, by utilizing this industrial waste marble powder by replacing cement content in concrete can lessen the emission of carbon di-oxide gas emission and these problems can be mitigated.

1.4 Environmental Problems Attributed to Waste Marble Powder (WMP)

The WMP imposes serious threats to ecosystem, physical, chemical and biological components of environment. Problems encountered are:

- It adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.
- When dried, it becomes air borne and cause severe air pollution. Introduces occupational health problems, it also affects machinery and instruments installed in industrial areas.
- Affecting quality of water during rainy season, and reducing storage capacities and damaging aquatic life.

It adversely affect social and industrial activities of people since the heaps of powder remain scattered all round the country are an eye sore and spoil aesthetics of entire region.

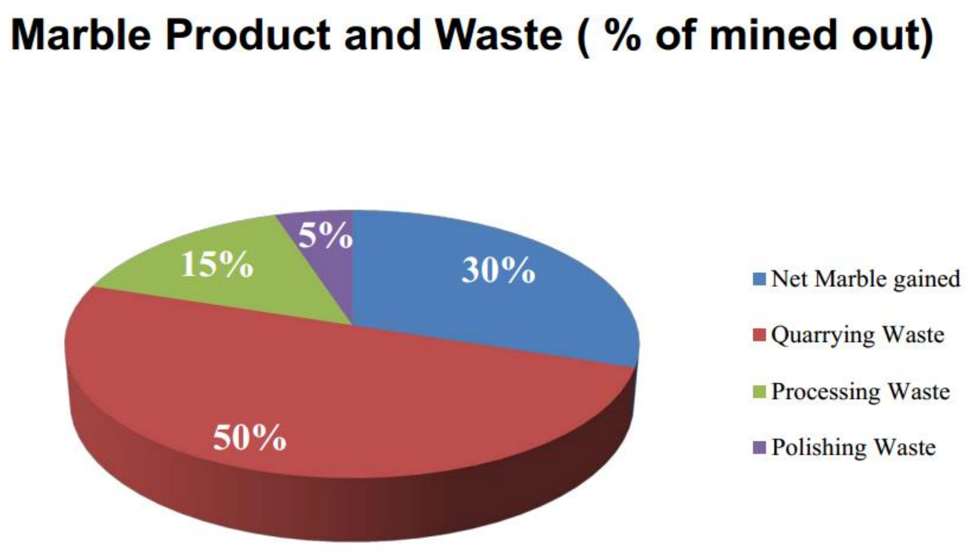

Fig 1 – Marble product and waste

It is therefore a social and legal responsibility of government and industry to solve the problem of WMP pollution. As such, development of country is only possible by sustainable balanced industrialization. Thus, new approaches that consider industrial wastes as alternative raw materials becomes interesting, both technically and economically, for a wide range of applications. of our particular interest is the use of WMP in cement industry as a filler for the production of concrete.

1.5 Application of marble dust

1.5.1 Filler

Fillers are particles added to material (plastics, composite material, and concrete) to lower the consumption of more expensive binder material or to better some properties of the mixtured material. Fillers have a profound effect on concrete in both the fresh and hardened state. Especially as the development of more effective super-plasticizers has made it possible to increase the amount of fillers which opens new opportunity and fields of application. The particles may be used to reduce the amount of cement and give the fresh concrete other properties, example, self-compatibility. Fillers can be made, but large quantities are also available as by-products from different industries. Use of these products will benefit the environment, since it will reduce the need for deposition. At the same time, the use of by-products can reduce cement consumption, which is also positive for the environment.

The fillers interact with the cement in several ways. The may be chemically inert but can still indirectly influence the chemical structure of the cement paste and concrete in a positive way. The large surface of the small particles may foster nucleation, densify and homogenize the paste. Moreover, it will influence the concrete by giving it other rheological properties, which in turn will influence also the properties of the hardened concrete.

Addition of filler particles can affect the concrete in three ways: -

- on the physical level- filler effect, when the added particles fill the inter-granular voids between cement particles and thus improve the compactness of the concrete.
- on the surface chemical level- when the added particles enhance hydration by acting as nucleation sites, becoming an integrated part of the cement paste.

on the chemical level- when the particles react with a component and the cement, for example with calcium hydroxide and thus from cement gel.

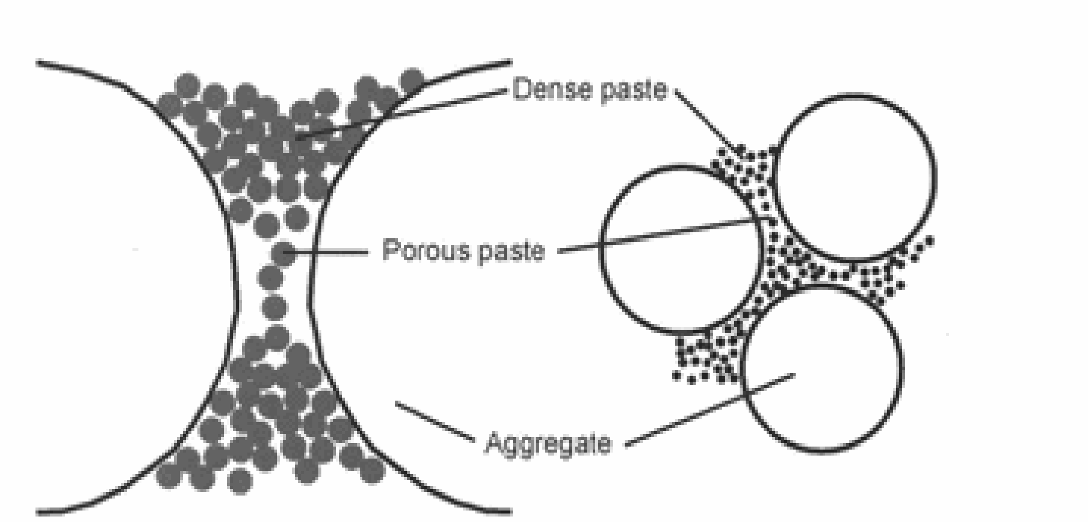

Fig. 2 Cross section of filler in concrete

1.5.2 Marble dust as filler

Marble dust can be used either to produce new pro- ducts or as an admixture so that the natural sources are used more efficiently and the environment is saved from dumpsites of marble waste. Many studies have been conducted in literature on the performance of the concrete containing waste marble dust or waste marble aggregate, such as its addition into self-compacting concrete as an admixture or sand, as well as its utilization in the mixture of asphaltic concrete and its utilization as an additive in cement production, the usage of marble as a coarse aggregate and as a fine aggregate passing through 1 mm sieve.

Fig 3 – Marble powder dust

Generally, in literature waste marble dust has been replaced with either all of the fine aggregate (0 - 4 mm) or passing 1 mm sieve. However, not a single study on the performance of the concrete prepared by replacing very fine sand (passing 0.25 mm sieve) with WMD. The studies concerning the utilization of marble dust, which is obtained as a by-product of marble sawing and shaping processes in the factories those operating in our region as a fine sand aggregate into the normal strength concrete have not reached a convincing conclusion; in other words, additional studies and investigations are necessary to fully evaluate the potential usages of this waste material. Therefore, the aim of this current study is to avoid the environmental pollution.

1.5.3 In Industrial brick

The usability of waste marble dust as an additive material in industrial brick was that the amount of marble dust additive had positive effect on the physical, chemical and mechanical strength of the produced industrial brick. With increasing demands of the construction industry, bricks quality and cost become more important day by day. In addition, the usage of marble wastes for the production of industrial bricks has significant important role on the recycling waste marble powder in the brick production along with a great contributions to economy and ecology of the country.

Use of industrial wastes and by products as an aggregate or raw material is of great practical significance developing building material components as substitutes for materials and providing an alternative or supplementary materials to the housing industry in a cost effective manner and the conservation of natural resources.

The physical property studies, records that the addition of marble waste mixture imparts physical strength to the bricks when they are kilned at higher temperature. More specifically, bulk density, compressive strength, flexural strength was found to increase due to the addition of the above mixtures. This is because of the fact that the addition of the mineral matter especially quartz and feldspar to the clay, act as flux when they are kilned at higher temperature as evidenced by the physical test of the bricks.

1.5.4 Substitute of Limestone in Cement

The WMP based clinkers were found to contain the expected cementitious phases and a good agreement was obtained between the characterizations techniques used. The WMP based cement obtained from wastes shows a stronger hardening character than the standard material, which tends to show dusting phenomena due to the presence of a reasonable amount of free lime (as the result of its expansive reaction with ambient moisture). Some fluxing impurities (e.g. alkalis) present in the waste materials improve the overall reactivity of the mixture.

This newly develop binder is parallel to other conventional binder in the field of building construction like Lime, cement and other admixture but is different from them as it utilizes WMP with other ingredients. WMP based cement is capable of improving hardened concrete performance up to 16%, enhancing fresh concrete behavior and can be used in architectural concrete mixtures containing white cement. The new binder is environment friendly, cheaper in cost from the other conventional material also it involves small equipment with no complicated technologies and requires very low energy for manufacturing.

CHAPTER 2 LITERATURE REVIEW

A Study has been conducted by BabooRai et.al(2011) have done their research on Influence of Marble powder/granules in Concrete mix. They found that using marble powder and granules as constituents of fines in mortar or concrete by partially reducing quantities of cement as well as other conventional fines in terms of the relative workability & compressive as well as flexural strengths. Partial replacement of cement and usual fine aggregates by varying percentage of marble powder and marble granules reveals that increased waste marble powder or waste marble granule ratio result in increased workability and compressive strengths of the mortar and concrete.

A Study has been conducted by Vaidevi C (2013) have done their research on Study on the marble dust as partially replacement of cement in concrete. They found that the marble dust from marble processing is a waste utilized. The use of this waste was proposed in different percentages both as an addition to and instead of cement, to produce concrete mixtures. In this study, the use of marble dust collected during the shaping process of marble blocks has been investigated in the concrete mixtures as cementitious material. The study showed that marble wastes, which are in the dust form, could be used as cementitious material in concrete mixtures where they are available and the cost of construction is lower than ordinary concrete materials. The concrete is prepared containing 5, 10, 15 and 20% waste of marble dust with cement compared to the total quantity of normal concrete. The prepared mixtures were then studied in terms of their properties both in fresh and in hardened state. In this particular, tests they conducted and cured at different times to find compressive strength and tensile strength with and without partial replacement of marble dust in cement concrete and for mortar also determined for 14 and 28 days.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.

A Study has been conducted by V. M. Southararajan et.al(2013)have done their research on Effect of the Lime Content in Marble Powder for Producing High Strength Concrete. They found that the waste marble powder up to 10% by weight of cement was investigated for hardened concrete properties. Furthermore, the effect of different percentage replacement of marble dust on the compressive strength, splitting tensile strength and flexural strength was evaluated. It can be noted that the influence of fine to coarse aggregate ratio and cement-to-total aggregate ratio 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 was noted and also showed an improved mechanical property compared to controlled concrete.

A Study has been conducted by Manju Pawar et.al (2014) have done their research 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 Cubes are increased with addition of waste marble Powder up to 12.5 % replace by weight of cement and further any addition of waste Marble powder the compressive strength decreases. The Tensile strength of Cylinders are increased with addition of waste marble powder up to 12.5 % replace by weight of cement and further any addition of waste marble powder the Tensile strength decreases. Thus, they found out the optimum percentage for replacement of marble powder with cement and it is almost 12.5 % cement for both cubes and cylinders

Joy et al. [1] checked the 28 days compressive strength, flexural strength and splitting tensile strength at various mix proportions. They cast specified number of cubes, cylinder and beams by replacing fine aggregate with sawdust by 15%, 20%, 25% & 30% and to compare their property with standard mix (M25).Based on the investigation on sawdust, following conclusions were made i.e. in 28 days compressive strength and splitting tensile strength of the concrete is not increased to large extent but it almost matches with the compressive and splitting tensile strength of nominal mix concrete. The compressive strength obtained for the replacement of fine aggregate with 25% sawdust was proved to be the optimum mix to get M25 grade of concrete. But the flexural strength gradually increases as sawdust content increases. The fibre content in sawdust is very high and is responsible for the increase of strength. Weight of the sawdust concrete was reduced as compared with normal concrete and also become more economical. As a result of this experiment it was observed that the concrete containing sawdust get compacted more efficiently than the normal concrete. Dry porous sawdust could absorb sufficient amount of water that could be an effective mean of internal curing and absorb the excess water in the mix and provide the water required for the hydration of the cement.

Abdullahi et al. [2] checked the compressive strength of concrete and analyse its effect on the construction cost. They casted (150x150x150)mm cube & evaluated the compressive strength of concrete at 7,14,21and 28 days by replacing fine aggregate from 0% to 50% (in percentage gap of 10). Based on the investigation following conclusions were made i.e. Sawdust as an air-entraining agent has no appreciable positive effect on the compressive strength of concrete. Variation in the compressive strength results is traceable to the fact that it is difficult to obtain sawdust which is not a mixture of several species. A possibility exists for the partial replacement of sand with sawdust in the production of Lightweight concrete. optimum replacement of sand with sawdust has been found to be 10%. Beyond this limit, the concrete produced did not meet code requirements. As a result of this experiment it was observed that as the percentage sawdust content increased in the mix the compressive strength decreased. The low values of the compressive strength of the concrete used in this investigation could be attributed to the fact that sawdust contains some substances which are injurious 5 to the cement. These substances actually inhibit the hydration of cement and hence the development of strength.

Suji.D et al. [3] determined the optimum quantity of river sand to be replaced by Quarry dust and saw dust and to obtain maximum results and compared the characteristic strength of normal concrete and concrete with Quarry dust and Saw dust. In this experimental study, the test was conducted for M30 mix containing Quarry dust ranging from 0, 10%, 20%,30%,40% combined with Saw dust ranging from 0,5%,10%,15% &20% remaining percentage river sand is used. Based on the experimental study following conclusions were made i.e.The compressive strength of quarry dust and saw dust up to 30% and 15% respectively is almost similar to that of control mix. Split tensile strength of quarry dust and saw dust up to 30% and 15% respectively is almost similar to that of control mix. Two-point loading test result shows that the first crack load is almost same for both control mix and quarry dust and saw dust concrete. As a result of this experiment Quarry dust and saw dust content of 30% and 15% by weight has shown the best results. Thus indicates the possibility of using quarry dust and saw dust as a partial replacement of fine aggregate up to this level. The weight can be reduced up to 20%.

Jeson.P et al. [6] carried out the test experimental study on properties of concrete by partial replacement of cement with silica powder and fine aggregate with saw dust ash. In this experiment natural sand was partially replaced (5%, 10%, and 15%) with SDA. Compressive strength and Tensile strength (cubes and cylinders) on 7, 14 and 28 days of age were compared with those of concrete made with natural fine aggregate. Based on the study carried out on the strength behaviour of saw dust the following conclusions are drawn i.e.in the project it is observed by 5%, 10% and 15% partial replacement of Fine Aggregate with SawDust Ash and 25% partial replacement of Cement with Silica Powder, the 5% of Compressive Strength is more than the Conventional Concrete Target Strength. The other percentage mix has a low Compressive and Tensile Strength this may be due to low bulk density of Saw Dust Ash. But literature says that Saw Dust Ash give good strength if replacement with fine aggregate on concrete.

obilade et al. [12] conducted experiments to check the validity of using sawdust ash as partial replacement for cement in concrete. The experiments were run with partial replacement of cement with Saw dust ash (SDA) in 0%, 5%, 10%, 15%, 20%, 25%, and 30%. The compressive strength test of the sample was carried out and the compressing factor values were recorded to be 0.91, 0.89, 0.88, 0.87, 0.86, 0.86 and 0.85 respectively. The bulk densities of the concrete cubes were recorded at interval of 7, 14 and 28 days for the same SDA percentages mentioned earlier the trend shows a decrease in the densities with increasing percentages. From the investigation carried out, the optimum addition of SDA as partial replacement for cement ranges up to 15%. The compressive strength of the concrete, however, took a dip when percentage SDA replacement increased. From the study it was further recommended that the use of local recycled materials like SDA as pozzolanas should be encouraged more in this sector to enhance material usage efficiency and reduce the usage of sand or silica as a fine aggregate in concrete mixtures

CHAPTER 3 EXPERIMENTAL INVESTIGATION

3.1 TESTING OF CEMENT

Testing of cement is done in order to check its performance when used for engineering construction. Testing of cement is done in the following ways-

1.Field test

2.Laboratory test

3.1.1Field test-

A sample of cement to be tested should be uniform grey in color and also the sample should feel smooth when rubbed in between the fingers.

Fig 4 – Sample of cement

The sample should be free from the presence of air set lumps that are basically formed due to the absorption of moisture from the atmosphere. If the small amount of cement is thrown in the bucket of the water it should sink and it should not float over the surface of water.

3.1.2Laboratory test-

1. Fineness test

Fineness of cement is being tested to check the proper grinding of cement which significantly influences the rate of hydration that in turn affects the rate of development of strength and rate of evolution of heat.

Fineness of the cement can be tested by any of the following methods-

a)Sieve Test

IS 4031 is the reference code .In this test 100gm of the sample of the cement to be tested is to be taken over IS sieve no 9 that is 90µ(90 micron). Sieving is to be done continuously for atleast 15min. also it has to be kept in mind the breaking of air set lumps if formed in it.Weight of the residue left over the sieve is noted after 15min.

Fig – 5 Dry sieving of cement

Weight of the sample taken = 100gm

Weight after retained after 90 micron sieve = 6gm

Percentage fineness = (6/100 x 100) =6%

For OPC , value should not exceed 10%.

b) Air Permeability Test

The method of this test covers the procedure of determination of fineness of the cement represented in terms of specific surface area and expressed as surface area per unit weight.Generally blaines air permeability apparatus is used in this test.The principle of this test depends upon the relationship between flow of the air through the bed of cement particles and the surface area of the particle that is forming the cement bed.

For OPC , specific surface area should not be less than 2250cm^2/gm.

2. Consistency Test

In order to find initial setting time , final setting time , soundness and strength characteristics of the cement , a parameter reffered as standard consistency is used.Standard consistency is defined as the consistency of the cement paste that permits the vicat's plunger of diameter 10mm and height 50mm to penetrate into the mould upto the depth of 33mm to 35mm from the top.

This test is basically performed to find the moisture content which is required to produce the cement paste of standard consistency.In order to perform this test , 400 gm of the cement is taken and gauge it with 24% of the water in the first try and note the depth of penetration into the mould. Repeat this test at different water contents upto an extent , penetration of 33 to 35mm from the top of the mould is observed. Water content corresponding to this is noted and it is reffered as 'P'.

This test should be performed at the temp of about 27 ± 2^o C and relative humidity of 90%.

Weight of the cement taken = 400 gm

Weight of the water added = 116ml

Standard consistency of cement = (116/400 x 100) = 29%

3.Setting time test

Setting time of the cement is tested in order to check its deterioration due to storage. And setting time of the cement is further calculated as initial and final setting times as follows-

Fig – 6 Vicat apparatus showing different needles

For initial setting time the square needle of size 1mm is used whereas on the other hand for the calculation of final setting time when the needle at the center of the annular ring is able to make the impression over the mould but annular collar fails to do so is noted.

Fig -7 Vicat mould

(i)Initial Setting Time

Initial setting time is defined as the time that is measured from the instant, water is added into the cement upto the time it starts losing its plasticity. In order to perform this test 500gm of cement sample is taken and gauged it with 0.85P (85% of the water required to prepare the cement paste of standard consistency) , the paste is prepared and is filled in the mould. Initial setting time is reffered as the time in which the square needle of size of 1mm shows the penetration of 33 to 35mm into the mould from the top.

For OPC initial setting time is approximately 30 min.

(ii)Final setting time

Final setting time is reffered as the time , which is measured from the instant ,water is added into the cement upto the time ,it completely losses its plasticity and attains sufficient firmness so as to resist definite pressure.In order to find final setting time ,mould is prepared as above and final setting time is reffered as the time in which the needle at the center of the annular ring is able to make the impression over the mould but annular color fails to do so.

For OPC final setting time is approximately 10hrs.

Table 1 – Test results of the material

S.NO	TEST	Result	IS 4031 (part 1 &5) requirements
1.	Fineness of cement	6%	Max 10%
2.	Consistency of cement	29%	
3.	Initial setting time	70min	Min(30 min)
4.	Final setting time	180min	Max (600min)

3.2 TESTING OF AGGREGATE

3.2.1Aggregate Strength Test/Crushing test

IS 2386 part 4 is the reference code.Strength of the aggregates affects the strength of the mixture in which it is used.Strength of the aggregate is basically defined as the resistance of the aggregate against gradual loading.It is determined by aggregate crushing value test which is performed on the particles passing through 12.5mm sieve and retained over 10mm sieve.These particles are subjected to the gradual loading of 40 tonnes with the help of the plunger and the sample is then further passed through the sieve of size 2.36mm.Weight of these particles passing through the sieve expressed as the percentage of the original weight of particles is reffered as aggregate crushing value.For aggregates to be used in pavement construction it should not exceed 30% and for any other construction it should not exceed 45%.

Fig –8 Aggregate crushing test

observations-

The ratio of the weight passing through 2.36mm sieve to the original weight of the aggregate is taken and is expressed as percentage.

Weight of the aggregate taken W1= 2000gm

Weight of the aggregate passing through 2.36mm sieve W2=530 gm

Aggregate crushing value $= \frac{W2}{W1}$ X 100

= (530 / 2000) x 100 = 26.5%

For aggregates to be used in pavement construction it should not exceed 30% and for any other construction it should not exceed 45%.

3.2.2.Aggregate Impact Test

IS 2386 part 4 is the reference code.Toughness of the aggregate is reffered as the ability to resist impact loading.Toughness of the aggregate is determined by aggregate impact value test in which the given sample of the aggregate is subjected to 15 number of blows with the help of the metallic hammer having a total mass of 14kg and free fall height of 38cm.The sample is then passed through the sieve of 2.36mm and the weight of the particle passing through it is noted which when expressed in terms of total weight of the particles is reffered as aggregate impact value. For aggregate to be used in pavement construction ,it must not exceed 30% and for other construction it must not exceed 45%.

Fig – 9 Impact test of aggregate

observations-

The ratio of the weight passing through 2.36mm sieve to the original weight of the aggregate is taken and is expressed as percentage.

Weight of the aggregate taken W1= 400

Weight of the aggregate passing through 2.36mm sieve W2= 81.6gm

Aggregate crushing value $= \frac{W2}{W1}$ X 100

= (81.6 / 400) x 100 = 20.4%

For aggregates to be used in pavement construction it should not exceed 30% and for any other construction it should not exceed 45%.

3.2.3Aggregate Hardness Test

IS 2386 part 4 is the reference code.It is the property of the aggregate by virtue of which it is able to resist wear and tear on abrasion.

Hardness of the aggregates can be determined by any of the following test-

(i)Deval Abrasion test

(ii)Dowry Abrasion test

(iii)Los Angeles test

Los angeles test is used here to find out the hardness of aggregate.

In this test ,the sample of the aggregate is placed in cylinder having steel balls in it.The sample is subjected to the abrasion by rotating the cylinder 500 number of times at the speed of 30 to 33rpm.The sample is then passed through 1.7mm sieve and weight of the particles passing through the sieve is noted ,which expressed in terms of original weight of the particle is reffered as aggregate abrasion value.For the aggregates to be used in pavement construction ,aggregate abrasion value should not be greater than 30% and for general construction it should not exceed 50%.

observations-

The ratio of the weight passing through 1.7mm sieve to the original weight of the aggregate is taken and is expressed as percentage.

Weight of the aggregate taken W1= 2000 gm

Weight of the aggregate passing through 1.7mm sieve W2= 495 gm

Aggregate crushing value $= \frac{W2}{W1}$ X 100

= (495/ 2000) x 100 = 24.75%

For aggregates to be used in pavement construction it should not exceed 30% and for any other construction it should not exceed 50%.

other test that can be performed on the aggregate are listed as follows-

Flakiness test-

Flakiness index of the aggregate is defined as the % by weight of the particles in it, having their least dimension smaller than the $3/5^{th}$ of the mean dimension. This test is not applicable for the particles having size smaller than 6.3mm. In order to perform this test ,sufficient quantity of aggregates must be considered such that 200 pieces of each fraction can be gauged. Particles of each fraction are passed turn by turn through the respective opening and the weight of the particles passing through respective opening is noted when can expressed in terms of original weight of the particles is reffered as flakiness index.

Elongation index-

Elongation index is defined as the %by weight of the particles present in the sample having there greatest size greater than 1.8times of there mean size. This test is also not applicable for the particles having size smaller than 6.3mm. In order to perform this test ,sufficient quantity of aggregates must be considered ,such that 200 pieces of each fraction can be gauged. Particles are passed through turn-by-turn through there respective opening over the length gauge and the weight of the particle retain over each opening is noted which when expressed in terms of original weight of the particle is reffered as elongation index.

3.2.4 Sieve analysis of fine aggregate

Fig – 10 Sieve shaker apparatus

Fig – 11 Sieve shaking of fine aggregate

observations-

Weight of the sample : 2000gms Specifications standard – IS 383 -2016

Table 2 – Gradation of fine aggregate

IS Sieve	Wt retained (gm)	Cumulative wt retained (gm)	Cumulative % retained (gm)	Cumulative % passing (gm)	ZONE I	ZONE II	ZONE III	ZONE IV
10mm	0	0	0	100	100	100	100	100
4.75mm	22	22	1.1	98.9	90-100	90-100	90-100	90-100
2.36mm	112	134	6.7	93.3	75-100	75-100	85-100	95-100
1.18mm	200	334	16.7	83.3	55-90	55-90	75-100	90-100
600mic	290	624	31.2	68.8	35-59	35-59	60-79	80-100
300mic	1112	1732	86.6	13.4	8-30	8-30	12-40	15-50
150mic	222	1954	97.7	2.3	0-10	0-10	0-10	0-15
Pan	46	2000	100	0				

From the above table it can be easily infer that our sand belongs to zone III which this data is further used in the mix design as explained in the further chapters.

We can also find the fineness modulus of sand as follows-

(FM) Fineness modulus = (sum of cumulative % retained upto 150mic)/100

= 240/100 = 2.4 hence fine sand.

FM limits 2.2 - 2.6 Fine sand

2.6 – 2.9 Medium sand

2.9 – 3.2 Coarse sand

CHAPTER 4 MIX DESIGN

Mix design of M40 grade of concrete is shown below-

Useful data- cement grade OPC43 , admixture used was auramix 400 , specific gravity of aggregate – 2.74 , specific gravity of cement – 3.15.

TARGET STRENGTH FOR MIX PROPORTIONING:

Characteristic compressive strength at 28 days: fck = 40 MPa

Assumed standard deviation (Table 1 of IS 10262:2009): sd = 5 MPa

Target average compressive strength at 28 days: ftarget = fck + 1.65sd =48.25 MPa

I. SELECTION OF WATER-CEMENT RATIO:

From Table 5 of IS: 456-2000, maximum water-cement ratio = 0.50

To start with let us assume a water-cement ratio of 0.40

0.40<0.45 O.K.

II. SELECTION OF WATER CONTENT:

Maximum water content per cubic metre of concrete (refer Table 2 of IS: 10262-2009): Wmax = 186L (for 50 mm slump).

Since, the slump was less than 50 mm, no adjustment was required.

Since superplasticiser was used so based on experience water content reduction of 29 percent has been achieved. Hence the final water content used was = 186 x 0.71=132.06L

III. CALCULATION OF CEMENT CONTENT:

Mass of water selected per cubic metre of concrete = 132.06 kg.

Mass of cement per cubic metre of concrete = 132.06/0.40 = 330.15 kg.

Minimum cement content = 300 kg/m3 (for moderate exposure condition, Table 5 of IS 456:2000)

Maximum cement content = 450 kg/m3 (Cl. 8.2.4.2 of IS 456:2000) .

So, the selected cement content is alright.

IV. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT:

Volume of coarse aggregate per unit volume of total aggregate (Table 3 of IS: 10262-2009) = 0.64 (This is corresponding to 20 mm size aggregate and Zone III fine aggregate for water-cement ratio of 0.50)

As the water-cement ratio is lowered by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 as per IS :10262-2009.

Corrected volume of coarse aggregate per unit volume of total aggregate = (0.64+0.02) = 0.66

Volume of fine aggregate per unit volume of total aggregate = 1-0.66 =0.34

V. MIX CALCULATIONS

a) Volume of concrete = 1m^3

b) Volume of cement = (mass of cement/ specific gravity of cement) x (1/1000)
= (330.15/3.15) x (1/1000)
= 0.104 m^3

c) Volume of water = (mass of water / specific gravity of water) x (1/1000)
= (132.06 / 1) x (1/1000)
=0.132 m^3

d) Volume of chemical admixture @ 1% by mass of cementitious material
=(mass of chemical admixture/specific gravity of admixture)x (1/1000)
=(3.30 / 1.145) x (1/1000)
=0.002 m^3

e) Volume of all in aggregate = 1 – (0.104 + 0.132 + 0.002)
= 0.762

f) Mass of coarse aggregate = 0.762 x 0.66 x 2.74 x 1000
=1378 kg

g) Mass of fine aggregate = 0.762 x 0.34 x 2.74 x 1000
= 709 kg

VI: MIX PROPORTION:

For 3 cubes of 150mm side and 3 cylinders of 150mm x 300mm size, the volume of concrete required

= $((150)^3$ x3+3 x 3.14 x $150^2/4$ x 300)x 1.1 = 0.028 m3 (taking into account 10 % extra for losses)

Cement required = 0.028x330.15 = 9.24 kg

Fine aggregate required = 0.028x709 = 19.85 kg

Coarse aggregate required = 0.028x 1378= 38.58 kg

Water required = 0.028x132.06 = 3.69kg

Admixture = 0.028 x 3.3 = 0.092 kg

CHAPTER 5- RESULTS AND DISCUSSIONS

5.1 Compressive strength

Compressive strength of the concrete is determined either using cubical, cylindrical or prismoidal mould. If the maximum nominal size of the aggregate is greater than 20mm, cube of 15cm is considered and if maximum nominal size of the aggregate is less than 20mm, cube of 10cm is considered. In case of cylindrical mould, length to dia ratio is insured to be 2:1 (generally 30cm length and 15cm dia is considered). Concrete to be tested is filled in the mould in the layers of 5cm and each layer is tamped 35 no of times with the help of the tamping rod having dia of 16mm and height of 60cm. When the mould is completely filled it is stored at the temp of about 27±2^{o}C for 24 hrs at the humidity of 90% at the place which is free from vibration.

After 24 hrs, the sample is removed from the mould, it is immersed in the water for curing in order to avoid the loss of the moisture during hydration. The sample is then removed from the water and is tested for its compressive strength in UTM(universal testing machine) by subjecting it to uniform gradual load of 14N/mm^2 per minute upto failure. An average of three results having maximum deviation of ±15% is taken as the compressive strength of the specimen. Application of the compressive load leads to the development of complex compressive stresses in the specimen due to the restraining effect of the steel platens used over the specimen while testing.

This restraining affect is observed due to the difference in development of lateral strain in steel platens and concrete specimen. Lateral strain in steel platens is approximately 0.4 times the lateral strain in concrete specimen. Hence the results obtain by this test are more than actual. This restraining affect of the steel platens is observed throughout the height of the cubical specimen but is restricted below the point of application in cylindrical specimen.

Hence, the results obtain by cylindrical specimen are more closer to the actual one and comparatively less than the result obtain by the cubical specimen. Result obtain by the cylindrical specimen is approx. 0.8 times those obtained by the cubical specimen. In case of cylindrical specimen, casting and loading in the same directions that resembles the loading condition in field but the shape of the structural members resembles with that of the cubical specimen. Development of stresses in cylindrical specimen is more uniform than cubical specimen as restraining affect in this case is limited only upto a particular depth.

Fig -12 Cube specimen

Fig- 13 Cylindrical specimen

Fig 14 - 3 samples of concrete mix CM-1

Fig 15 - 3 samples of concrete mix CM-2

Fig 16 - 3 samples of concrete mix CM-3

Fig 17 - 3 samples of concrete mix CM-4

Fig 18 - 3 samples of concrete mix CM-5

Calculation of compressive strength of Concrete Mixes.(CM)

1-FOR CM-1

Average load at failure(avg of 3 specimens) = 1115.67 KN

Compressive strength = (1115.67 / 150^2) x 1000 = 49.585 N/mm^2.

2-FOR CM-2

Average load at failure(avg of 3 specimens) = 1247 KN

Compressive strength = (1247 / 150^2) x 1000 = 55.42 N/mm^2

.

3-FOR CM-3

Average load at failure(avg of 3 specimens) = 1308.67 KN

Compressive strength = (1308.67 / 150^2) x 1000 = 58.163 N/mm^2

4-FOR CM-4

Average load at failure(avg of 3 specimens) = 1059 KN

Compressive strength = (1059 / 150^2) x 1000 = 47.06 N/mm^2

5-FOR CM-5

Average load at failure(avg of 3 specimens) = 1018 KN

Compressive strength = (1018 / 150^2) x 1000 = 45.24 N/mm^2

CM1 – 0 % replacement

CM2 – 5% replacement

CM3 – 10% replacement

CM4 – 15% replacement

CM5 – 20% replacement

Compression Testing of cube of M40 grade of concrete have been shown above and also the failure of the specimen have been indicated.The table indicating various proportions having part replacement of cement with marble dust powder with different mix proportion have been indicated in the below table.

The table indicating various proportions having part replacement of cement with marble dust powder with different mix proportion have been indicated in the below table.

Table 3 – Different proportions of marble as part replacement of cement

CONCRETE MIX	Cement (kg)	Marble dust as%replacement of cement	Marble Content (kg)	Sand (kg)	Coarse aggregate (kg)	Water (L)
CM1	9.24	0	0	19.8	38.5	3.69
CM2	8.77	5	0.462	19.8	38.5	3.69
CM3	8.31	10	0.924	19.8	38.5	3.69
CM4	7.85	15	1.386	19.8	38.5	3.69
CM5	7.39	20	1.848	19.8	38.5	3.69

Table 4 – Compressive strength of cubes having different proportions

CONCRETE MIX	%Replacement	Days	Avg load (tested on 3 cubes)(KN)	Compressive strength N/mm^2
CM1	0	28-days	1115.67	49.585
CM2	5	28-days	1247	55.42
CM3	10	28-days	1308.67	58.163
CM4	15	28-days	1059	47.06
CM5	20	28-days	1018	45.24

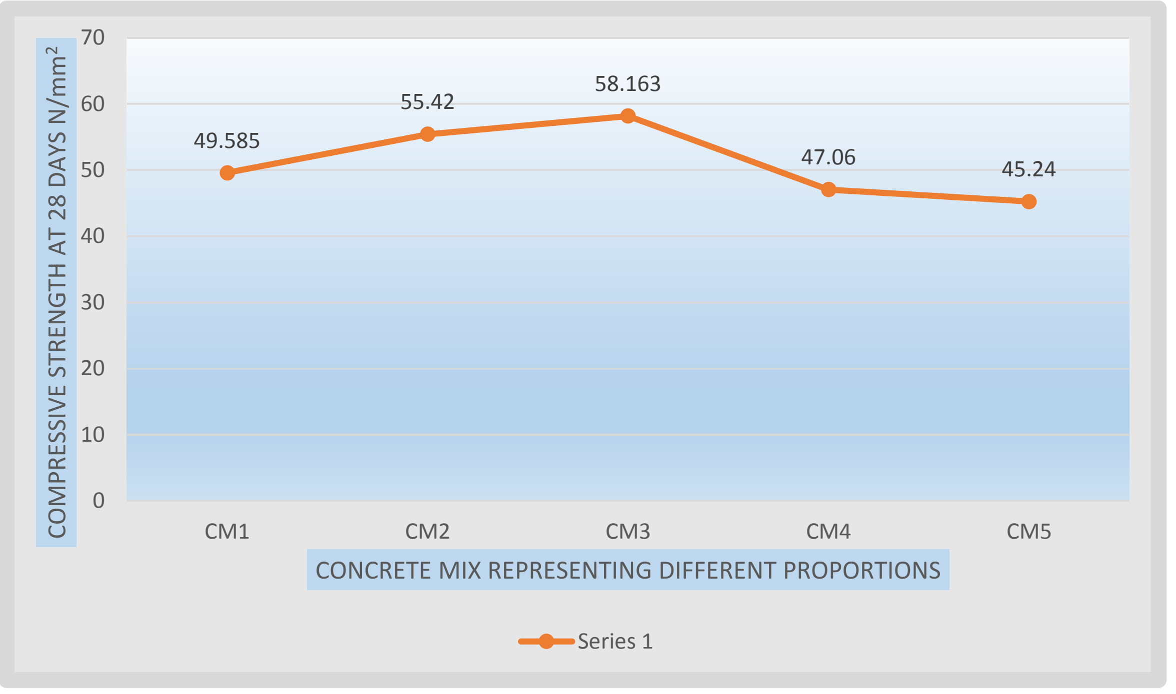

Fig – 19 Graph representing compressive strength

From the above graph it is clearly indicated that the results shows that the Compressive strength increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the compressive strength decreases.

At 10% replacement of cement there is an increase of ((58.163-49.585)/49.585) x 100 = 17.29% in the strength of concrete.

5.2Splitting Cylinder Test

It is also known as Brazilian test. In this test the cylindrical specimen of size length 30cm and dia 15cm is used and is loaded horizontally in between the platens of the compression testing machine. Application of the compressive load leads to the development of compressive stresses upto certain depth below the application of the point of the load, where as the substantial portion of the specimen is subjected to induced tensile stress, that leads to the splitting failure of the specimen (compressive stresses is develop upto the D/6 below the point load where as the remaining 5D/6 is subjected to tensile stresses. D is the diameter of the cylindrical specimen).

The greatest advantage of this test is that the same specimen and apparatus can be used for testing of both compressive strength and tensile strength of concrete. This test is very easy to perform and leads to the development of uniform tensile stresses across the section in comparison to any other test. The results obtained by this test are comparatively greater than direct tensile strength test and comparatively smaller than flexural tensile strength test.

Fig 20 - 3 Cylindrical Samples of Concrete Mix CM-1

Fig 21 - 3 Cylindrical Samples of Concrete Mix CM-2

Fig 22 - 3 Cylindrical Samples of Concrete Mix CM-3

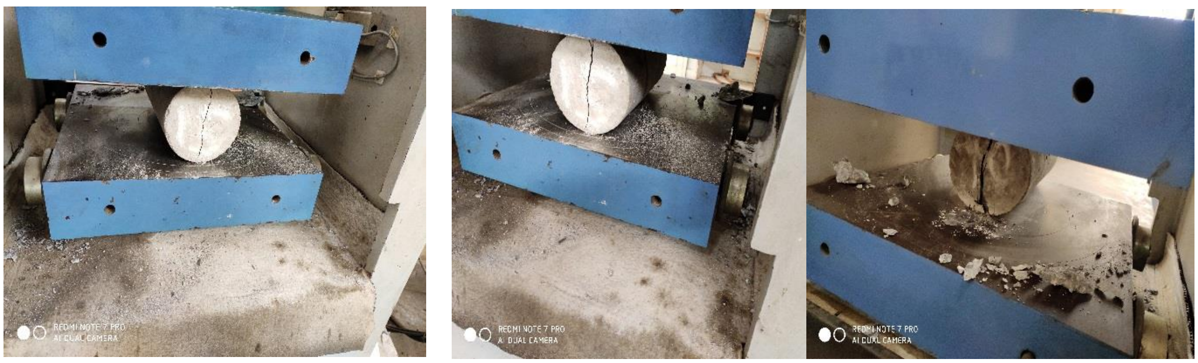

Fig 23 - 3 Cylindrical Samples of Concrete Mix CM-4

Fig 24 - 3 Cylindrical Samples of Concrete Mix CM-5

Calculation of split tensile strength:-

1. FOR CM-1

   Average load at failure = 297.67 KN

   Split tensile strength = (2P / πDL)

   = (2 x 297.67 x 1000)/ (π x 150 x 300)

   = 4.21 N/mm^2

2. FOR CM-2

   Average load at failure = 324.67 KN

   Split tensile strength = (2P / πDL)

   = (2 x 324.67 x 1000)/ (π x 150 x 300)

   = 4.593 N/mm^2

3. FOR CM-3

   Average load at failure = 354.33 KN

   Split tensile strength = (2P / πDL)

   = (2 x 354.33 x 1000)/ (π x 150 x 300)

   = 5.01 N/mm^2

4. FOR CM-4

   Average load at failure = 285 KN

   Split tensile strength = (2P / πDL)

   = (2 x 285 x 1000)/ (π x 150 x 300)

   = 4.03 N/mm^2

5. FOR CM-5

   Average load at failure = 279.67 KN

   Split tensile strength = (2P / πDL)

   = (2 x 279.67 x 1000)/ (π x 150 x 300)

   = 3.95 N/mm^2

The table indicating various proportions having part replacement of cement with marble dust powder with different mix proportion have been indicated in the below table

Table 5 – Different proportions of marble dust as part replacement of cement.

CONCRETE MIX	Cement (kg)	Marble dust as%replacement of cement	Marble Content (kg)	Sand (kg)	Coarse aggregate (kg)	Water (L)
CM1	9.24	0	0	19.8	38.5	3.69
CM2	8.77	5	0.462	19.8	38.5	3.69
CM3	8.31	10	0.924	19.8	38.5	3.69
CM4	7.85	15	1.386	19.8	38.5	3.69
CM5	7.39	20	1.848	19.8	38.5	3.69

Table 6 – Split tensile strength of the specimens having different proportions

CONCRETE MIX	%Replacement	Days	Average load (tested on 3 cylinders)(KN)	Split tensile strength N/mm^2
CM1	0	28-days	297.67	4.21
CM2	5	28-days	324.67	4.593
CM3	10	28-days	354.33	5.01
CM4	15	28-days	285	4.03
CM5	20	28-days	279.67	3.95

Calculation of split tensile strength of CM1 cube having 0% percentage replacement.

Average load at failure = 297.67 KN

Split tensile strength = (2P / πDL)

= (2 x 297.67 x 1000)/ (π x 150 x 300)

= 4.21 N/mm^2

Similarly other split tensile strength have been calculated above.

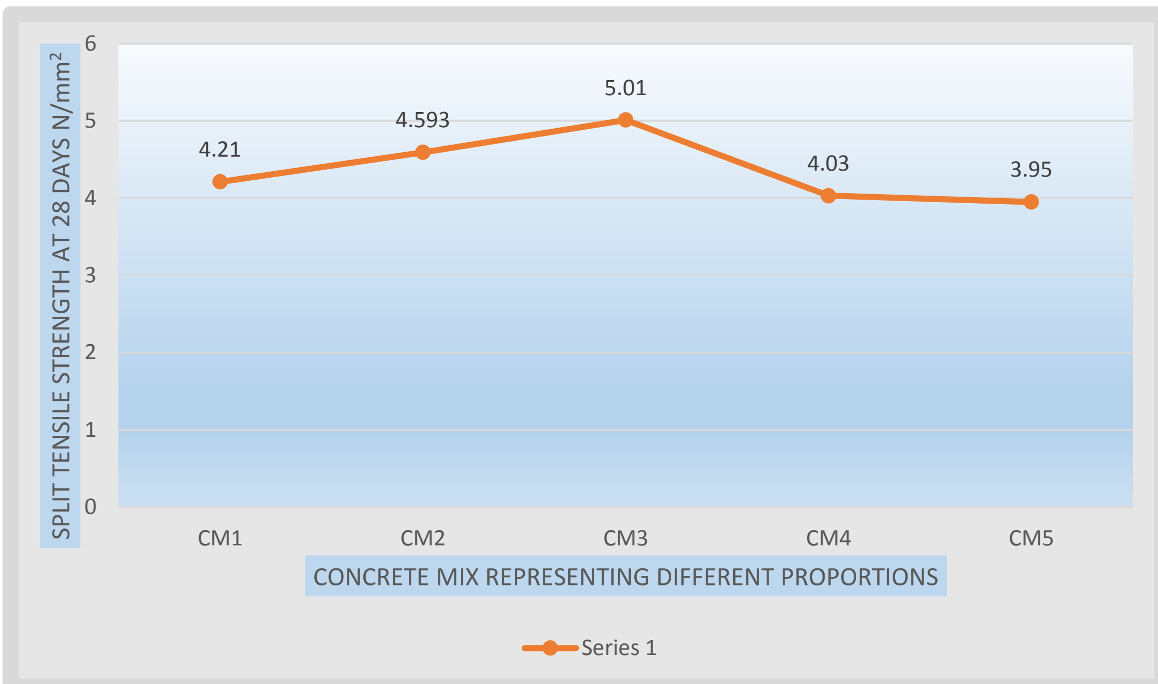

Fig 25 – Graph representing split tensile strength

From the above graph it is clearly indicated that the results shows that the split tensile strength increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the split tensile strength decreases.

At 10% replacement of cement there is an increase of ((5.01-4.21)/4.21) x 100 = 19.002% in the split tensile strength of concrete.

5.3 CONCLUSIONS

- The Compressive strength of the cubes are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the compressive strength decreases.

- The Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases.

- Thus we found out the optimum percentage for replacement of marble powder with cement and it is almost 10% of the total cement.

- The results form a basis for strong recommendation for the use of marble dust as replacement of cement in concrete thereby saving the environment from dust pollution.

- The use of marble dust in construction is cost effective because marble dust is available free of cost

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