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ANALYSIS OF CONCRETE STRENGTH BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE & MARBLE DUST POWDER

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Abstract

Concrete is the second most commonly used substance on Earth. Since cement is such an essential element of the building material, it must be produced in copious quantities. Carbon dioxide (CO2) emissions from cement production are a significant contributing factor in the greenhouse effect and climate change. High performance concrete (HPC) is also experiencing rising demand from the infrastructure sector. That's why it's crucial to find a material that may replace traditional cement in concrete that is both ecologically friendly and adds strength. Putting trash out for the ecosystem to find on its own can be an issue, too. The concrete industry can reap material optimization and economic benefits with the use of a growing composite material called marble dust powder (MDP). It is possible to partially replace cement with Alccofine, a new breed ultrafine supplemental cementitious material. Furthermore, it usually results in improved concrete performance. Using Alccofine and MDP together as supplemental cementitious material (SCM) to partially replace cement in concrete is an important step toward a more environmentally friendly concrete industry. This research is driven by a desire to compare and contrast the physical characteristics of the newly developed refined concrete with those of traditional concrete.

Keywords: Partial replacement, Alccofine, marble dust powder, refined concrete.

I. INTRODUCTION

1.1.GENERAL

Many buildings, especially those with massive or irregularity in the geometry, have made extensive use of concrete. In terms of global consumption, it is second only to water. The benefits of this work are twofold: it results in concrete that is both environmentally friendly and highly functional (HPC). The concrete industry has recently found success in developing environmentally friendly and dependable concrete structures that require less maintenance thanks to the use of environmentally friendly wastes or by-products from the industrial sector. Because of cement's vital role in making concrete, it's mass-produced to meet the sector's soaring demand.

Cement manufacturing releases vast quantities of carbon dioxide into the atmosphere, making a significant contribution to the greenhouse effect and consequently, global warming. According to 2018 data, cement manufacturing accounts for around 5% of total CO2 emissions,

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making it a significant contributor to the formation of greenhouse gases. Therefore, it is beneficial to the growth of the construction sector to use supplemental cementitious materials to partially replace cement.

The cement used to make concrete releases a lot of carbon dioxide into the atmosphere. The environmental effect of concrete buildings can be lessened by increasing its durability criteria. To ensure high durability and excellent performance through the end of the design life, even a tiny amount of leftover by it and micro materials may be incorporated into the concrete to alter the composition of cementitious materials. In this case, by-products and micromaterials like marble dust and talc powder were put to use.

Marble dust is deposited by sedimentation and subsequently discharged, causing environmental degradation and creating dust in the summer, which poses a hazard to agricultural and public health in India. Reducing trash and putting it to good use has thus become a priority. Natural resources can be used more effectively, and the environment can be safeguarded from waste deposits, when trash is used to manufacture new goods or as an admixture.

Waste The physic mechanical qualities of regular concrete can be enhanced by including marble dust into the mix. Since the price of raw materials has been rising steadily over the past few years, recycling old concrete could help keep costs down. Thus, the environmental benefits of using marble dust in building, agriculture, glass, and paper would be maximized if these industries adopted its use.

When cement is partially substituted with leftover marble dust powder, the resulting concrete improves in both workability and compressive strengths. As the need for high-performance concrete grows, the use of extra cementitious elements is a viable solution. In most contexts, the term "practically high strength concrete" refers to high strength concrete with a high cement concentration and a very low water-to-cement ratio.

The particles of Alccofine, a new type of micro fine material produced in India, are significantly smaller in size than those in traditional hydraulic products such as cement, fly ash, silica, etc. Thanks to its adjusted particle size distribution, Alccofine has special properties that improve the 'performance of concrete' both when it is still wet and when it has hardened. Its ultra-fine texture means you can use less water to achieve the same level of workability. Since this is the case, it may be the most viable alternative to cement when used in smaller quantities.

The experimental endeavor would involve attempting to partially replace cement with a mixture of Alccofine and marble dust powder. One of the main goals of this research is to conduct tests on the new modified concrete and compare its physical qualities to those of standard M20 concrete.

Marble dust is a byproduct of the marble-cutting process. Inevitably, cutting will produce a great deal of powder. As a result, roughly 25% of the marble's initial mass is dispersed as dust. An increase in soil alkalinity, negative effects on plants and animals, and even potential health problems for humans are just a few of the environmental concerns that could result from dumping these materials directly into the environment. As a byproduct of the marble industry, marble dust can be used as a substitute for sand or gravel in concrete's fine aggregates. The strength of concrete can be improved by adding marble powder as an additive. Since this debris can be used to make concrete that is both cheaper and more durable, it might be used to help civil engineers keep their infrastructure projects under budget while also addressing the issue of environmental degradation. The microfine substance Alccofine-1203 has a high glass content and is very reactive; it is environmentally benign and made from a low calcium silicate basis. The waste product of India's iron ore industries, known as ground granulated blast furnace slag (GGBS), is refined into a highly refined material known as Alccofine-1203. Fine powder form of Alccofine-1203. Because of the precise granulation procedure, alccofine-1203 is composed of incredibly small particles.

Alccofine-1203 boosts concrete's compressive strength and makes it easier to deal with during development. Alccofine-1203 material has significantly finer particles than cement, GGBS, silica, fly ash, etc. Therefore, alccofine-1203 can be used to fill the spaces between cement particles. The experimental effort would consist of attempting various combinations of Alccofine and marble dust powder as supplemental cementitious material for partially substituting cement.

1.2.NEED FOR REPLACEMENT

Potential exists in the construction sector for the use of various waste products as a replacement for traditional resources. This method of trash management helps preserve natural resources and lessens the quantity of space needed for landfill disposal of these waste materials.

Marble Dust Powder contains mostly carbonate minerals, most commonly it contains calcite and dolomite minerals. Due to this presence of minerals these imparts the strength to the concrete. Increasing in the percentages of the Marble dust powder results in the concrete's compressive strength and made it easier to shape as a workability. Along with this, we can reduce the waste by-products and can control environmental degradation.

Alccofine is derived as a by-product out from iron-ore industry, and so it possesses pozzolanic character and can be utilized as partial substitution of the cement used in concrete. Due to the micro-sized particle nature of Alccofine and reactive ness of the material works to increase the compressive strength and workability of concrete in addition to its flexural strength.

By combining these materials or substitutes in different proportions we can analyze the compressive strength, flexural strength and workability of the concrete and also reduce and replace the same amount of cement in concrete mixture. And can reduce a greater extent of these waste by-products from their respective sources and predominantly this will reduce the severe effects of environmental pollution and degradation.

In this case, Alccofine and marble dust powder are employed in the following varying ratios:

Table 1.1 Combinations

Powdered Alccofine and Marble Dust combined
0% of Both
15% of Alccofine & 15% of MDP
15% of Alccofine & 20% of MDP
15% of Alccofine & 25% of MDP

15% of Alccofine & 30% of MDP

II. LITERATURE REVIEW

[1] Abhishek Sachdeva, V.Rajesh Kumar, and others have tried using Alccofine to partially replace cement. Important discoveries have been made in the field of concrete. As a superior Supplementary Cementitious Material, Alccofine has been shown to improve the workability, strength, and durability of concrete, both when it is fresh and when it has hardened. According to their findings, 15% Alccofine is an optimal percentage.

[2] K. Gayathri, K. R. chandran, and J. Saravanan investigated how changing the cement in concrete affected its strength. Research shows that replacing 15% of the cement in concrete with Alccofine increases strength, whereas other percentages do not have the same benefits. According to their findings, using Alccofine in place of cement boosts the concrete's early strength.

[3] Mohd. Hamraj worked on a project where Alccofine 1203 was used to partially replace cement and crimped steel fibers with two distinct aspect ratios were included into concrete at varying percentages of the volume. By integrating crimped steel fibers in varying percentages, the durability qualities of binary integrated steel-fiber reinforced concrete using Alccofine 1203 just like mineral admixture were blended. Additionally, the percentage of weight loss and the leftover compressive strength of binary blend steel-fiber reinforced concrete were calculated. The testing was done with M50 grade concrete. The concentrations of Alccofine tried were 5%, 10%, 15%, and 20%. Steel fiber reinforced concrete mixes with varying fiber volume fraction and aspect ratio were cast following the optimization of Alccofine, which was determined to be 15% based on their findings. After doing this research, we found that replacing 15% of the cement in Binary Blended Concrete with Alccofine provided the best combination of strength and workability. Using Alccofine as a partial cement replacement made steel-fiber reinforced concrete mixes more workable.It was also discovered that acid-attacked concrete strengthened when Alccofine was substituted for 15% of the cement.

[4] Ali A. Aliabdo, Abd Elmoaty M. Abd Elmoaty Esraa M. Auda experimented with using discarded marble dust like a replacement material in concrete to see whether it would work. They conducted a series of experiments with varying percentages of marble dust added to the mix, finding that the dust improved performance in a variety of situations. TGA, XRD, and SEM tests have also been conducted. They concluded that, within the constraints of Egyptian requirements, concrete whose cement was replaced with marble dust had superior qualities. They've also found that this mixture works well in concrete since it improves the material's properties. They go on to say that this mixture helps to reduce the water-to-cement ratio. They found that replacing up to 15% of the steel in the concrete with marble dust significantly increased the binding strength between the two materials.

[5] A.H.Awad, AymanAly Abd El-Wahab, RamadanEl- Gamsy, M.HazemAbdel-latif analyzed the impact of marble as well as granite grit size and composition on mechanical properties Findings demonstrated that using marble and granite grit enhanced thermal and mechanical qualities. Thermogravimetric analysis (TGA) results showed that dust particles raise the decomposition temperature by 11 °C. The material's hardness, elasticity, and Shore D index (a measure of its yield strength) were all analyzed. When marble and granite grit are added to an HDPE matrix, the melting point does not alter noticeably.

III. METHODOLOGY

3.1. MATERIALS

3.1.1. Ordinary port land cement

There are many different types of cement, but Portland cement is by far the most widely used. Concrete, mortar, plaster, and the vast majority of types of grouts are based on it. It is derived from limestone and was refined in England in the nineteenth century from several varieties of hydraulic-lime. Cement is a granular material made from a combination of elements that have been heated in a thermal process to create clinker, ground into a powder, and then mixed with other ingredients.

Because of its caustic nature, Portland cement can cause chemical burns, and its powder can cause itching or irritation. There are certain harmful elements in this powder, including silica and chromium, and prolonged exposure to it may induce respiratory problems. They are problematic for the environment since they demand a lot of energy during production and shipping. Air pollution occurs as a result of the discharge of hazardous gases such as greenhouse gases (such as carbon dioxide), dioxin, NO x, SO_2, and particulates.

Because of its low price and the ease with which materials like limestone, shale, and natural materials can be accessed, the use of Portland cement has increased. As a result, it is among the most widely used inexpensive materials in the world. In terms of density, cement has a specific gravity of 3.11.

Properties of Portland cement:

These characteristics are gleaned from canonical texts such as books and magazines, as well as normative frameworks such as certain codes. The purpose of this analysis is to identify the sample's true chemical make-up as reported by the firm. Table No. 3.1 displays the results of a chemical characterization of Portland cement.

Table No 3.1 Chemical breakdown of Portland cement

S.NO	Constituent	Percentage
1.	Cao	64.00
2.	Sio_2	22.00
3.	Al_2o_3	4.10
4.	Fe_2o_3	3.60
5.	Mgo	1.53
6.	So_3	1.90

3.1.2. FINE AGGREGATE:

Sand is a naturally occurring substance composed of minuscule fragments of rock and mineral. In both inland continental and non-tropical coastal settings is silica as silicon dioxide, typically in the form of quartz, is the most frequent ingredient of sand. Quartz's chemical

inertness and substantial hardness make it the most prevalent material that can withstand harsh weathering. In concrete, it serves as a fine aggregate.
To do this task, we used the river sand found locally, which has a specific gravity of 2.65 and conforms to Zone II of IS: 383- 19707.

3.1.3. COARSE AGGREGATE:

The coarse aggregates originate from a combination of naturally existing rock fragments and crushed granite. Concrete's strength qualities may also be affected by the coarse aggregate's form. These can be found in a variety of shapes, with angular aggregates potentially providing the best density of mix and minimizing void holes. As per IS: 383-1970, we are now using angular coarse aggregates with a maximum size of 20mm in this project. The nearby quarry provides this crushed granite stone with a specific gravity of 2.72.

3.1.4. WATER:

The primary ingredient in making concrete is water. Concrete was mixed and cured using drinkable water.

Table No 3.2 Specific Gravity for constituent materials

S.NO	Ingredients	Specific Gravity
1	Cement	3.11
2	Fine Aggregate	2.65
3	Coarse Aggregate	2.72

3.1.5. ALCCOFINE 1203

Slag processing results in this by-product. Both Alccofine 1203 & Alccofine 1101 exist, with the former having a low calcium silicate content and the latter having a high calcium silicate content. It's a type of slag that has an extremely small particle size and a very even distribution of those tiny particles. It can be used to make concrete with higher compressive strength by reducing the amount of water used in the mix. Likewise, it has a lot of calcium oxide in it. It can serve as a partial replacement for cement because of its cement-like characteristics. The qualities of concrete, both when fresh and after curing, are improved.

3.1.6. MARBLE DUST POWDER:

Marble scraps are the inert remnants of the cutting and polishing of marble that are discarded as waste. Globally, we produce a good amount of marble trash, which has been a major environmental issue. When stones are cut, they release heat, slurry, rock fragments, and dust. Twenty percent to thirty percent of marble slabs are ground into powder. In 2009-2010, 3,172,000 tons of marble dust were generated. In light of the environmental damage caused by marble dust and the pollution generated by cement production, using marble dust in place of cement can help remedy the situation, as it will result in the elimination of waste while simultaneously improving the concrete's mechanical and physical properties.

3.2. MIX DESIGN OF CONCRETE:

Water-to-cement ratio is the most important factor determining strength character of concrete. The properties of the aggregate, in addition to the water-to-cement ratio, affect the characteristics of the concrete with a compressive strength of 20MPa. Because a low w/c ratio is required to achieve desirable strength, the mix's workability suffers as a result.With today's technology, it's possible to use standard techniques for compacting mixes to create concrete with a compressive strength of at least 20 MPa after 28 days.

<u>Stipulations for Proportioning</u>:

a) Grade designation : M20
b) Type of cement : OPC53grade(IS12269)
c) Maximum nominal size of aggregate : 20mm
d) Minimum cement content : 300kg/m^3
e) Maximum cement content : 450kg/m^3
f) Maximum water-cement ratio : 0.50
g) Workability : 75mm(slump)
h) Exposure condition : Moderate
i) Method of concrete placing : Hand
j) Degree of supervision : Good
k) Type of aggregate : Crushed angular

<u>Test Data for Materials</u>:

a) Cement used : OPC53grade
b) Specific Gravity of cement : 3.11
c) Specific Gravity of
    i. Coarse Aggregate : 2.72
    ii. Fine Aggregate : 2.65
d) Water Absorption
    i. Coarse Aggregate : 0.3%
    ii. Fine Aggregate : 1%
e) Sieve Analysis
    i. Coarse Aggregate : Crushed angular
    ii. Fine Aggregate : Confirming to Grading Zone-2 of IS-383

Mixing typical concrete of grade M20 (0.5 parts water to 1 part cement) is the first step. We took a regular batch of concrete and altered it by adding admixtures like Alccofine and MDP. Here, we're including the admixtures at concentrations of 15%, 20%, 25%, and 30%. Mixing occurs at a 0.5 water-to-cement ratio for each of the individual proportions.

Table No 3.3 Percentage Combination of Alccofine-1203 & Marble Dust Powder

Combination	Alccofine	Marble Dust Powder	Cement
(Alccofine+mdp)	(Kg/m^3)	(Kg/m^3)	(Kg/m^3)
0% + 0%	0	0	384
15% + 15%	57.6	57.6	268.8
15% + 20%	57.6	76.8	249.6
15% + 25%	57.6	96	230.4
15% + 30%	57.6	115.2	211.2

3.3. TESTS ON CONCRETE:

In this project, OPC will be used to make concrete with a mix proportion of 1: 1.78: 3.0, in which Alccofine-1203 & Marble Dust Powder will be added to the traditional concrete recipe alongside sand for fine aggregate & kankar for coarse aggregate to replace some of the cement. Different samples (cubes & cylinders) are created based on the mix proportion.After conducting tests, we evaluate the performance of both regular concrete and Concrete with Alccofine & MDP.

The following concrete qualities will be determined by testing concrete mix samples:Compressive strength after 7 days, 28 days.

- Split tensile strength after 7 days, 28 days.
- Flexural strength of concrete

3.3.1. Compressive strength results:

To study the effect on compressive strength of concrete, Compressive strength is evaluated by casting 45 identical cubes (150mm x 150mm x 150mm) at 3, 7, and 28 days old with varying ratios of Alccofine-1203 & Marble Dust Powder.

3.3.2. Split tensile strength:

To study the effect on Split Tensile strength, for this experiment, we cast 45 cylinders (150 mm in diameter and 300 mm in length) using the calculated material weight for varying percentages of Alccofine-1203 and Marble Dust Powder at the corresponding test days 3, 7, and 28.

3.3.3. Flexural strength of concrete:

To study the effect on flexural strength, thirty beams (each measuring 500mm x 100mm x 100mm) are cast using the calculated material weight of varying percentages of Alccofine-1203 and Marble Dust Powder, and then tested at 3, 7, and 28 days

IV. RESULTS AND DISCUSSIONS

4.1. Compressive Strength of Concrete at 3, 7, 28-days:

Table No 4.1 Compressive Test Results at 3, 7, 28 days

S.no	Combinations	Percentage of Alccofine-1203 %	% of MDP	Average Compressive Strength N/mm2		
	Alccofine+mdp			3 days	7 days	28 days
1	OPC	0%	0%	10.325	16.67	22.53
2	C1	15%	15%	11.07	17.6	24.63
3	C2	15%	20%	12.5	19.9	28.53
4	C3	15%	25%	11.3	17.91	25.32
5	C4	15%	30%	11.45	16.73	24.87

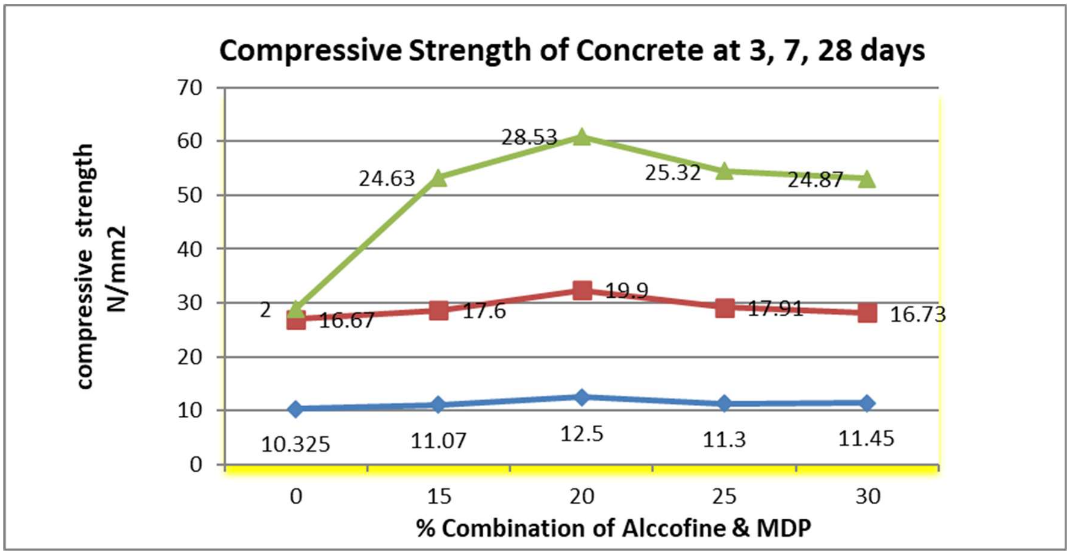

Figure 4.1 Comparison of compressive strength for all combinations

4.2. Split Tensile strength of Concrete at 3, 7, 28 days:

Table No 4.2 Split Tensile strength Test Results

S.No	% of Alccofine-1203	% of MDP	Average Split Tensile Strength N/mm2		
			3 days	7 days	28 days
1	0%	0%	1.03	1.567	2.253
2	15%	15%	1.12	1.98	2.79
3	15%	20%	1.25	2.326	3.46
4	15%	25%	1.156	1.84	3.32
5	15%	30%	1.145	1.61	2.55

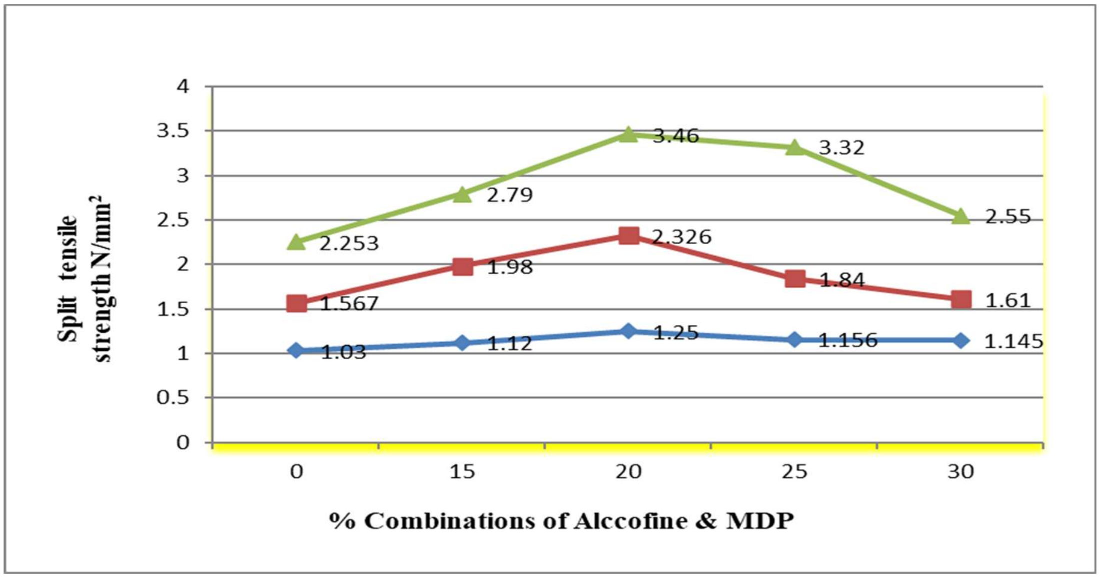

Fig 4.2 Comparison of Split Tensile strength for all combinations

4.3. Flexural strength of Concrete at 3, 7, and 28 days:

Table No 4.3 Flexural Strength Test Results

S.no	% of Alccofine-1203	% of MDP	Average Flexural Strength N/mm2		
			3 days	7 days	28 days
1	0%	0%	3.56	3.95	4.85
2	15%	15%	4	4.4	5.6
3	15%	20%	4.83	5.35	5.93
4	15%	25%	3.9	4.2	5.8
5	15%	30%	4.13	4.4	5.6

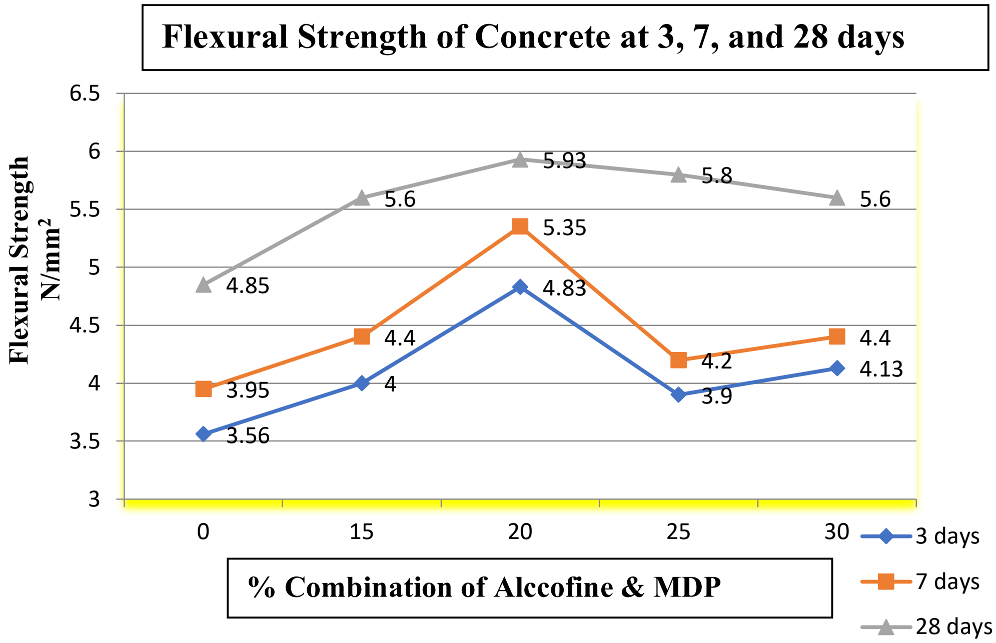

Fig 4.3 Comparison of Flexural strength for all combinations

V. CONCLUSIONS

Based on the experimental investigations, compressive strength, split tensile strength, and flexural strength of concrete with varying concentrations of the admixture (in this case, Alccofine-1203 and MDP) were measured after 3, 7, and 28 days of curing. This leads us to the following inferences.

- It is possible to partially replace cement with a mixture of marble dust powder & Alccofine-1203.Excessive replacement of cement may result in increasing in the requirement of admixtures, which may result in increasing of overall cost of project.
- Due to presence of CaO, High calcium silicate in Alccofine-1203 and their Ultra-fineness particle size imparts high strength to concrete and acts as water reduction agent.
- Marble Dust Powder contains 20-30 % residual power of Marble Stone, Due to their pozzolanic activity and their fineness, it can easily mix with aggregates and possible to create strong bond between aggregates, which gives strength and durability to the concrete.
- When compared to regular concrete, the mean compressive strength of concrete is significantly increased when Alccofine and MDP are added at a combined 15%.

5.1. COMPRESSIVE STRENGTH:

- The average compressive strength of typical concrete for M20 was determined as 22.53 N/mm2, which is 10% more than the characteristic compressive strength, thanks to the presence of fine grained and superior quality components.

<u>For 7 days:</u>

- 7-day-old concrete mixed with 15% Alccofine-1203 and 20% Marble Dust Powder had a compressive strength of 19.9 N/mm2, a 19.25% increase over regular concrete.
- When using 15% Alccofine and 15% MDP, the mean compressive strength of concrete about 17.6 N/mm2, which is 8% higher than that of normal concrete.

<u>For 28 days:</u>

- Compressive Strength of concrete at 28 days with 15% of Alccofine-1203 and 20% of Marble Dust Powder attained 28.53 N/mm^2 which is 26.5% increase in strength to conventional concrete.
- Compressive Strength of concrete at 28 days attained 28.53N/mm^2 which is greater than Characteristic compressive strength (20N/mm^2) and Target Mean strength (26.5N/mm^2).
- Addition of 15% of Alccofine & 25% of MDP given Strength which ultimately more than that of conventional concrete by 15%.
- There is considerable increment in strength of concrete at different proportions, but at the optimum percentage, it gives the maximum compressive strength.

5.2. SPLIT TENSILE STRENGTH:

- The 28-day split tensile strength of concrete with no admixture is 2.3 N/mm2, which is higher than the calculated Characteristic Strength, the Target Strength, and the split tensile strength obtained by utilizing the formula. (Fcts = 0.5*(fck) 0.5 = **2.2** N/mm^2).

<u>For 7 days:</u>

- Split Tensile Strength of Concrete is increased from **1.56** N/mm^2 to **2.326** N/mm^2, which 40% greater than to Conventional Concrete at C2 combination of admixtures.

<u>For 28 days:</u>

- The concrete's split tensile strength has enhanced between 2.25 N/mm2 to 3.46 N/mm2.
- Split tensile Strength, Maximum average strength occurs at the optimum percentage i.e., C2 combination of admixtures.

5.3. FLEXURAL STRENGTH:

- Flexure Strength of Concrete for 0% mix admixture at 28 days attained is

4.85 N/mm2 which is greater than that calculated using formula
(Fcts = 0.64*(fck) 0.5 = **2.9** N/mm^2).

- Flexural Strength of Concrete is increased from **4.85** N/mm^2 to **5.93** N/mm^2.

- From this experimental investigation, the absolute strength of concrete is occurred at a percentage **of 15% Alccofine and 20% MDP** which is to be the **optimum percentage** of the admixtures replaced to cement.
- The mechanical characteristics of the concrete enhanced significantly and effectively at this optimal additive percentage.

- The strength of concrete reduced when cement was heavily replaced with admixtures compared to the recommended percentage of replacement.

Hence by this experiment we can greatly achieve the strength of concrete and can reduced the considerable range of waste by-product and helps in environmental growth.

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