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Partial Replacement of Cement With Combination of Alccofine and Marble Dust for Development of Sustainable Concrete

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Abstract: ***Concrete is second most consumed material in the world after water. Cement being the important material of concrete needs to be manufactured in large amount. Production of cement involves large amount of carbon dioxide emissions into the atmosphere, a major contributor for greenhouse effect and global warming. Also demand of high performance concrete (HPC) for infrastructural industry is growing. Thus, it becomes necessary to discover a partial replacement of material for cement in concrete which is environmental friendly and strength gaining which solves both issues. Leaving the waste materials to the environment directly can also cause environmental problem. Marble Dust Powder (MDP) is a developing composite material that will allow the concrete industry to optimize materiel use, generate economic benefits. Alccofine is a new generation ultra fine supplementary cementetious material as a partial replacement of cement. It also tends to gain high performance of concrete. Usage of alccofine and MDP in a combination as supplementary cementetious material (SCM) by partially replacing cement in concrete can be a leading step towards sustainable development of concrete industry. Comparing and examining the physical properties of this new modified concrete with conventional concrete is the motivation of this study.***

Keywords: ***Partial replacement, alccofine, marble dust powder, modified concrete.***

I. INTRODUCTION

Highlight Concrete has widely been used in many structures of massive or irregular geometry. It is second most consumed material in the world after water. The current work presented dual beneficiary to produce environmental friendly concrete and high performance of concrete (HPC). Recently, the sustainability of concrete can be achieved using environmental friendly wastes or industrial by-products added that the concrete industry can succeed in creating environmental friendly and reliable concrete structures with very little maintenance. Cement being the important material of the concrete is produced in large amount to fulfil the exceeding demand of construction industry. Production of cement involves large amount of carbon dioxide emissions into the atmosphere, a major contributor for greenhouse effect and global warming. As per the census of 2018 cement production plays an important role in generation of greenhouse gases that share about 5% of total CO2 emissions. Hence partially replacing cement with supplementary cementitious materials is a good idea towards development of construction industry.

In India, marble dust is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Waste Marble dust can be used to improve the mechanical and physical properties of the conventional concrete. Now-a-days the cost of material is increasing so if we use the waste material in the production of the concrete so we decrease the price. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Partial replacement of cement by varying percentage of marble dust powder reveals that increased waste marble dust powder ratio result in increased workability and compressive strengths of the concrete.

Increasing demand of high performance concrete can also be settled by using supplementary cementitious materials. Practically high strength concrete is generally said to be high strength concrete having high cement content and very low water cement ratio. Alccofine is a new generation, micro fine material of particle size much finer than other hydraulic materials like cement, fly ash, silica etc. being manufactured in India. Alccofine has unique characteristics to enhance 'performance of concrete' in fresh and hardened stages due to its optimized particle size distribution. Due to its ultra-fineness, it provides reduced water demand for a given workability. Hence it can be the best option to be used as partial replacement of cement.

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Combining alccofine and marble dust powder as combination of supplementary cementitious material for partially replacing cement would be the experimental work attempt. Testing and comparing physical properties such as compressive strength, split tensile strength, flexural strength for this new modified concrete with conventional concrete of M40 grade is the study program of this paper.

II. LITERATURE REVIEW

Abhishek Sachdeva1, V.Rajesh Kumar have conducted an experiment on partial replacement of cement with alccofine. And they have found significant results in concrete. as the fresh and hardened properties of concrete were improve with replacement of cement with Alccofine is proved to be a superior Supplementary Cementitious Material which enhance the workability, strength and durability of concrete. Optimum percentage of Alccofine can be considered as 15% according to their results.

K. Gayathri, K. R. chandran and J. Saravanan (2016) performed research on changes in strength of concrete by replacing the cement in concrete. It is found that 15% replacement of cement by alccofine in concrete gains good strength while other percentage does not show this satisfactory results .they have also concluded that early strength of the concrete increases by addition of alccofine as a replacement of cement .

Mohd. Hamraj worked on the partial replacement of cement with Alccofine 1203 along with incorporation of crimped steel fibres of two aspect ratios with different percentages of the volume concrete. The durability properties of binary blended steel fiber reinforced concrete with Alccofine 1203 as mineral admixture by incorporating crimped steel fibers of different proportions were mixed. And the residual compressive strength and percentage weight loss of binary blended steel fiber reinforced concrete were determined. M50 grade concrete was taken for the testing. 5%, 10%, 15% and 20% of Alccofine was used for testing purpose. After the optimization of Alccofine which was 15% according to their results, the steel fibre reinforced concrete mixes were casted with different fiber content and aspect ratio. From this investigation, it was concluded that 15% cement replacement with Alccofine gave optimum strength and workability for Binary Blended Concrete. The workability of steel fiber reinforced concrete mixes was improved with the partial replacement of cement with Alccofine. It was also found that 15% replacement of cement with Alccofine was more durable when compared to normal concrete after exposure to acid attack

Ali A. Aliabdo, Abd Elmoaty M. Abd Elmoaty Esraa M. Auda conducted an experimental study to investigate the utilization of waste marble dust as a replacing material in concrete. they have perform experimental study in which they have taken the ratios of marble dust as 0.0%, 5.0%, 7.5%, 10.0% and 15% by weight for replacement. they have also performed TGA, XRD and SEM. Test. And they have come to a conclusion that the concrete made with replacement of cement by marble dust can enhance the properties of concrete which also within limits of Egyptian standards. they have also noted that this blend can be use successfully in concrete mix as it enhances the property of concrete. Further on they have mention that this blend is useful in lower water cement ratio. From their experimental study and research they have concluded that the use of marble dust up to 15.0% replacement gives significant result about the steel-concrete bond strength.

A.H.Awad , AymanAly Abd El-Wahab, RamadanEl-Gamsy, M.HazemAbdel-latif have conducted an research to study the marble and granite dust size and its content on the physical and mechanical properties The results showed that the addition of marble and granite dust improves the thermal and mechanical properties . The experimental results of TGA test showed that addition of dust particles increase the degradation temperature by 11 °C .Yield strength , elastic modulus and hardness Shore D were studied. Addition of marble and granite dust to HDPE matrix causes no significant change in melting point.

III. EXPERIMENTAL PROGRAM

3.1 Materials

3.1.1 Conventional Materials Used

1. Cement –The Ordinary Portland cement in general can be defined as a material, which possesses very good adhesive and cohesive properties that make it possible to bond with other materials to form a compact mass. 53 grade Ordinary Portland cement conforming to BIS 12269-1987 is used for this study.
2. Fine Aggregate – The Fine aggregate should consist of smooth rounded particles, to reduce the water demand. It is recommended that the grading should lie on the coarser side of the limits, a fineness modulus of 3 or greater is recommended, both to decrease the water requirements and to improve the workability of these paste rich mixes, of course, the sand to must be free of silt or clay particles. River sand is used in this mix.
3. Coarse Aggregate – For high performance of concrete, the coarse aggregate particles themselves must be strong, from both strength and rheological considerations, the coarse aggregate particles should be roughly equi-dimensional, either crushed rock or natural gravels, particularly if they are of glacial origin, are suitable. Aggregate of 10mm and 20mm sizes is used after performing sieve analysis.
4. Water – Water is the main ingredients of preparation for concrete. The potable water was used for mixing concrete and curing the specimens.
5. Admixture – Conplast SP500 is used for High performance water reducing and super plasticising admixture for micro silica concrete.

Table1 Specific gravity for materials

Ingredients	Specific gravity
Cement	3.15
Fine aggregate	2.61
Coarse aggregate (20mm)	2.65
Coarse aggregate (10mm)	2.66
Admixture (conplast SP500)	1.25

3.1.2 Supplementary cementitious materials

(a) Alccofine 1203

It is a by-product of processed product obtained from slag. Alcofine 1203 and Alcofine 1101 are two types of Alccofine with low calcium silicate and high calcium silicate resp.

It is slag having ultra-fineness with optimized particle size distribution. It can also be used as water reduction agent in concrete to improve comp strength. It also content high of CaO.

Due to its properties similar to cement it can be a partial replacement to cement. It also enhances the fresh and hardened properties of concrete. As per the study of literature

alccofine 1203 can be used as supplementary cementitious material. Replacement of cement with alccofine 1203 up to 15% gives optimum results.

Table2 Physical parameters of Alccofine 1203

Specific gravity	Bulk Density (kg/m^3)	particle size distribution (μ)		
2.9	600-700	d 10	d 50	d90
		1-2	4-5	8-9

(b) Marble dust powder

Marble waste is a solid waste material generated from the marble processing. Marble waste is generated in a fairly large quantity in the world and has been causing serious environmental problems. Cutting of stones produces heat, slurry, rock fragments and dust. 20 to 30% of marble blocks are converted in to powder. 3,172 thousand tons of marble dust was produced in year 2009-10. Thus owing to this environmental condition due to marble dust as well as due to pollution caused during the manufacturing of cement, the cement can be replaced by marble dust which will lead to eliminate the waste and as well as will benefit the mechanical and physical properties of concrete. The Compressive strength and Split Tensile strength of Concrete can be increased with addition of waste marble powder up to 15%-25% replace by weight of cement. Due to fineness of the marble powder, it will easily mix with aggregates so that perfect bonding is possible.

Table3 Physical parameters of Marble Dust Powder

Specific Gravity	Water Absorption (%)	Bulk Density (Kg/m^3)
2.57	2	1135

3.2 Mix design

All the specimens were prepared by mechanical mixing in accordance with IS: 2250-1981. The Conventional concrete of M40 grade with constant Water/cement ratio (W/C) of 0.40 was prepared without replacement of cement. Cement was partially replaced by combination of alccofine and MDP where replacement of alccofine was done with 15% in each combination (15% being optimum partial replacement proportion for alccofine) content of MDP varying from 15% to 30 % @ 5%.

Combination (alcco+MDP)	Alccofine (Kg/m^3)	MDP (Kg/m^3)	Cement (Kg/m^3)
0%+0%	0	0	470.00
15%+15%	70.50	70.50	329.00
15%+20%	70.50	94.00	305.50
15%+25%	70.50	117.5	282.00
15%+30%	70.50	141.0	258.50

Table4 Proportions of cement for all combinations

Age(day)	Strength per cent (%)
1	16
3	40
7	65
14	90
28	99

IS 456-2000 was used to derive the mix proportion for M40 grade concrete. Strength parameters are tested in three spans after curing; $3^{rd,}$ 7^{th} and 28^{th} days respectively. The strength of concrete increases with age. Percentage strength of concrete at various ages can be calculated using the following table.

Table5 Strength of concrete at different ages

3.3 Concrete testing

High Performance concrete is prepared with help of the guideline given by ACI-211-4R and in accordance with IS10262-2009. Tests for compression, tension and flexure were performed.

1. Compressive strength – Cubes of size 150x150x150mm were casted for testing compressive strength of all these modified mixes. 9cubes were casted for every combination and also for conventional concrete. 3cubes were tested with compression testing machine for span of 3days, 7days and 28days each.
2. Split tensile strength – cylinders of 150mm diameter and 300mm height were casted for testing of tensile strength of all these modified mixes. Test was performed by placing cylinder horizontally then applying the compressive load until the cylinder fail. It gives the strength indirectly to cylinder. 9cylinders were casted for every combination and also for conventional concrete. 3cylinders were tested with tension testing machine for span of 3days, 7days and 28days each.
3. Flexure strength – IS 516-1959 is referred for performing flexural tests, flexural testing machine was used to test the beams of all combinations of modified concrete. Beams of 700x150x150mm were casted; 9beams were casted for every combination and also for conventional concrete. 3beams were tested for span of 3days, 7days and 28days each.

IV. RESULTS AND DISCUSSIONS

4.1 Compressive strength

Compressive strength results for all combinations for modified concrete are given below. Comparison of their strength is done in graphical format.

Table6 Compressive strength for all combination

COMBINATIONS	DAYS		
	3^{rd}	7^{th}	28^{th}
CC.	26.06	34.59	48.07
K1.	19.81	26.90	52.53
K2.	17.85	29.13	28.25
K3.	26.06	34.59	48.07
K4.	16.84	28.25	43.32

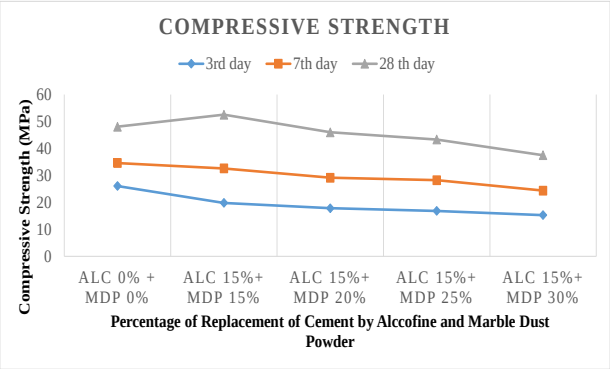

Fig.1 Comparison of compressive strength for all combinations

3.1 Split tensile strength

Split tensile strength results for all combinations for modified concrete are given below. Comparison of their strength is done in graphical format.

Table7 Split tensile strength for all combination

COMBINATIONS	DAYS		
	3^{rd}	7^{th}	28^{th}
CC.	1.51	2.65	3.97
K1.	1.67	2.74	4.05
K2.	1.26	2.34	3.43
K3.	1.19	2.08	3.12
K4.	1.07	1.71	2.76

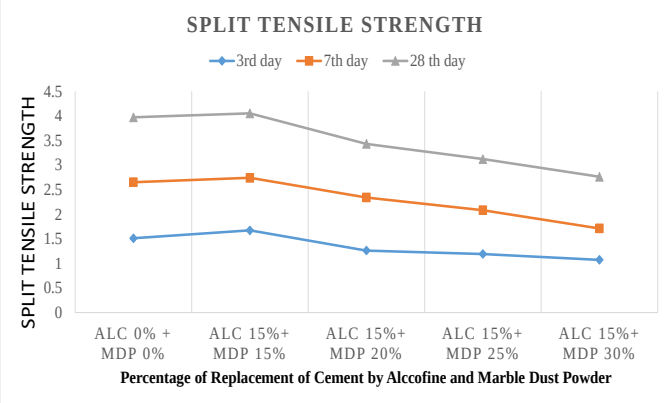

Fig.2 Comparison of split tensile strength for all combinations

3.2 Flexure tensile strength

Flexure tensile strength results for all combinations for modified concrete are given below. Comparison of their strength is done in graphical format.

Table8 Flexural tensile strength for all combination

COMBINATIONS	DAYS		
	3^{rd}	7^{th}	28^{th}
CC.	2.12	3.36	5.02
K1.	2.30	3.54	5.09
K2.	1.99	3.14	4.83
K3.	1.77	2.90	4.60
K4.	1.53	2.72	4.34

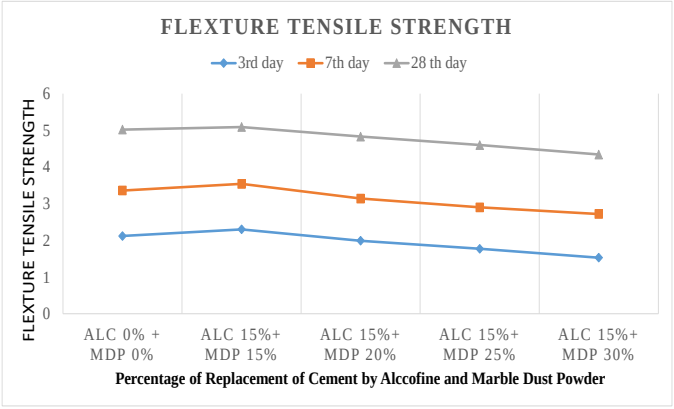

Fig.3 Comparison of Flexural tensile strength for all combinations

V. CONCLUSION

- Marble dust powder and alccofine can be used in a combination as supplementary cementitious material as partial replacement of cement.
- 15% alccofine with 15% marble dust powder (K1) gives 32% increase in compressive strength of this newly modified concrete in comparison with conventional concrete of M40 grade which is optimum amongst other combinations.
- 15% alccofine with 15% marble dust powder (K1) gives satisfactory results in flexural strength and split tensile strength for this modified concrete.
- Percentage increase in MDP results in decrease of strength parameters i.e. combination having 20%, 25%, 30% of MDP gives less increase in results for this mix proportion

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Revati Sawant is Civil Engineer graduated from Gokhale Education Society College of Engineering, Nashik. I have certification for MSP, Primavera, ETABS and also able to promptly operate AutoCAD, MS office softwares. My project work was done for Impact resistance of rubberised Concrete. I have also worked as trainee engineer at Jadhav Builder's in Nashik (2015). Also I have done internship at B G Shirke Construction Technology Pvt. Ltd; Pune for the project of Railway Over Bridge(2018) And C. V. Kand Consultants Pvt. Ltd; Pune for the project of Double Flyover(2018). Presently pursuing my post graduation for Construction and Management in D Y Patil College of Engineering, Akurdi, Pune.

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Sachin Mane is Presently working as Assistant professor in D Y Patil College of Engineering Akurdi, Pune. I am having 15 years of teaching experience in the field of civil engineering. I have published more than 20 papers in International Journal.