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An Experimental Study on Self Compacting Concrete with Marble Powder and Cement Kiln Dust as Mineral Admixtures

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Abstract: In this experiment study of self compacting concrete, Ordinary Portland Cement is partial replacement by mineral adMIXtures like marble powder and cement kiln dust. If only Ordinary Portland Cement is used in self compacting concrete, then it become uneconomical, there is possibility of thermal cracks also. Therefore, it is necessary to replace some of the cement content by mineral admixtures to achieve an economical concrete. Marble powder is waste material with limestone origin and there is no recycle marble powder. Cement kiln dust is by-product which collected at different units during manufacturing of Ordinary Portland cement. So we use marble powder and cement kiln dust used as mineral admixture. The slump flow, L box and V funnel tests carried out on the fresh state of self compacting concrete. The compressive strength, tensile strength and flexural strength tests are carried out on the hardened state of self compacting concrete and also to study the durability property like acid resistance. The established benefits substitution marble powder and cement kiln dust by cement to make concrete such as economic, saving landfill, reduce CO_2 emission by the use of less cement.

I. INTRODUCTION

The self compacting or super workable concrete, also known as self consolidating concrete is a highly flow able or self levelling cohesive concrete that can spread readily into place through and around dense reinforcement under its own weight. It adequately fills formwork without segregation or bleeding, and without the need for significant vibration. Self compacting concrete mix has a low yield stress and an increased plastic viscosity. The mix requires minimal force to initiate flow yet have adequate cohesion to resist aggregate segregation and excessive bleeding, i.e., coarse aggregate can float in the mortar without segregating. The yield stress is reduced by using an advanced synthetic high range water reducing admixture (HRWR), while the viscosity of the paste is increased by using a viscosity modifying admixture (VMA) or by increasing the percentage of fines incorporated into the self compacting concrete mix design. Modern applications of self compacting concrete is focused on high performance; better and more reliable quality, dense and uniform surface texture, improved durability, high strength and faster construction. In Japan and Europe, self compacting concrete technology has been extensively used in bridges, buildings and tunnel construction, where as in USA, used in precast concrete industry, tanks, bridge decks and architectural concretes.

II. LITERATURE REVIEW

Chandrakant U. Mehetre and Pradnya P. Urade (2014) The literature indicates that studies on the self compacting concrete with different mineral admixtures as powder content (filler) and also made comprehensive studies on fresh properties of self compacting concrete with different percentages of metakaolin and cement kiln dust. The addition of 10 % metakaolin and cement kiln dust in self compacting concrete mixes increases the self compact ability characteristic like filling ability, passing ability, flowing ability and segregation resistance. It can also be seen that compressive strength, flexural strength, split tensile strength is maximum for 10% replacement as compared to 20% and 30%.

Kishan P Pala and Krunal J Dhandha (2015).The literature indicates that studies on the self compacting concrete with marble powder and fly ash as mineral admixtures. Many studies proved that 25% replacement of cement with fly ash has optimum results in both fresh and hardened state properties and also economical. The replacement of cement with different mixes proportions of marble powder (0%, 5%, 10%, 15%, 20% and 25%) and 25% fly ash (constant replaced). The positive effect of marble powder 10% and fly ash 25% by substitute cement in binder material in self compacting concrete. In fresh property such as filling ability and passing ability and in hardened property such as compressive strength, flexural strength and split tensile strength shows optimum results for marble powder can be use up to 10% and fly ash 25%.

Ramisetti Swamy and M K M V Ratnam (2015) The literature indicates that comparative studies on the self compacting concrete with marble powder and limestone powder as mineral admixtures. The replacement of cement with different mixes proportions of marble powder and limestone powder (0%, 10%, 20%, 30%, 40% and 50% for both). The mineral admixtures have shown significant performance differences and the highest compressive strength has been obtained for the marble powder mixtures. All the mixtures had satisfactory self compacting properties in the fresh state. The addition of limestone powder and marble powder had positive effects on the workability.

S Dhiyaneshwaran and P Ramanathan (2013) The literature indicates that study on durability characteristics of self compacting concrete with fly ash as mineral admixture. The durability characteristics like acid resistance, sulphate attack and saturated water absorption test are carried out for different mixes proportions of fly ash at the age of 28, 56 and 90 days. For 30% fly ash replacement, the fresh and hardened properties observed were good as compared to 40% and 50% fly ash replacement.

Prof. Shriram H. Mahure and Dr. V. M. Mohitkar (2013) The brief literature review of self compacting concrete mixes made with cement kiln dust as a filler and addition of cement kiln dust as a partial replacement of cement used in self compacting concrete whenever economic, environmental and easy availability considerations predominate, without much apprehension. The feasibility of developing self compacting concrete in the range of medium strength using cement kiln dust as a filler and investigated three mixtures with different percentages of cement replacement by cement kiln dust. Properties at fresh and hardened state were studied. The SCC mix

es with the addition of 20% cement kiln dust gave an optimum strength for M30 grade.

Mohammad Kamran and Mudit Mishra (2014) This paper talks about its comparison in behavior using PPC and OPC with different proportions of fly ash in the MIX which were taken as 15%, 25%, and 35% in place of cement. For one proportion, a set of 6 cubes was casted and the same was to be tested at 7 days and 28 days for strength. The temperature of sample cubes was kept constant at 24°C for the whole period. The mix design was done for M25 grade. The W/C ratio was kept constant at 0.45. The proportion of fine aggregates to coarse aggregates was kept at 70:30 and maximum size of aggregates was 20 mm. Total powder content was kept at 530 Kg/m^3. The quantity of super plasticizer was kept at 450 ml for the samples which was 1% of the total volume. The properties were checked by conducting slump test, J-Ring Test, L-Box Test, V-funnel Test, and U-Box Test with compressive strength test after 7 days and 28 days.

Biswadeep Bharali (2015) In this paper experimental studies are carried out to understand the fresh and hardened properties of Self Compacting Concrete (SSC) in which cement is replaced by Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash (FA) in various proportions for M30 grade concrete. The proportions in which cement replaced are 30% of GGBS, 20% of both GGBS and FA, 40% of GGBS, 15% of both GGBS and FA, 40% of FA and 30% of FA. The strength behaviour, flexural behaviour and split tensile strength behaviour of SSC are studied. The parameters are tested at different ages in accordance with Bureau of Indian Standards (BIS) for the various proportions in which cement is replaced and also the obtained parameters are compared with normal SSC (100% cement). Super plasticizer GLENIUM B233 a product from BASF is used to maintain workability with constant Water-Binder ratio.

Reena K and Mallesh M (2014) In the present work a wide range of SCC mix were developed using fly ash as a filler material along with Portland cement of 43 grade. To qualify Self-Compacting Concrete mixes Slump flow, V-funnel, L-Box, U-Box tests were conducted and the fresh properties obtained are checked against the specifications given by EFNARC guidelines. Compressive strength tests were conducted to know the strength properties of the MIXes at the age of 7 and 28 days of curing.

Vageesh H.P and Reena K. (2014) The scope of this work is limited to the development of a suitable mix design to satisfy the requirements of Self Compacting Concrete with Fly ash as partial replacement in plastic stage using local aggregates and then to determine the Compressive, Split tensile and Flexural strengths. To qualify Self-Compacting Concrete mixes Slump flow, V-funnel, L-Box, U Box tests were conducted and the fresh properties obtained are checked against the specifications given by EFNARC guidelines. Compressive, Split tensile and Flexural strength tests were conducted by the replacement of Fly ash in 10%, 20% and 30% by the weight of cement was done, Self Compacting concrete containing fly ash was compared with Normal SCC. The strength properties are carried out at the age of 7, 14, 21 and 28 days of curing. It was observed that Fly ash can be replaced in SCC up to 10% to obtain a reasonable good MIX as that of SCC without Fly ash. SCC with 10% Fly ash replacement has same Compressive strength and as good as Normal SCC without Fly ash.

Er.Ranjodh Singh and Er.Rohin Kaushik (2013) In this paper the use of fine materials such as brick dust, marble powder and viscosity modifying agent can ensure the required concrete properties. In this experimental work attempt has been made to replace fine aggregate with brick dust and marble powder. Both brick kiln dust and marble powder are waste materials and are dumped as waste, causing land scarcity and environmental pollution.

III. MATERIALS IT'S PROPERTIES

A. Cement

Ordinary Portland cement of 53 grade conforming to both the requirements of IS: 12269 and ASTM C 642-82 type-I have been used. different types of tests had conducted on cement which include Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific Gravity and Fineness of cement.

Coarse Aggregate: The particle size distribution and the shape of coarse aggregate directly influence the flow and passing ability of SCC and its paste demand. The more spherical the aggregate particles the less they are likely to cause blocking and the greater the flow because of reduced internal friction. The normal maximum size is generally 10-20 mm. In this experiment, aggregates pass through 12.5 mm and retained at 10 mm. coarse aggregate shall consist of naturally occurring materials such as gravel or crushing of parent rock which includes natural rock.

Fine Aggregate: Well graded river sand that passing through 4.75 mm was used as fine aggregate. It consists of natural sand and other inert materials with similar characteristics by having hard, strong, durable particles.

Water: The quality of water is an important because the contaminants present in it can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used in mix proportioning and curing of concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other harmful substances. In order to gain more strength, the water which is used for drinking is most suitable for construction purpose. Hence, potable tap water was used in this study for mixing and curing. The pH value of fresh water should be 6 to 8.

Table 1: The test results of materials

Physical properties Of materials	Tests Results
Normal consistency of cement	31%
Setting Times of cement Initial Final	 35 minutes 9 hours 20 min
Compressive Strength of cement 3 days 7 days 28 days	 27.2 N/mm^2 38.36 N/mm^2 54.46 N/mm^2
Specific Gravity of cement	3.15
Fineness of cement	8%
Specific Gravity of aggregates Coarse aggregates Fine aggregates	 2.7 2.67

Cement Kiln Dust: Cement kiln dust is a mixture of incompletely calcinated and un-reacted raw feed, clinker dust and fly ash, enriched with alkali sulphate and other volatile.

B. Marble Powder

Marble is a metamorphic rock which results from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance. Marble powder is produced from the marble processing plants during the cutting, shaping and polishing. It is white if the limestone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration. Marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin.

Table 2: Physical properties of cement kiln dust & Marble powder

Colour	White	White
Fineness	90 µ passing (sieve)	90 µ passing
Specific	2.4	2.51

Table 3: Chemical properties of cement kiln dust & Marble powder

Contents	Cement kiln dust(%)	Marble powder(%)
Calcium oxide CaO	47.86	44.98
Silicon dioxide SiO_2	18.99	10.38
Iron oxide Fe_2O_3	2.45	0.10
Aluminium oxide Al_2O_3	4.56	0. 22
Magnesium oxide MgO	3.12	0. 19
Sulphur trioxide SO_3	2.1	0.008
Sodium dioxide Na_2O	0.8	--
Potassium dioxide K_2O	1.2	--

C. Self compacting concrete properties

EFNARC Guidelines: The mix design and methods of evaluating the properties of SCC can be set up in the EFNARC Guidelines for SCC.

Table 4: EFNARC guidelines for self compacting concrete

S.No	Constituent	Range by mass (Kg/m^3)	Range by volume (lit/m^3)
1	Powder content	380-600	N.A
2	Water content	150-210	150-210
3	Coarse aggregate	750-1000	270-360
4	Fine aggregate	48-55% of total aggregates	
5	Paste	N.A	300-380
6	Water to powder ratio	N.A	0.85-1.1

D. Super plasticizer (SP)

The adMIXture Master Glenium SKY 8630 was used a superplasticizer with a It was used to provide necessary workability and it is free of chloride and low alkali. The hyperplasticiser shall be MasterGlenium SKY 8630, high range water reducing, Superplasticiser based on polycarboxylic ether formulation. The product shall have specific gravity of 1.08& solid contents not less than 29% by weight. The product shall comply with ASTM C494 Type G and shall be free of lignosulphonates, naphthalene salts and melamine formaldehyde when subjected to IR Spectra.

E. Acid Resistance

After 28 days of curing, each cube is tested for weight and lengths.The cubes are subjected to 5% solutions of Hydrochloric acids (HCl) individually and continuously immersed in solution for 30 days. The specimens are arranged in the plastic tubs in such a way that the clearance around and above the specimen is not less than 3 cm. The response of the specimens to the solution is evaluated through change in appearance, weight, compressive strength, thickness and solid diagonals. Then , the specimens were taken out from acid water and the surface of the cubes were brushed and rinsed with tap water. This process removes loose surface material from the specimen. Then, the weight and the compressive strength of were found out and the average percentage of loss of weight and compressive strength were calculated

IV. RESULT AND DISCURSSION

The filling and passing ability is increase up to 10% marble powder and 15% cement kiln dust. As marble powder increase, slump flow of self compacting concrete is also increase. As marble powder increase, V funnel time of self compacting concrete is decrease.

Table 5: Fresh state tests for different mix proportions

S.NO	MIX Type	Slump flow (mm)	L box (H_2/H_1)	V funnel (sec)
1	MIX1 (0% MP + 15%	670	0.85	10.3
2	MIX2 (5% MP + 15%	683	0.88	9.82
3	MIX3 (10% MP +15%	692	0.91	9.4
4	MIX4 (15% MP +15%	702	0.93	9.1
5	MIX5 (20% MP +15%	709	0.95	8.9
6	MIX6 (25% MP+15%	712	0.96	8.2
7	MIX7 (30% MP +15%	719	0.98	8.0

The compressive strength is generally decreases with increasing Marble Powder. But optimum values are obtained at Mix3 (10% MP +15% CKD) for 7, 28, and 90 days.

Table 6: Compressive strength test for different mix proportions

S.NO	MIX Type	Compressive strength at N/mm^2		
		7days	28 days	90 days
1	MIX1 (0% MP + 15% CKD)	28.98	43.97	44.96
2	MIX2 (5% MP + 15% CKD)	27.81	41.69	42.15
3	MIX3 (10% MP +15%	26.98	39.16	40.19
4	MIX4 (15% MP + 15%	*25.01*	*35.14*	*37.26*
5	MIX5 (20% MP + 15%	*24.19*	*34.25*	*35.64*
6	MIX6 (25% MP+15% CKD)	*22.78*	*31.38*	*33.23*
7	MIX7 (30% MP + 15%	*21.01*	*29.96*	*31.02*

The split tensile strength is generally decreases with increasing Marble Powder. But optimum values are obtained at Mix3 (10% MP +15% CKD) for 7, 28 and 90 days.

Table 7: Split Tensile strength test for different mix proportions

S.NO	MIX Type	Split tensile strength at N/mm^2		
		7days	28 days	90 days
1	MIX1 (0% MP + 15% CKD)	3.41	4.78	4.99
2	MIX2 (5% MP + 15% CKD)	3.32	4.56	4.74
3	MIX3 (10% MP +15% CKD)	2.91	3.92	4.61
4	MIX4 (15% MP +15% CKD)	*2.62*	*3.71*	*4.22*
5	MIX5 (20% MP +15% CKD)	*2.45*	*3.63*	*4.01*
6	MIX6 (25% MP+15% CKD)	*2.25*	*3.35*	*3.72*
7	MIX7 (30% MP +15% CKD)	*2.12*	*3.19*	*3.56*

Flexural strength is generally decreases with increasing Marble Powder. But optimum values are obtained at Mix3 (10% MP +15% CKD) for 7, 28, and 90 days.

Table 8: Flexural strength test for different MIX proportions

S.NO	MIX Type	Flexural strength at N/mm^2		
		7days	28 days	90 days
1	MIX1 (0% MP + 15%	2.71	4.58	4.71
2	MIX2 (5% MP + 15%	2.52	4.40	4.50
3	MIX3 (10% MP +15%	2.30	4.34	4.45
4	MIX4 (15% MP +15%	*1.95*	*3.91*	*4.01*
5	MIX5 (20% MP +15%	*1.67*	*3.74*	*3.85*
6	MIX6 (25% MP+15%	*1.52*	*3.43*	*3.53*
7	MIX7 (30% MP +15%	*1.2*	*3.16*	*3.25*

V. CONCLUSIONS

To increase the stability of fresh concrete using increased amount of fine materials in the mixes. To develop of self compacting concrete with reduced segregation potential. The latest trend in concrete research is to use industrial by-products in preparing the concrete mixes. The addition of CKD and MP as mineral admixtures in SCC is a step that would gainfully employ these two otherwise waste products whose disposal is an issue in itself. The systematic experimental approach showed that partial replacement of cement with mineral admixture could produce self compacting concrete with low segregation potential as assessed by the V funnel test. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V funnel, L box, and compressive strength, split tensile and flexure strength tests were carried out to examine the performance of SCC. If we add the mineral admixtures replacement for we can have a better workable concrete. It has been verified, by using the slump flow, L-box test and U-tube tests, that self-compacting concrete (SCC) achieved consistency and self compatibility under its own weight, without any external vibration or compaction. SCC with mineral admixture exhibited satisfactory results in workability, because of small particle size and more surface area. All the mixtures had satisfactory self compacting properties in the fresh state. The addition of cement kiln dust and marble powder had positive effects on the workability. It is possible to produce SCC by combined replacement of cement kiln dust and marble powder satisfies the criteria for fresh concrete properties such as slump flow, passing ability, filing ability. As marble powder increase, slump flow of self compacting concrete is also increase. As marble powder increase, V funnel time of self compacting concrete is decrease. The optimum compressive strength, split tensile strength and flexural strength of tested concrete specimen's shows up to 10% marble powder and 15% cement kiln dust. The percentage loss of compressive strength shows optimum values up to 5% marble powder and 15% cement kiln dust.

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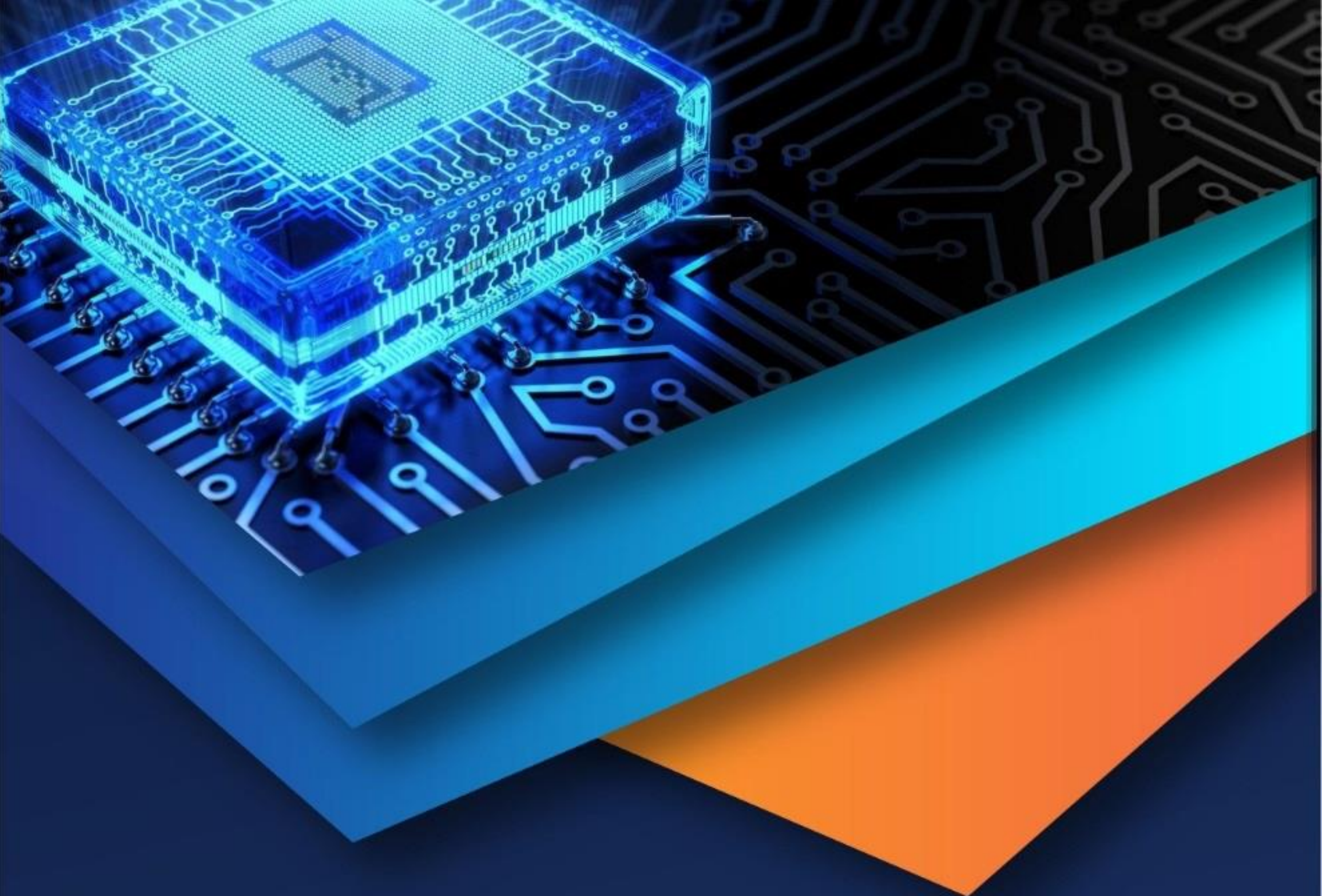

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