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An Experimental Study on Fresh and Hardened Properties of Self Compacting Concrete with Marble Powder and Cement Kiln Dust As Mineral Admixture

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ABSTRACT: ***This experiment study of self compacting concrete with partial replacement of Portland cement with marble powder and cement kiln dust. If only Portland cement is used in self compacting concrete, then it become uneconomical, there's chance of thermal cracks conjointly. Therefore, it's 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's no recycle marble powder. Cement kiln dust is fine powder by product which is collected at different units in manufacturing of Ordinary Portland cement. So we use marble powder and cement kiln dust used as mineral admixtures. The slump, L box and V funnel tests carried out on the fresh state of self compacting concrete. The compressive strength and tensile strength tests are carried out on the hardened state of self compacting concrete. By using self compacting concrete, results in reduced sound (noise) pollution and also reduced construction time.***

Keyword: Self compacting concrete (SCC), cement kiln dust (CKD), marble powder (MP), fresh and hardened properties

1. Introduction

A concrete which is able to flow and consolidate under its own weight, fill any formwork even in the presence of high dense reinforcement and without any additional compaction. Self compacting concrete has more amount of powder content and less of coarse aggregate. Fillers used can fly ash, silica fume, metakaoline, rich husk ash, lime powder etc. Self compacting concrete incorporates high range water reducers (super plasticizers) and viscosity modifying agent. Cement kiln dust is a mixture of incompletely calcined and un-reacted raw feed, clinker dust and fly ash, enriched with alkali sulphate and other volatile. All around the world cement industries has estimated that over 40 million tons of cement kiln dust are produced per year (annually). The disposal of cement kiln dust has an environmental threat, by the research it can be used in the replacement of the cement and stabilization of soil. In order to overcome the problem research has been carried out, to find out efficient and economical means of using cement kiln dust. 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.

Table 1: Physical properties of cement kiln dust

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

Table 2: Chemical properties of cement kiln dust

CaO	47.86
SiO_2	18.99
Fe_2O_3	2.45
Al_2O_3	4.56
MgO	3.12
SO_3	2.1
Na_2O	0.8
K_2O	1.2

Table 3: Physical properties of Marble powder

Colour	White
Fineness	325 mesh
Specific gravity	2.5

Table 4: Chemical properties of Marble powder:

SiO_2	11.38%
Al_2O_3	0. 23%
Fe_2O_3	0. 09%
CaO	45.18%
$CaCO_3$	88.5%
MgO	0. 20%
$MgCO_3$	0. 42%
SO_3	0. 008%

2. Constitute Materials

2.1Cement

Ordinary Portland cement 53 grade conforming to IS: 8112-1989.

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Table 5: Properties of OPC

Property	Results Value
Fineness test	7.5%
Vicat Setting initial time	50 min
Vicat Setting final time	250 min
Specific gravity	3.15

2.2 Fine aggregates

The fine aggregates used in this experiment is locally available river sand and conforming to zone II. Specific gravity of fine aggregates is 2.7.

2.3 Coarse aggregates

The normal maximum size is generally 10-20 mm. In this experiment, aggregates pass through 12.5 mm and retained at 10mm. Specific gravity of fine aggregates is 2.7.

2.4 Water

Water used for mixing and curing shall be and free from salts, oils, acids, sugars and other harmful substances. The pH value of water should be 6-8.

2.5 Admixture

The most important admixtures are the super plasticizers which also known as high range water reducers to reduce water content more than 20%.

In this experiment, Master Glenium SKY 8630 is used. Master Glenium SKY 8630 is an admixture of a new generation based on modified polycarboxylic ether. It has been primarily developed for applications in high performance concrete where the highest durability and performance is required. And it is free of chloride and low alkali.

Table 6: Properties of Super Plasticizer (SP)

Colour	Light brown liquid
pH	> 6 at 25 ° C
Chloride ion content	< 0.2%
Specific gravity	1.1

3. Fresh state properties of self compacting concrete (SCC)

A concrete mix which satisfies the requirement of passing ability, filling ability and also segregation resistance is said to be self compacting concrete (SCC).

3.1 Slump flow test

Slump cone has 10 cm and 20 cm diameters of top and base respectively with 30 cm in height. For this test, the slump cone is placed with base 20 cm diameter then filled with concrete and lifted up. The concrete spread is measured in two mutual perpendicular directions and record the average measured value.

3.2 L box test

In this test, fresh concrete is filled in the vertical section of L box and then gate is lifted to flow concrete in horizontal section. When the flow has stopped, the heights h_1 and h_2 are measured. The value of h_2/ h_1 is calculated which near to unity.

3.3 V funnel test

The V funnel test is used to measure the viscosity and filling capability of self compacting concrete (SCC). A V shaped funnel is filled with fresh concrete and the time taken for the concrete is able to flow out of the V shaped funnel can be recorded (measured) known as the V funnel flow time.

Table 7: Fresh state properties of SCC

Characteristic	Preferred test method	Value range
Flow ability	Slump flow test	650-800 mm
Passing ability	L box test (h_2/ h_1)	0.8-1.0
Filling ability	V funnel test	6 -12 sec

4. Mix Design

These mix design principles of self compacting concrete (SCC) that, compared to traditional vibrated or tamping concrete, usually contains:

1) Lesser coarse aggregate content
2) Low water to powder ratio
3) Increased concrete paste content
4) Increased super plasticizer (SP)
5) Viscosity modifying admixture (VMA) sometime needed

5. Mix Design Proportions

Table 8: Mix design proportion of SCC

	TP	C	MP	CKD	FA	CA	W	SP
M1	526	420.8	0	105.2	925	788	191	1.5
M2	526	394.5	26.3	105.2	925	788	191	1.5
M3	526	368.2	52.6	105.2	925	788	191	1.5
M4	526	341.9	78.9	105.2	925	788	191	1.5
M5	526	315.6	105.2	105.2	925	788	191	2.0
M6	526	289.3	131.5	105.2	925	788	191	2.0
M7	526	263	157.8	105.2	925	788	191	2.0

Note: Mix M1 (0% MP + 20% CKD), M2 (5% MP + 20% CKD), M3 (10% MP+20% CKD), M4 (15% MP+20% CKD), M5 (20% MP+20% CKD), M6 (25%MP+20% CKD) and M7 (30% MP+20% CKD) where TP – Total powder content in Kg/m^3, C – Cement, MP – Marble Powder, CKD – Cement Kiln Dust, FA –Fine Aggregate, CA – Coarse Aggregate, W – Water and SP – Super Plasticizer in %.

6. Fresh state different tests on SCC

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Figure 1: Slump flow test

Figure 2: L box test

Figure 3: V funnel test

Table 9: Slump flow, L box and V funnel tests for different mixes

Mix Type	Slump flow (mm)	L box (h_2/h_1)	V funnel (sec)
M1	662	0.83	10.9
M2	668	0.86	10.6
M3	674	0.89	9.7
M4	685	0.90	9.4
M5	704	0.92	9.3
M6	709	0.94	8 .7
M7	711	0.95	8.5

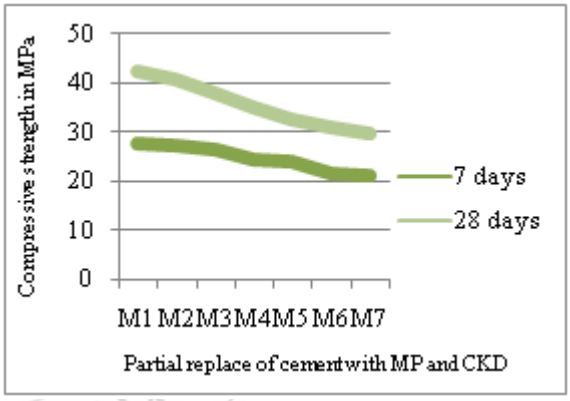
7. Hard State Different Tests on SCC

7.1 Compressive strength (MPa) of cubes for different curing days

Figure 4: Compressive and tensile test of cube and cylinder

Table 10: Compressive strength for 7 and 28 days

Mix Type	7 days	28 days
M1	27.45	42.31
M2	27.10	40.69
M3	26.41	37.73
M4	24.34	34.95
M5	23.78	32.64
M6	21.21	30.86
M7	20.92	29.74



Graph 1: Compressive strength at 7 and 28 days

7.2 Tensile strength (MPa) of cylinders for different curing days

Table 11: Tensile strength for 7 and 28 days

Mix Type	7days	28 days
M1	4.7	7.34
M2	4.5	6.57
M3	4.33	6.34
M4	3.95	6.15
M5	3.67	5.82
M6	3.52	5.42
M7	3.2	5.13

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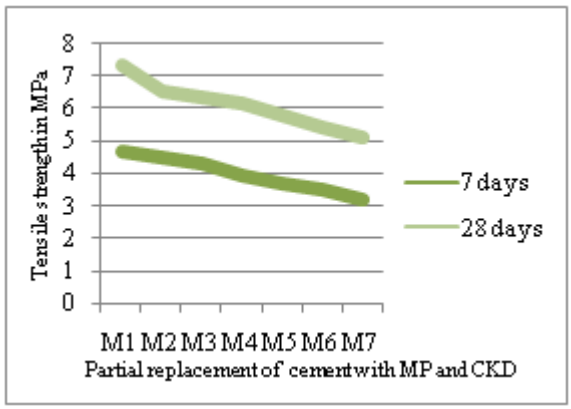

Graph 2: Tensile strength at 7 and 28 days

8. Conclusions

1) The replacement of cement with marble powder and cement kiln dust has no negative impact on workability of self compacting concrete.
2) The filling and passing ability is increase up to 10% marble powder and 20% cement kiln dust.
3) As marble powder increase, slump flow of self compacting concrete is also increase.
4) As marble powder increase, V funnel time of self compacting concrete is decrease.
5) The optimum compressive strength and tensile strength of tested concrete specimen's shows up to15% marble powder and 20% cement kiln dust.

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