Experimental Investigation On Self Compacting Concrete Using Cement Kiln Dust

Prof. Shriram H. Mahure *, Mayur B. Vanjare **

*(Head of Civil Engineering Department, Babasaheb Naik College of Engineering Pusad, Amravati University, Pusad-445215, Yavatmal, Maharashtra, India

** (Department of Civil Engineering, Babasaheb Naik College of Engineering Pusad, Amravati University, Pusad-445215, Yavatmal, Maharashtra, India

ABSTRACT

Self compacting concrete is a type of concrete that get's under its self weight. It is commonly abbreviated as the concrete. Which can placed and compacted into every corner of a formwork; purely means of its self weight by eliminating the need of either external energy input from vibrators or any type of compacting effort.There is a current trend in all over the world to utilize the treated and untreated industrial by- products, domestic wastes etc. as raw materials in concrete. These not only help in the reuse of the waste materials but also create a cleaner and greener environment. This study aims to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Cement Kiln Dust (CKD). The use of this waste (CKD) was proposed in different percentage as an instead of cement for production of self compacting concrete. The paper deals with the ingredient of these mixtures (CKD, fly ash, super plasticizer, cement).

Keywords **– Cement Kiln Dust (CKD), Self Compacting Concrete (SCC), Self Compactability, Compressive strength, Flexural strength**

1. INTRODUCTION

Worldwide, the use of self-compacting concrete (SCC) has gained wide acceptance in the precast industry, which has many advantages such as: reduces the total time of construction and the costs, improves work conditions by eliminating vibration, makes easier to achieve a better final product (finish and durability), allows the use of complex molds and parts with congested reinforcements [1,2,6].

Nowadays, the ecological trend aims at limiting the use of natural raw materials in the field of building materials and hence there is an increased interest in the use of alternative materials (waste) from industrial activities, which presents significant advantages in economic, energetic and environmental terms. Concrete's performances have continuously rise in order to accomplish the society needs. Many studies have been made concerning the use of additives and super–plasticizers in the concrete for passing the frontier of minimum water content for a good workability of a concrete. As a result of this, high performance concretes developed having a superior durability. Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete.

Usually, SCC mixtures have high contents of fines in order to obtain the required rheological properties to achieve self compactability, which usually results in mixtures with high content of Portland cement, and consequently, high values of initial and final strength, much higher than those strictly required by the project. Thus, the costs of the components that constitute a SCC are higher than those of conventional concrete of equal strength.

Other researchers, actuating on the fines content (physical process) obtained medium strength SCC using different types of additions in partial replacement of cement: high percentages of residual quarry limestone powder [3], high percentages of fly ash [2,6], a combination of fly ash and granulated blast furnace slag [7] or fly ash and limestone filler. The purpose of the present research was to develop Self Compacting Concrete using two industry wastes: cement kiln dust (CKD) and fly ash (FA).

CKD contains partially calcined materials with some hydraulic and cementitious properties. It also has high alkali, chloride, and sulfate content, which may cause problems in cement performance. FA is mainly composed of vitrified (amorphous) alumina-silicate melt in addition to a small amount of crystalline minerals, such as quartz, mica etc. Due to the high degree of polymerization at which tetrahedral silicate is bridged with oxygen, most fly ashes, especially Class F FA, react with water very slowly at a room temperature. Some research has indicated that, if the two materials are appropriately blended, the alkalis from CKD may activate hydration of FA, and the blends may create a cementitious material in which the waste material deficiencies will be converted into benefits [4, 5].

2. EXPERIMENTAL

2.1 Materials

2.1.1 Cement

In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 [8] was used. The physical and mechanical properties of the cement used are shown in Table1.

Table. 1: Properties of Cement

Physical property	Results
Fineness (retained on 90-µm sieve)	2940 cm^2/gm
Normal Consistency	28%
Vicat initial setting time (minutes)	75
Vicat final setting time (minutes)	215
Specific gravity	3.15
Compressive strength at 7-days	20.6 MPa
Compressive strength at 28-days	51.2 MPa

2.1.2 Fly ash

The flow ability of self compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used. The fly ash was obtained from Thermal Power Station, PARAS, Akola (M.S) India. The normal consistency of the fly ash was found to be 43%.
Table 2 gives the physical properties of the fly ash.

Table. 2: Properties of Fly Ash

Physical Properties	Test Results
Colour	Grey (Blackish)
Specific Gravity	2.13

2.1.3 Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 3 and crushed stone with 16mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 3 was used as coarse aggregate.

Table 3. Physical Properties of Coarse and Fine Aggregates

Property	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.66	2.95
Fineness Modulus	3.1	7.69
Surface Texture	Smooth	--
Particle Shape	Rounded	Angular
Crushing Value	---	17.40
Impact Value	---	12.50

2.1.4 Cement kiln Dust (CKD)

Cement kiln dust (CKD) is a waste product generated by the cement industry; it is a powder mainly composed of micron-sized particles collected from electrostatic precipitators during the manufacture of cement clinker. The CKD chemical composition and particle size depend on the raw materials used to produce clinker, fuels and kiln types. The Environmental Protection Agency (EPA) estimated that the amount of CKD could range from 0 to 25% of the clinker produced, depending on the above-mentioned factors. For this work CKD was obtained from Cement factory at Chandrapur. Table 5 gives the physical properties of the CKD.

Table 4: Chemical composition of CKD

SiO2	14.65
Fe_2O_3	2.13
$A1_20_3$	4.75
CaO	41.72
MgO	1.12
$S0_3$	0.72
Na_2O	0.9
K_2O	0.6

2.1.5 Super plasticizer (SP)

The admixture used was a superplasticizer based on modified polycarboxylates, with a density of 1.08 kg/l and a solids content of 32.5%. It was used to provide necessary workability.

Table 5: Physical Properties of Super plasticizer

Physical Properties	Test Results
Colour	white
Specific Gravity	2.11

2.2 Mix Proportioning

The mix proportion was done based on the method proposed by Nan. et.al.[9]. The mix designs were carried out for concrete grades 20, 25, and 30. This method was preferred as it has the advantage of considering the strength of the SCC mix. Unlike other proportioning methods like the Okamura [10] and EFNARC [11] methods, it gives an indication of the target strength that will be obtained after 28days of curing. The water to powder ratio was varied so as to obtain SCC mixes of various strengths. A total of 12 trial mixes were done by varying the proportions of water and powder within the calculated ranges. The details of the mixes are as in Table 6. All the ingredients were first mixed in dry condition. Then 70% of the calculated amount of water was to be added to the dry mix and mixed thoroughly. Then, 30% of water was mixed with the super-plasticizer and included in the mix. Then, the mix was checked for self compact ability by flow test, V-funnel test and L-Box test.

Table. 6: Mixture Proportion for 1 m^3 of SCC.

Mix	Cement (Kg/m^3)	CKD (Kg/m^3)	CKD (%)	Fly ash (Kg/m^3)	FA (Kg/m^3)	CA (Kg/m^3)	SP (%)
SCC1	410	0.00	0	82	892	715	0.90
SCC2	389.5	20.50	5	82	892	715	0.85
SCC3	369	41	10	82	892	715	0.80
SCC4	348.5	61.50	15	82	892	715	0.75
SCC5	430.2	0.00	0	86	892	715	0.90
SCC6	408.69	21.51	5	86	892	715	0.85
SCC7	387.18	43.02	10	86	892	715	0.80
SCC8	365.67	64.53	15	86	892	715	0.75
SCC9	452	0.00	0	90.4	892	715	0.90
SCC10	429.40	22.60	5	90.4	892	715	0.85
SCC11	406.80	45.20	10	90.4	892	715	0.80
SCC12	384.20	67.80	15	90.4	892	715	0.75

2.2.1Self Compactability Tests on SCC mixes

Various tests were conducted on the trial mixes to check for their acceptance and self compactability properties. The tests included Flow test and V-funnel tests for checking the filling ability and L-box test for the passing ability. The mixes were checked for the SCC acceptance criteria given in Table 4.

Table 7: SCC - Acceptance Criteria

Method	Properties	Range of values
Flow value	Filling ability	650-800mm
V-funnel	Viscosity	6-12 sec
L-box	Passing ability	0.8-1.0

Table 8: SCC - Test Results of SCC Mixes

Mix code	Flow (mm)	V-funnel time (s)	L-box h_2/h_1	Segregation	Remark
SCC1	720	8.6	0.90	NO	SCC
SCC2	720	8.6	0.91	NO	SCC
SCC3	721	8.5	0.91	NO	SCC
SCC4	723	8.4	0.92	NO	SCC
SCC5	715	8.8	0.92	NO	SCC
SCC6	716	8.8	0.93	NO	SCC
SCC7	718	8.7	0.94	NO	SCC
SCC8	719	8.6	0.94	NO	SCC
SCC9	710	9.3	0.93	NO	SCC
SCC10	710	9.2	0.94	NO	SCC
SCC11	711	9.1	0.95	NO	SCC
SCC12	713	9.0	0.96	NO	SCC

The results of the self compactability tests are tabulated in Table 8. The all mixes satisfied the acceptance criteria for self compacting concrete. Hence, these mixes were chosen as the successful mixes. The cube specimens of size 150 x 150 x 150mm were cast for the successful mixes and were tested for the 7-day and 28-day compressive strengths.

3. RESULT AND DISCUSSION

3.1 Fresh properties SCC with CKD

CKD was used to replace the cement content by three various percentages (5, 10 and 15%) and fly ash was kept as constant (20%). The partial replacement with CKD was carried out for three grades of concrete. Due to the fine particle shape, the concrete mixes required a relatively small increase in water/powder ratio and decrease in superplasticizer dosage with an increase in CKD content. The mixing sequence was modified as follows. All the ingredients were first mixed in dry condition. Then, 70% of the calculated amount of water was added to the dry mix and mixed thoroughly. Then, 30% of water was mixed with the super plasticizer.

Then the mix was checked for selfcompactability by Flow test, V-funnel test, L-Box test etc. The test results are presented in Fig 1 through Fig 3.

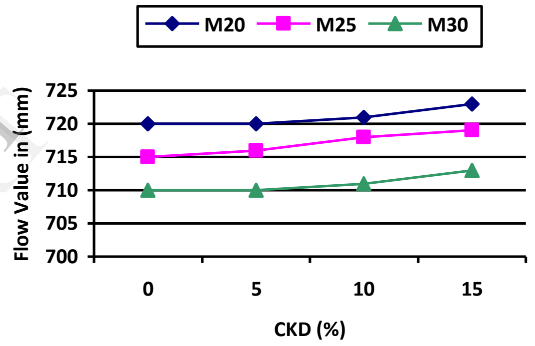

Fig. 1: Flow Value with varying CKD content

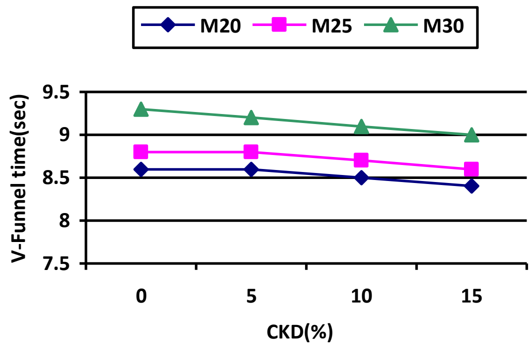

Fig. 2: V-Funnel Time with varying CKD content

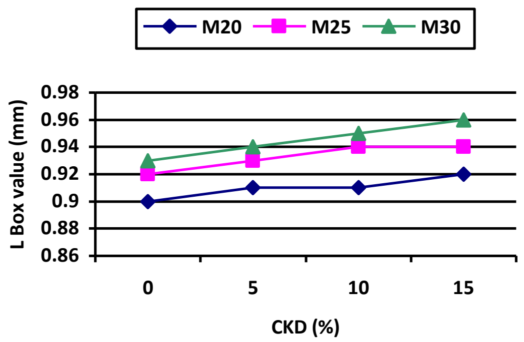

Fig. 3: L-Box Value with varying CKD content

It can be inferred from the results that the addition of CKD in SCC mixes increases the filling ability, passing ability and segregation resistance.

3.2 Hardened properties of SCC with CKD

All the mixes were tested for various hardened properties like compressive strength, and flexural strength. Fig 4 through Fig 5 shows the variation in compressive strength and flexural strength values obtained for SCC & SCC made by partially replacing cement with varying percentages of CKD.

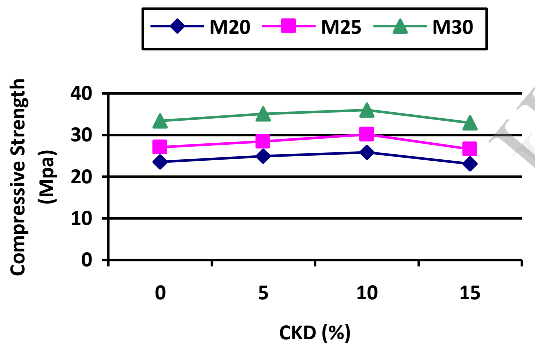

Fig. 4: Compressive Strength with varying CKD

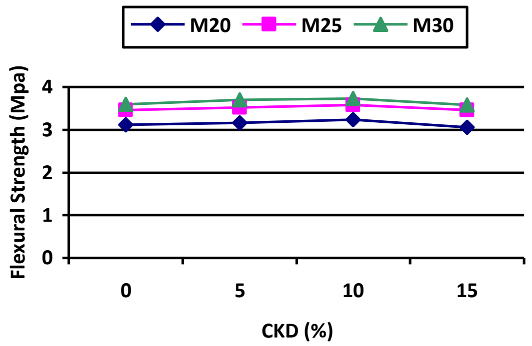

Fig. 5: Flexural Strength with varying CKD

According to the results, a increase on compressive strength had been observed for CKD added SCC composite compared to conventional SCC. It was observed that the CKD distribution within the composite was uniform, but the compressive strength varied directly with the percentage of CKD content up to 10%. The flexural strength of the mixes was also observed to increase with increase in CKD content up to 10%. But, the rate of decrease was found to be much smaller than that of the compressive strength.

4. CONCLUSIONS

The latest researches are concentrating on ways to create new concrete by using various industrial wastes. The addition of CKD into concrete was a step that was taken to utilize CKD obtained from the cement factory in an effective manner. Various properties of the CKD integrated SCC mixes such as self compactability, compressive strength, and flexural strength were evaluated and compared with those of conventional SCC. From the experimental investigations, the following conclusions were arrived at:

i. The addition of CKD in SCC mixes increases the self compactability characteristics like filling ability, passing ability and segregation resistance.
ii. Higher % of CKD used the lower the amount of Admixture required to achieve Self-compactability. From result it is said that the CKD has Fluidizing effect in the mix.
iii. The CKD has Fluidizing effect in the mixture thereby achieving an economy in the amount of admixture used.
iv. The fresh properties of SCC follow direct relations with the CKD contents for all grades of concrete. The filling ability, passing ability and segregation resistance increases with increase in CKD contents.
v. The mechanical properties of SCC follow direct relations with the CKD contents for all grades of concrete. The compressive strength & flexural strengths increases with increase in CKD contents up to 10%.
vi. The use of CKD in SCC can be solved the problem of its disposal thus keeping the environment free from pollution.

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