SELF COMPACTED / SELF CURING / KILN ASH CONCRETE

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Abstract

The cement content of High Strength Concrete is generally high which often leads to higher shrinkage and greater evaluation of heat of hydration besides increase in cost. A partial substitution of cement by an industrial waste, such as kiln ash is not only economical but also improves the properties of fresh and hardened concrete and enhances the durability characteristics besides the safe disposal of otherwise waste material thereby protecting the environment from pollution. Generally, the specifications restrict the replacement level of cement with kiln ash to about 25-35%. An Experimental investigation was conducted to make a comparative study on the properties of High Performance Concrete with kiln ash (25% and 50% replacement) and without kiln ash (control concrete) in normal and aggressive environment using self curing instead of water curing. It is concluded that High Performance Kiln ash self curing Concrete performs well both in normal and aggressive conditions when compared to control cement concrete without kiln ash.

Keywords: Kiln ash, High performance Concrete, self curing, Aggressive Environment.

INTRODUCTION

High Performance Concrete is generally cement based composite and is produced using the mineral and chemical admixtures. HPC can be considered as an appropriate material for the construction of large infrastructural facilities. The use of HPC in developing countries, including India has been rather limited at present. With the availability of mineral and chemical admixtures in the country, use of HPC is expected to grow rapidly in the future. High Strength Concrete with water cement ratio of 0.35 to 0.45 and compressive strength in the range of 40 MPa to 60 MPa are usually made using super plasticizer with or without mineral admixtures. It can be generally produced from locally available materials using conventional mixing, handling and curing methods. This type of concrete finds its applications in heavily reinforced sophisticated structural elements in high rise buildings, offshore platforms, super span bridges and heavy pavements. India is a resourceful country for kiln ash generation with an output of over 100 million tonnes, registered almost 50% escalation over the last decade. Though utilization of kiln ash has been a subject of great concern in India for the past two and half decades, its use has picked up during the last five to six years, recording 15 to 18% use. In India, only a few investigations have been reported on the utilization of kiln ash for the development of HPC with low water binder ratio of the order of 0.30 and their durability characteristics have not been investigated in detail. Cement replacement materials are known to improve sulphate resistance, durability and impermeability of concrete .

For example, low-calcium kiln ash is an effective blending material for combating sulphate attack on concrete. To produce concrete with improved sulphate resistance, the amount of calcium hydroxide and calcium aluminate hydrate must be kept to a minimum.

A self-curing concrete is provided to absorb water from atmosphere from air to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete. The self-curing agent can absorb moisture from atmosphere and then release it to concrete. The self-curing concrete means that no curing is required for concrete, or even no any external supplied water is required after placing. The properties of this self-cured concrete of this invention are at least comparable to and even better than those of concrete with traditional curing. tion on high performance kiln ash concrete

II. EXPERIMENTAL DETAILSSTTRAC

The aim of the experimental investigation is to make a comparative study on the properties of High Performance Concrete with kiln ash in aggressive and normal conditions with control cement concrete without kiln ash. In this investigation, concrete having 28 days compressive strength of 60 MPa under normal condition was considered as control concrete. 25 % and 50% of the cement content of this concrete was replaced with kiln ash. Specimens prepared using concrete with and without kiln ash were exposed to normal and aggressive conditions and comparative study was conducted.

Materials used

53 Grade OPC and kiln ash (from India cements Ltd,Tirunelveli, TamilNadu, India) were used throughout the investigation. Locally available river sand and crushed granite stones with maximum size of 20 mm were used as fine aggregate and coarse aggregate and Structuro 100 used as a self curing admixture respectively, in this investigation. The experimental work was divided into 3 phases.

- Tests on cement and other ingredient materials
- Tests on hardened concrete (Normal condition)
- Tests on hardened concrete (Aggressive environment)

A. High Performance Concrete and Aggressive environment

High Performance Concrete is greatly facilitated by the incorporation of a water reducing agent as admixture. This enables easy handling of concrete with low water cement ratio without loss of adequate workability. The superplasticizer used in this investigation is Conplast SP 430, a product of FOSROC Chemicals Ltd, Bangalore.

Water with two different qualities was used for preparing concrete specimens to simulate normal and aggressive conditions. Water from one source (A), which is fit for concreting, was used for preparing specimens to simulate normal condition. In water from another source (B) which is not fit for concreting, calculated amount of Aluminium Sulphate and Sodium Chloride were added to make the water more aggressive condition.

B. Specimen Details and Designation of Concrete Mix

The specimens used for the tests included cubes, cylinders and prisms. Required numbers of specimens were cast. Cubes were used for compression test, cylinders for split tensile test and prisms for flexural test. The details of the concrete mix are given in Table 1.

Table1 Designation of Concrete Mix

Sl.No.	Mix designation	Type of concrete
1	CN	Concrete without kiln ash – Normal water for mixing and self curing.
2	NF25	Concrete with kiln ash (25%) – Normal water for mixing and self curing
3	NF 50	Concrete with kiln ash (50%) – Normal water for mixing and self curing
4	CA	Concrete without kiln ash – Normal water for mixing and aggressive water for self curing.
5	AF25	Concrete with kiln ash (25%) – Normal water for mixing and aggressive water for self curing.
6	AF50	Concrete with kiln ash (50%) – Normal water for mixing and aggressive water for self curing.

C. Tests on cement

The normal consistency, initial setting time, final setting time, soundness, specific gravity and compressive strength of cement were determined as per IS Specifications and results are tabulated in Table 2.

Table 2 Test result of cement

Sl.No.	Particulars	Results
1	Specific Gravity	3.05
2	Soundness test (Le – Chatelier test)	2 mm expansion
3	Initial setting time	75 minutes
4	Final setting time	230 minutes
5	Average compressive strength at	
	3 days	34.3 MPa
	7 days	44.6 MPa
	28 days	63.2 MPa

D. Tests on aggregates

The properties of aggregates used were determined as per IS Specifications and reported on Table 3.

Table 3 Properties of Aggregates

Sl.No.	Particulars	Fine aggregate
1	Specific Gravity	2.73
2	Fineness Modulus	2.80
3	Grading Zone 2.73	Zone III

E. Tests on water

Analysis of water was done to determine the presence of aggressive chemicals and the results are given in Table 4.

Table 4: Test results of normal and aggressive water

Sl. No.	Description of the test	Normal water	Aggressive water	Permissible value as per IS 456-2000
1	pH	7.38	3.8	Not less than 6
2	Sulphate	174 mg/lit	950 mg/lit	400 mg/lit
3	Chloride	108 mg/lit	1280 mg/lit	500 mg/lit

F. Chemical composition of Kiln ash

According to ASTM C618, the kiln ash used in this work contains Ca O below 10 percent. This kiln ash contains the fractions $SiO_2 + Al_2O_3 + Fe_2O_3$ greater than 70 percent. The results are reported in Table 5.

Table 5 : Chemical composition of kiln ash(%)

Sl. No	Component	Quantity (%)
1	SiO_2	15-45
2	Al_2O_3	10-25
3	Fe_2O_3	4-15
4	CaO	15-40
5	MgO	3-10
6	SO_3	0-10
7	Na_2O	0-6
8	K_2O	0-4
9	LOI	0-5

G. Concrete Mix Design

The Erntroy and Shacklock’s method was used for the mix design. After conducting tests on trial mixes, the final proportion arrived at was 0.28: 1:1.29:3.01 to get a compressive strength of 60 MPa without kiln ash.

H. Tests on Hardened Concrete

Required numbers of specimens were cast to determine the compressive strength, split tensile strength and flexural strength. The tests were conducted at 7,28,60days on High Performance Kiln ash Concrete and control cement concrete specimens as per IS specifications .The results are tabulated in Table 6, 7, 8 and the variations are shown in Fig.1 to 3.

Table 6 Average cube compressive strength of concrete

Sl.No.	Type of concrete	Compressive strength (MPa)		
		7 days	28 days	60 days
1	CN	49.0	60.3	62.2
2	NF25	30.0	40.8	52.8
3	NF50	21.0	30.0	40.0
4	CA	16.0	31.8	23.5
5	AF25	29.2	40.9	50.8
6	AF50	18.4	24.4	35.6

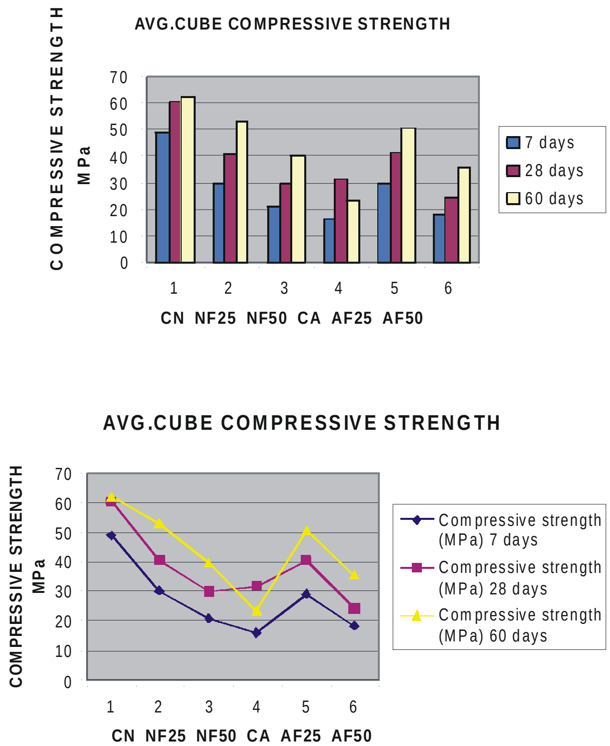

Fig 1. Comparison of Compressive Strength of Concrete

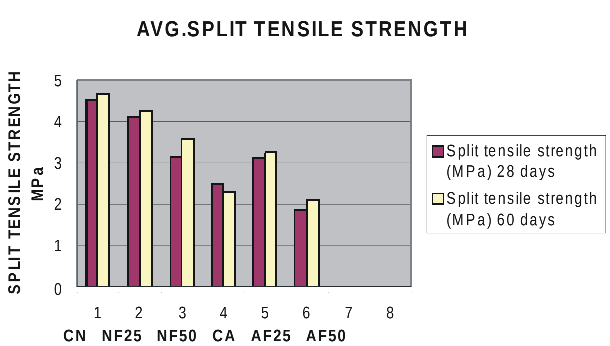

Fig 2. Comparison of Split Tensile Strength of Concrete

Table 7 Average split tensile strength of concrete

Sl. No.	Type of Concrete	Split tensile strength (MPa)	
		28 days	60 days
1	CN	4.52	4.66
2	NF25	4.10	4.24
3	NF50	3.15	3.58
4	CA	2.48	2.30
5	AF25	3.08	3.25
6	AF50	1.84	2.12

Table 8 Average flexural strength of Concrete

Sl.No.	Type of concrete	Flexural strength (Mpa)	
		28 days	60 days
1	CN	5.20	5.65
2	NF25	5.75	6.05
3	NF50	4.00	5.05
4	CA	4.70	4.60
5	AF25	4.80	5.88
6	AF50	1.70	2.90

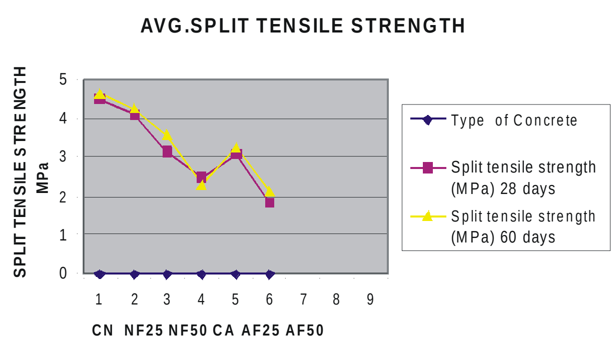

Fig 3. Comparison of Flexural Strength of Concrete

Interpretation of Test Results

The following interpretations of results are made based on the test conducted within a span of 60 days.

I. Compressive strength of concrete

1. There is a continuous increase in strength from 7 to 60 days for control concrete and High Performance Kiln ash Concrete (both 25% and 50% cement replacement) under normal conditions. However the addition of kiln ash decreases the rate of development of compressive strength due to slower pozzolanic action of kiln ash.
2. In the case of control concrete under aggressive environment, though there is an increase in strength from 7 to 28 days, it decreases from 28 to 60 days by about 25% of 28 days strength. But there is a continuous increase in compressive strength from 7 to 60 days for High Performance Kiln ash Concrete (both 25% and 50% cement replacement) even under aggressive condition.
3. Comparing the strength of control concrete at 28 days and 60 days both at normal and aggressive environment, it is noticed that there is a drastic decrease in strength by about 50% and 62% at the respective days. But High Performance Kiln ash Concrete with 25% cement replacement keeps the respective compressive strength at 28 days and 60 days under both normal and aggressive conditions almost same.
4. Compared to 50% cement replacement, 25% replacement with kiln ash makes the concrete to behave well both in normal and aggressive environment.

J. Split Tensile Strength of Concrete

It is seen that, increase in strength is observed in the case of kiln ash concrete under normal and aggressive conditions. However, improvement of strength in both conditions for kiln ash concrete with 25% cement replacement seems to be higher than 50% cement replacement. In the case of control cement concrete under aggressive condition, strength reduction of about 50% is observed at 28 days and 60 days.

K. Flexural Strength of Concrete

1. There is an increase in strength from 28days to 60 days under normal conditions for control concrete and self curing kiln ash concrete (25% and 50% cement replacement). But in aggressive condition, kiln ash concrete with 25% and 50% cement replacement shows increase in strength whereas control concrete almost maintains the strength without any improvement at 28 days and 60 days
2. Flexural strength of self curing kiln ash concrete with 25% cement replacement is better than control concrete for both conditions at 28 days and 60 days.
3. Further the strength of self curing kiln ash concrete with 25% cement replacement is almost same at 60 days indicating better performance of kiln ash concrete in normal and aggressive environment whereas decrease in strength is noticed between control concrete at normal and aggressive environment at 60 days.

III. CONCLUSION

Based on the investigations carried out, the following conclusions are arrived at.

There is a continuous increase in strength with respect to ageing of concrete both under normal and aggressive conditions for the self curing kiln ash concrete where as a considerable reduction in strength is noticed after 28 days in concrete without kiln ash in aggressive environment. The initial rate of gain of strength of self curing kiln ash concrete is slightly lower which is mainly due to the slow pozzolanic action, but strength development at later ages (60 days) for kiln ash based concrete under both conditions seems to be better. In other words, kiln ash concrete performs well in both conditions.But comparing 25% and 50% cement replacement, concrete with 25% kiln ash performs better than concrete with 50% kiln ash. The same observation was made with respect to split tensile strength and flexural strength. Usage of industrial waste such as kiln ash as a partial replacement material for cement not only provides a more durable concrete but also finds the way for the safe disposal of otherwise waste material thereby protecting the environment from pollution.

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