Health Analysis of High Performance Concrete Using Zeolite and Coconut Fibre

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Abstract — *Concrete is the vital material used in construction. Concrete the most extensively used construction material consumes natural materials leading to environmental concerns about utilization of raw materials and also emission of Co_2 during production of cement. Portland cement industry is responsible for approximately 7% of global Co_2 emission. Hence certain conventional micro materials like zeolite are available in the market which can be used as supplementary cementatious material (SCM) thereby enhancing the quality and performance of concrete and leading to less pollutant environment. An experimental investigation is carried out to evaluate the mechanical properties of concrete mixtures containing zeolite and coconut fibers in a binary blended system by replacing cement by zeolite up to 20%. Here optimum amount of coconut fiber and various percentages of zeolite are added by weight of cement to the concrete mixture. The structural strength of such a binary mix is investigated by studying their Mechanical properties. The Mechanical properties are examined by Compressive strength, Split Tensile strength and Flexure strength test. The replacement has shown improved strength compared with that of a conventional concrete.*

Keywords — *Coconut fiber, Concrete, Mechanical properties, Supplementary Cementatious Material (SCM), Zeolite.*

I. INTRODUCTION

Concrete is an extraordinary and key structural material in the construction history. It is no doubt that with the development of human civilization, concrete will continue to be a dominant construction material in the future. However, the development of modern concrete industry also introduces many environmental problems such as pollution, emission of dangerous gases, depletion of natural resources and other such problems. Presently, Portland cement and supplementary cementious materials are cheapest binders which enhance the performance of concrete. However, out of these binders, production of Portland cement is very energy exhaustive along with Co_2 production. Cement production accounts for about 5% of total global Co_2 emissions (Tatem, 2003). Hence many industrial pozzolanic by-products like fly ash, slag, SF and zeolite have been partially incorporated in concrete and addition of Natural fibres like coconut fibre, sisal fibre and many other fibres added to the concrete bear many technical advantages by the fact that concrete with these materials provides the best economic and technological solution to less emission of Co_2 thereby making a way to cause the least harm to the environment.

II. MATERIALS USED

A. Cement

The basic raw material is clinker, which is made from the limestone. In this Project Work, the Dalmia Cement 43 Grade is used as per

IS: 8112-1989

Fig. 1 Ordinary Portland Cement

B. Zeolites

Zeolites are micro porous, aluminosilicate minerals which are used as adsorbents and catalysts. The term *zeolite* was originally coined in 1756 by Swedish mineralogist Axel Fredrik Cronstedt, a large amounts of steam from water has been produced which has been absorbed by the material. Based on this, he called the material *zeolite*, from the Greek word (*zéō*), meaning "to boil" and (*líthos*), meaning "stone". Zeolites consist of an open silica framework, for which alumina can substitute in variable proportions, with alkaline and alkaline earth metals. Together with variable amounts of water, the cations are more or less loosely bound to oxygen's framework in the open channels and they show considerable pozzolanic activity despite their distinct crystalline structure

Fig. 2 Zeolite

C. Aggregates

Concrete is made of aggregates which are bound with cement paste, which is a product from cement hydration, a reaction between cement and water. The aggregate for concrete consists of coarse aggregate and fine aggregate. In this project work, Grade I **Fine aggregate** of particle size less than 2 mm and greater than 1mm is chosen. **Coarse aggregate** greater than 10 mm but lesser than 20 mm is chosen.

D. Coconut fibre

Coconut fibres obtained from coconut husk, is the agricultural waste products obtained in the processing of coconut oil, and these are available in in the tropical regions in large quantities. Coconut fibre has been used to enhance concrete and mortar, and has proven to improve the toughness of the concrete. Coconut fibers have the highest toughness amongst natural fibres.

Fig. 3 Coconut Fibre

E. Water

Tap water available in the laboratory was used in preparing the concrete. The qualities of water samples are uniform and potable. pH value lies between 6 to 8 and the water is free from organic matter and the solid content is within permissible limit as per IS 456-2000 and conforming to IS 3025-1964

III. PROPERTIES OF MATERIALS

TABLE I

PROPERTIES OF CEMENT

Property	Value
Specific gravity	3.15
Consistency	31%
Initial setting time	42 min
Final setting time	450 min

TABLE II

PROPERTIES OF ZEOLITE

Property	Value
Specific gravity	2.5
Consistency	25%
Physical form	Powder
Colour	White

TABLE III

PROPERTIES OF COCONUT FIBRE (AS PER ACI 544.1R-96) MANUAL OF CONCRETE PRACTICE

Property	Value
Length	50 mm
Diameter	0.25 mm
Aspect ratio	200

TABLE IV

MIX PROPORTIONS

Mix	Cement	Z	C	FA	CA	W/C
M_0	1	0	0	1.5	3	0.5
M_1	0.95	0.05	0.03	1.5	3	0.5
M_2	0.90	0.10	0.03	1.5	3	0.5
M_3	0.85	0.15	0.03	1.5	3	0.5
M_4	0.8	0.20	0.03	1.5	3	0.5
M_5	0.75	0.25	0.03	1.5	3	0.5

IV. CASTING AND CURING OF CONCRETE

The concrete specimens are casted and cured for 28 days and 56 days. The concrete specimens have dimensions of 150 x 150 x 150 mm cubes for compressive strength test, beams of 500x100x100 mm for flexural strength test and cylinder of dia. 150 mm x 300 mm for split tensile strength. To compare the result of conventional high performance concrete, a series of control concrete mixes was also investigated incorporating various percentages of SCM (zeolite).

V. TESTS ON HARDENED CONCRETE

A. Compressive Strength Test

The Compression Test was conducted as per IS 516–1959. Place the specimen centrally on the location mark of the compression testing machine and load is applied continuously, uniformly and without shock.

- **f_{cu} = load at failure / Plan area**
  = P/A (N/mm^2)

Where, P = Load at failure (N)
A = Area of the specimen (mm^2)

B. Compressive Strength Results and Discussion

TABLE V

COMPRESSIVE STRENGTH OF CONCRETE

Mix	% of Z	% of C	Compressive Strength N/mm^2	
			28 days	56 days
M0	0%	0%	31.5	34
M1	5%	3%	35	38.5
M2	10%	3%	38	42
M3	15%	3%	40.5	45.5
M4	20%	3%	37	41
M5	25%	3%	35.5	39

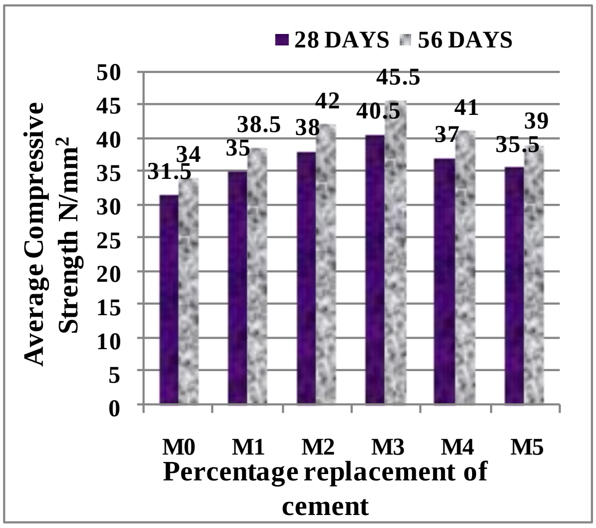

Fig. 4 Compressive Strength of concrete

- In 28th day curing the Compressive Strength value for the control mix M0 was 31.5 N/mm^2 , for M1(5%Z+3%C) was 35 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reduced to 35.6 N/mm^2 for (M5) 25% Z+3%C replacement. **Strength increment is 29% more than the nominal mix when zeolite is added upto 15% and above this percentage the strength decreases**.
- Similarly on 56th day of curing the compressive strength value for the control mix(M0) was 34 N/mm^2, for 5%Z+3%C(M1) was 38.5 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reduced to 39 N/mm^2 for (M5) 25% Z+3%C replacement. **Strength increment is 29% more than the nominal mix when zeolite is added upto 15% and above this percentage the strength decreases.**

C. Split Tensile Strength Test

The split tensile test as per IS 5816:1999 was conducted. A cylinder of 300 mm length and 150 mm diameter is used for the test. The test is carried out by placing a cylindrical specimen horizontally between the loading plates of a compression testing machine and the load is applied until failure of the cylinder takes place along the vertical diameter. The maximum load applied to the specimen was then recorded and the appearance of the concrete for any unusual type of failure was noted.

To find split tensile strength following equation has used.

- **Split tensile strength = 2P/ (πDL)**

Where, *P* = maximum applied load [*N*]

L = length, in [*mm*]
D = diameter, in [*mm*]

D. *Split Tensile Strength Results and Discussion*

TABLE VI

SPLIT TENSILE STRENGTH OF CONCRETE

Mix	% of Z	% of C	Split Tensile Strength N/mm^2	
			28 days	56 days
M0	0%	0%	4.2	4.49
M1	5%	3%	4.4	4.84
M2	10%	3%	4.6	5.08
M3	15%	3%	5.1	5.72
M4	20%	3%	4.9	5.2
M5	25%	3%	4.8	5

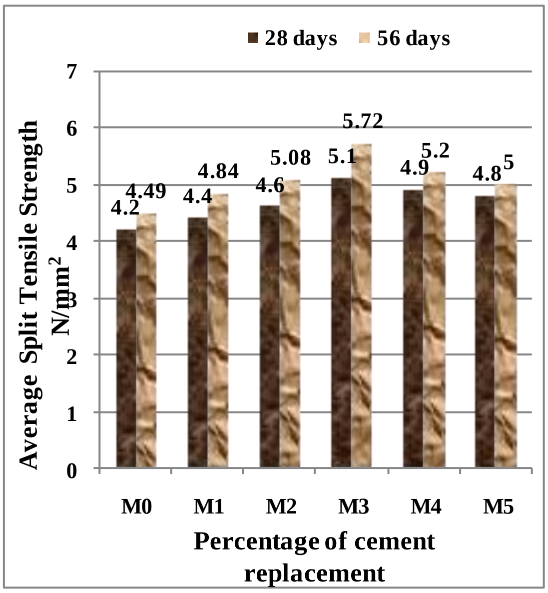

Fig. 5 Split Tensile Strength of concrete

- In 28th day curing the Tensile strength value for the control mortar was 4.2 N/mm^2, for 5%Z+3%C (M1) was 4.4 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reducing to 4.8 N/mm^2 for 25%Z+3%C (M5) replacement. **Strength increment is 21.4% more than the nominal mix when zeolite is added up to 15% and above this percentage the strength decreases.**
- Similarly on 56th day of curing the Tensile strength value for the control mortar was 4.49 N/mm^2, for 5%Z+3%C (M1) was 4.84 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reducing to 5 N/mm^2 for 25%Z+3%C (M5) replacement. **Strength increment is 27.3% more than the nominal mix when zeolite is added up to 15% and above this percentage the strength decreases**.

E. *Flexural Strength Test*

Flexural strength is often measured on flexural testing machine. Three points loading is applied on the centre of the beam. The load is applied without sock and increasing continuously. The load is increased until the specimen fails, and the **maximum load** is applied to the specimen during the test is recorded.

- The flexural strength

$$F_b = Pl/(bd^2)$$

Where, *P* = maximum applied load [*N*]
l = length of specimen, in [*mm*]
d = depthof specimen, in [*mm*]
b= breadth of specimen, in [*mm*]

F. *Flexural Strength Test Results and Discussion*

TABLE VII

FLEXURAL STRENGTH OF CONCRETE

Mix	% of Z	% of C	Flexural Strength N/mm^2	
			28 days	56 days
M0	0%	0%	4.7	4.95
M1	5%	3%	5	5.4
M2	10%	3%	5.5	5.8
M3	15%	3%	5.8	6.4
M4	20%	3%	5.55	6
M5	25%	3%	5.2	5.8

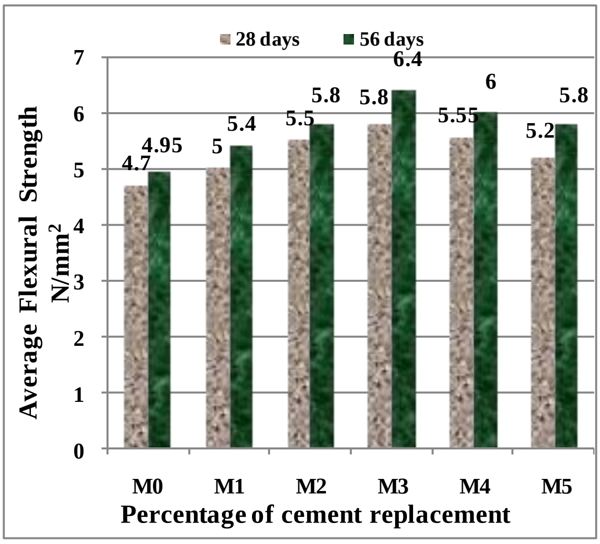

Fig. 6 Flexural Strength of concrete

- In 28th day curing, the flexural strength value for the control mortar was 4.7 N/mm^2, for 5%Z+3%C (M1) was 5 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reducing to 5.2 N/mm^2 for (M5) 25% Z+3%C replacement.

Strength increment is 23.4% more than the nominal mix when zeolite is added up to 15% and above this percentage the strength decreases.

- Similarly on the 56th day of curing the flexural strength value for the control mortar was 4.95 N/mm^2, for (M1) 5%Z+3%C was 5.2 N/mm^2 and beyond this percentage of replacement of cement, the strength was gradually increasing and reducing to 5.45 N/mm^2 for (M5) 25% Z+3%C replacement. **Strength increment is 29.2% more than the nominal mix when zeolite is added up to 15% and above this percentage the strength decreases**.

VI. Conclusions

The findings of the experimental investigations on the strength characteristics of concrete enhanced with various percentages of Zeolite and optimum amount of coconut fibres are reported. The following conclusion has been derived.

The mechanical properties like Compressive strength, Split Tensile strength and Flexural strength of hardened concrete are 29% to 30% more than the nominal mix when cement is partially replaced with zeolite up to 15% by weight of cement. More than this percentage the strength decreases.

Hence the optimum amount of zeolite was found to be 15% and this leads to the less pollutant concrete without compromising the strength.

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