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AN INVESTIGATION ON THE EFFECT OF PARTIAL REPLACEMENT OF CEMENT BY ZEOLITE ON THE PROPERTIES OF CONCRETE

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Abstract - *An experimental investigation was carried out to study the effect of addition of zeolite powder on the properties of concrete. Cement is replaced by zeolite in different percentages, such as 0%, 5%, 10%, 15%, 20%, 25%, 30% and 35%. The study is done on M30 grade* concrete*. Currently the CO_2 concentration in the environment is getting increased leading to serious climate change and green house effect. Arresting of CO_2 from atmosphere ,from point source and reducing atmospheric CO_2 concentration can be done by using zeolite powder. Zeolite, a type of natural pozzolanic material, is abundantly deposited in China and is easy to quarry. Natural zeolite is developed naturally in several regions ,where pre-historic volcanic activity has happened near alkaline or salt water. Concrete with zeolite as partial replacement material , absorb harmful gases and gives high compressive strength hence it is eco-friendly.*

***Key Words*: Zeolite, compressive strength, flexural strength, shear strength, water absorption, soroptivity.**

1.INTRODUCTION

Portland cement is the broadly used binding material in construction and maintenance industry because of its sound properties. In construction industry the Carbon di-oxide emissions primarily come from cement production. The cement production plants discharge or release carbon di-oxide approximately 85% of the cement quantity produced or manufactured .Thus they magnify the carbon di-oxide amount in atmosphere and it leads to global warming. Reducing of carbon di-oxide is required in atmosphere, due to rapid and serious climate change. By using Zeolite material in construction industry, it is found that it can absorb carbon di-oxide and reduce the air pollution.

The material Zeolite is a rock constituted of aluminium, silicon and oxygen. It is developed naturally in several regions ,where pre-historic volcanic activity has happened near alkaline or salt water . Zeolite has a natural porosity because its crystalline structure has windows, cages and super cages. The cages are smallest cell and super cages bigger than cages. The natural zeolite exhibits pozzolanic reactivity which is connected to its metastability and large surface area, and its mineralogical and chemical composition. And as per test results it improves the strength of the concrete. This project describes the feasibility of using the zeolite in concrete production as partial replacement of cement. Test result show that zeolite is capable of improving mechanical properties of concrete .

2. EXPERIMENTAL PROGRAM

2.1 Materials used

2.1.1 Ordinary Portland cement

Chettinad-OPC(43 Grade) cement is used in the experimentation. Properties of cement used are given in table 1.

Table -1: Properties of OPC 43 cement

Property	Result
Specific gravity	3.15
Consistency	31.94 %
Initial settling time	45 min.
Final settling time	330 min.
Fineness of cement	1.21 %

2.1.2 Zeolite powder

Zeolite is natural volcanic mineral that is mined in certain parts of the world. When volcanoes erupt, molten lava and thick ash pour out. Because many volcanoes are located on an island or near an ocean, this lava and ash often flow in to the sea. The chemical reaction between the ash and the salt water, results in amazing minerals like zeolites.

Table -2 : Physical properties of zeolite

Property	Result
Appearance	Off white powder
Brightness(ISO)	78 %
Loss on ignition	9.5% (Max.)
Ph	7.2
Specific gravity	2.2
Consistency	80%

2.1.3 : Fine aggregate

The fine aggregate used was locally available and conforming to Zone-II grading requirements of IS:383:1970.

Table - 3 : Properties of fine aggregate

Property	Result
Zone	II
Specific gravity	2.60
Fineness modulus	2.50
Water absorption	0.93 %
Bulk density	1730 kg/M^3
Loose density	1570 kg/M^3

2.1.4 : Coarse aggregate

The coarse aggregates used was locally available crushed natural stone of size 20 mm or less.

Table – 4 : Properties of coarse aggregate

Property	Result
Specific gravity	2.70
Water absorption	0.37 %
Bulk density	1590 kg/M^3
Loose density	1423.33 kg/M^3

2.2 Mix proportion

The experimental program was based on a reference cement concrete mix of grade M30 using natural aggregates. On the basis of the material properties , the proportioning of concrete mix was carried out in accordance to IS:456:2000 and as per the guidelines of IS 10262:2009. The mix proportion of reference mix was 1 : 1.5 : 2.53 with water cement ratio of 0.45 for M30 grade of concrete.

2.3 Preparation of test specimens

- Moulds are cleaned ,lightly oiled and properly fixed.
- Take water, cement, sand and aggregate in the proportion of 0.45:1:1.5:2.53 (M30,Mix design as per IS:10262:2009)
- Make the fresh concrete by replacing of cement by zeolite in different % , such as 0%, 5%, 10%, 15%, 20%, 25%, 30% & 35%.
- After conducting workability tests, pour the concrete into moulds and ensure proper compaction.
- After 24 hours of time , de-mould the specimen and transfer into the curing tank carefully.
- Take the specimen for testing after 28 days of curing.
- Provide 24 hours of drying period for specimens in atmosphere before conducting tests.

3. TESTING OF CONCRETE

Cement concrete cubes of size 150x150x150 mm were tested for compressive strength as per IS:516:1959.

For flexural strength , beam specimens of size 100x100x500 mm were tested. Two point loading was adopted on an effective span of 400 mm to get pure bending,while testing the beam specimens as per IS:516:1959. And L-shaped specimens were tested for shear strength.

Water absorption test and soroptivity test were performed on cube specimens. Water absorption is a measure of absorbing capacity of the concrete and soroptivity is a measure of movement of moisture through concrete by one directional capillary flow.

4. TEST RESULTS AND DISCUSSIONS

4.1 Workability test

It is observed that, workability measurements from 4 tests such as slump test, compaction factor test, Vee-Bee consistometer test and flow test, show the reduction of workability with increase of % replacement of cement by zeolite. The reduction of workability caused, is due to the sticking of very small nano-particles which inhibit the flow of concrete. Thus it may be concluded that, the workability of concrete goes on decreasing as the replacement of cement by zeolite increases. The workability values of concrete are presented in table 5.

Table 5 : Workability test results

% replacement of cement by zeolite	Slump (mm)	Compaction factor	Vee – Bee (Seconds)	Flow %
0%	115	0.95	3	60
5%	110	0.95	3	60
10%	106	0.94	3	52
15%	103	0.93	4	48
20%	100	0.93	4	48
25%	95	0.91	5	44
30%	90	0.88	6	40
35%	80	0.86	6	40

4.2 Water absorption & soroptivity tests

It is observed that ,the water absorption values of concrete produced by replacement of 5% cement by zeolite shows the least value. After 5% replacement the water absorption is increased. This is due to the fact that 5% replacement of cement by zeolite may fill all the pores of concrete there by making the concrete more impervious. The water absorption and soroptivity values of concrete are presented in table 6.

Thus it can be concluded that, 5% replacement of cement by zeolite can yield a concrete which absorb minimum water.

Table 6 : Water absorption & soroptivity test results

% replacement of cement by	% water absorption	Soroptivity values(mm/min$^{0.5}$)
0%	0.35	6.39
5%	0.23	4.10
10%	0.30	5.11
15%	0.35	5.75
20%	0.36	5.47
25%	0.37	6.02
30%	0.37	6.25
35%	0.38	6.5

It is observed that , the soroptivity values of concrete produced by replacement of 5% cement by zeolite shows the least value. After 5% replacement the soroptivity is increased. This is due to the fact that 5% replacement of cement by zeolite may fill all the pores of concrete there by making the concrete more impervious.

Thus it can be concluded that, 5% replacement of cement by zeolite can yield a concrete whose soroptivity is minimum.

4.3 Compressive strength test

It is observed that, the compressive strength of concrete produced by replacing 5% cement by zeolite shows higher results. After 5% replacement the compressive strength decreases. At 5% replacement level , the % increase in the compressive strength is found to be 32.90 % with reference to reference mix. The compressive strength values of concrete are presented in table 7.

Table 7 : Compressive strength test results

%replacement of cement by zeolite	Average comp. strength (MPa)	% increase/decrease of comp. strength with reference to reference mix
0%	33.11	0
5%	44.00	+32.90
10%	39.55	+19.45
15%	37.33	+12.74
20%	35.35	+6.76
25%	33.03	- 0.24
30%	30.96	- 6.49
35%	29.18	- 11.87

This may be due to the fact that, 5% replacement of cement by zeolite can fill all the pores of concrete there by improving the micro - structure of concrete. This improved micro-structure and the pozzolanic reaction between cement and zeolite will improve the compressive strength of concrete.

Thus it can be concluded that, the higher compressive strength for concrete may be obtained by replacing 5% cement by zeolite. The variation of compressive strength at different percentage replacement of cement by zeolite can be depicted in the form of graph as shown in Fig.1.

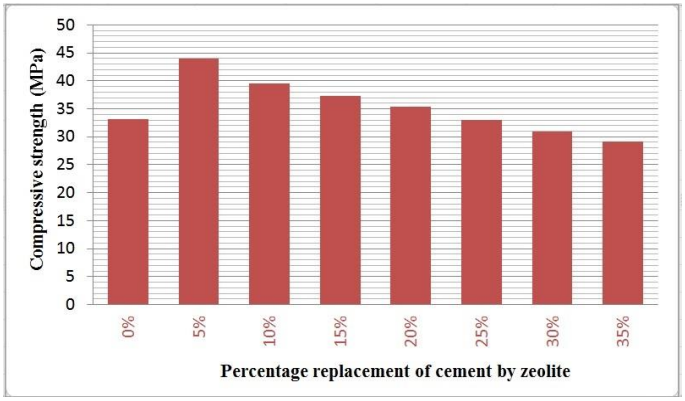

Fig.1: Variation of compressive strength

4.4 Flexural strength test

It is observed that, the flexural strength of concrete produced by replacing 5% cement by zeolite shows higher results. After 5% replacement the flexural strength decreases. At 5% replacement level, the % increase in the flexural strength is found to be 32.00 % with reference to reference mix. The flexural strength values of concrete are presented in table 8.

Table 8 : Flexural strength test results

%replacement of cement by Zeolite	Average flexural strength (MPa)	% increase/decrease of flexural strength with reference to reference mix
0%	8.53	0
5%	11.26	+32.00
10%	10.33	+21.10
15%	9.53	+11.72
20%	8.86	+3.86
25%	8.46	- 0.82
30%	7.60	- 10.90
35%	7.10	- 16.76

This may be due to the fact that, 5% replacement of cement by zeolite can fill all the pores of concrete there by improving the micro-structure of concrete. This improved microstructure and the pozzolanic reaction between cement and zeolite will improve the flexural strength of concrete.

Thus it can be concluded that, the higher flexural strength for concrete may be obtained by replacing 5% cement by zeolite.

The variation of flexural strength at different percentage replacement of cement by zeolite can be depicted in the form of graph as shown in Fig.2.

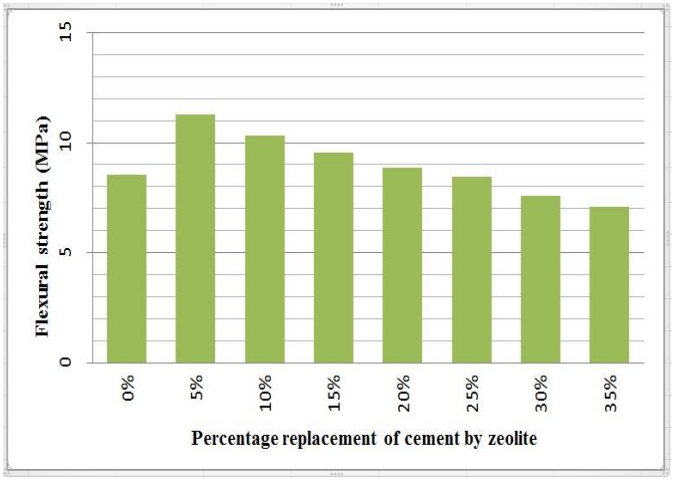

Fig.2: Variation of flexural strength.

4.5 Shear strength test

It is observed that, the shear strength of concrete produced by replacing 5% cement by zeolite shows higher results. After 5% replacement the shear strength decreases. At 5% replacement level , the % increase in the shear strength is found to be 23.84% with reference to reference mix. This may be due to the fact that, 5% replacement of cement by zeolite can fill all the pores of concrete there by improving the micro-structure of concrete. This improved micro-structure and the pozzolanic reaction between cement and zeolite will improve the shear strength of concrete.The shear strength values of concrete are presented in table 9.

Table 9 : Shear strength test results

%replacement of cement by zeolite	Average shear strength (MPa)	% increase/decrease of shear strength with reference to reference mix
0%	11.66	0
5%	14.44	+23.84
10%	14.16	+21.44
15%	13.88	+19.03
20%	13.33	+14.32
25%	10.55	- 9.51
30%	10.27	- 11.92
35%	9.16	- 21.44

Thus it can be concluded that, the higher shear strength for concrete may be obtained by replacing 5% cement by zeolite. The variation of shear strength at different percentage replacement of cement by zeolite can be depicted in the form of graph as shown in Fig.3.

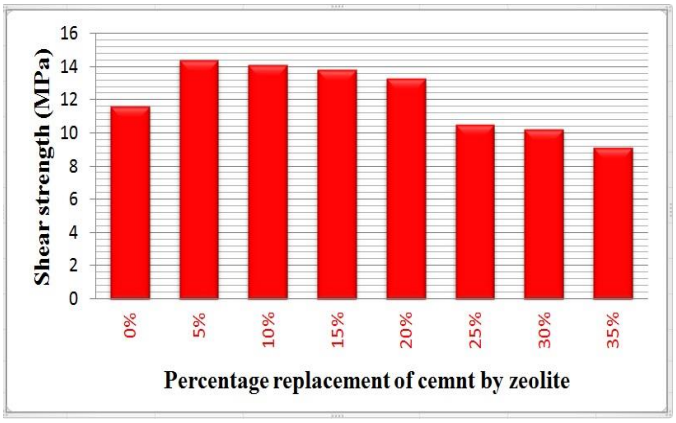

Fig.3: Variation of shear strength.

The strength improvement of concrete due to the fact that, replacement of cement by zeolite can fill all the pores of concrete there by improving the micro-structure of concrete. This improved micro-structure and the pozzolanic reaction between cement and zeolite will improve the properties of the concrete.

5. CONCLUSIONS

The findings of experimental investigations on the strength characteristics of concrete enhanced with zeolite are reported. Succeeding inferences can be made on the basis of obtained results.

- The workability of concrete goes on decreasing as the replacement of cement by zeolite increases.
- 5% replacement of cement by zeolite can yield a concrete which absorb minimum water.
- 5% replacement of cement by zeolite can yield a concrete whose soroptivity is minimum.
- Higher compressive strength for concrete may be obtained by replacing 5% cement by zeolite.
- Higher flexural strength for concrete may be obtained by replacing 5% cement by zeolite.
- Higher shear strength for concrete may be obtained by replacing 5% cement by zeolite.

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