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## Eco-Friendly Concrete Pavement

Shaikh Sameer J.<sup>1</sup>, Neha Zinjurde<sup>2</sup>, Rani Sadashiv<sup>3</sup>, Shweta Jadhav<sup>4</sup>, Pratik Wakle<sup>5</sup>, Abhishek Muley<sup>6</sup>,  
Pranav Holkar<sup>7</sup>.

Lecturer, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>1</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>2</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>3</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>4</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>5</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>6</sup>

T.Y. Student, Department of Civil Engineering, MGM's Polytechnic College, Aurangabad, Maharashtra, India<sup>7</sup>

**ABSTRACT:** Cement plays an essential role for the concrete production. Production of cement emits a greenhouse gas CO<sub>2</sub> during the calcination of limestone. CO<sub>2</sub> emissions have been reduced by using supplementary cementitious material (SCM) as replacement to cement in concrete. Use of supplementary cementitious material can also improve the performance of concrete. One such naturally available supplementary cementitious material, natural zeolite, is used in the present investigation. In the present experimental investigation, 15% of cement content (by weight) in standard concrete of grade M40 is replaced with zeolite. The important parameters that influence the strength of concrete such as water-cement ratio (0.40) are considered for the investigation. The compressive strength of concrete was tested on a cube of 150 X 150 X 150 mm size at the period of 7 and 28 days. From the obtained experimental results, water-binder ratio of 0.4 was found enough for the production of M40 grade concrete. Zeolite powder is a good agent to absorb harmful gases. Concrete with zeolite as partial replacement material with a mean ratio absorbs the harmful gases and gives high compressive strength, hence it is eco-friendly. CO<sub>2</sub> absorbing ecofriendly pavement was studied with properties of concrete pavement such as compressive strength, CO<sub>2</sub> absorption, durability, strength, etc.

**KEYWORDS:** Supplementary Cementitious Materials; Zeolite; Water-Cement Ratio; CO<sub>2</sub> absorption and Compressive Strength.

### I. INTRODUCTION

CO<sub>2</sub> absorbing ecofriendly pavement deals with the study of properties of concrete pavement such as compressive strength, CO<sub>2</sub> absorption, durability, strength, etc. In this paper, zeolite powder was used as an admixture. Zeolite has good pozzolanic reactivity and ability to absorb carbon dioxide from the atmosphere. Now a days, lack of trees and increased emissions in industries get increases the emission of carbon dioxide gas and to reduce the carbon dioxide content, plantation of trees is the option but tree plantation and caring of trees are not properly done then relative option on this situation was construction of pavement which absorbs CO<sub>2</sub>. M40 grade of concrete is adopted and we designed it. 150 X 150 X 150mm size of mould is used. We added 40% of wastage while mix design of block. The reduction of greenhouse gases shall become a priority issue in various industries. On the one hand, the electric power industry accounts for approximately 30% of the CO<sub>2</sub> emissions generated in Japan.

This paper describes the feasibility of using the Zeolite in concrete production as partial replacement of cement which helps in generating an ecofriendly building material. This paper checks the optimum percentage of

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Zeolite that can be replaced with cement without any loss of strength and the absorbability of carbon dioxide Studies, the application of natural zeolite as a supplementary cementitious material. Concrete has one of most extensively used construction materials in the world, with two billion tons placed worldwide each year. It's attractive in many applications because it offers considerable strength at a relatively low cost. Concrete is been generally be produced oflocally available constituents and is been cast into a wide variety of structural configurations, and requires minimal maintenance during service. Portland cement industries are responsible for approximately 7% of global CO<sub>2</sub> emission. Partial replacement of portland cements with one or more additives to obtain blended cements not only provides reduction in CO<sub>2</sub> emission and energy saving in cement product. Ionis also supplies more durable cementitious systems to construction industry. Not only Production of cement is not only energy intensive but it presents also one of the important CO<sub>2</sub> emission sources in the world. Depending on the production technology, the CO<sub>2</sub> emission is ranges from 0.73 to 0.99 t of CO<sub>2</sub> per 1 t of cement.

## II. LITERATUREREVIEW

**Babak Ahmadi and Mohammad Shekarchi (2009)** [1] studied the effectiveness of a locally quarried zeolite in enhancing mechanical and durability properties of concrete is evaluated and is also compared with other pozzolanic admixtures. The experimental tests included three parts: In the first part, the pozzolanic reactivity of natural zeolite and silica fume were examined by a thermogravimetric method. In this case, the results indicated that natural zeolite was not as reactive as silica fume but it showed a good pozzolanic reactivity. In the second part, zeolite and silica fume were substituted for cement in different proportions in concrete mixtures, and several physical and durability tests of concrete were performed. Based on these results, the performance of concretes containing different contents of zeolite improved and even were comparable to or better than that of concretes prepared with silica fume replacements in some cases.

**F. Canpolat et.al.(2003)** [2] studied the effects of zeolite, coal bottom ash and fly ash as Portland cement replacement materials on the properties of cement are investigated through three different combinations of tests. These materials are substituted for Portland cement in different proportions, and physical properties such as setting time, volume expansion, compressive strength and water consistency of the mortar are determined. Then, these physical properties are compared with those of PC 42.5. The results showed that replacement materials have some effects on the mechanical properties of the cement. The inclusion of zeolite up to the level of 15% resulted in an increase in compressive strength at early ages, but resulted in a decrease in compressive strength when used in combination with fly ash. Also, setting time was decreased when zeolite was substituted. The results obtained were compared with Turkish Standards (TS), and it was found that they are above the minimum requirements.

## III. RELATED WORK

### 3.1 Material used and its properties:

#### 1. Cement

The binding materials was used in concrete are Portland Pozzolana cement. This cement was of 53 grades conforming to IS 456-2000 and having desired properties.

#### Physical Property Cement:

- Normal consistency - 32 %
- Initial setting time (min) - 55
- Final setting time (min) - 340
- Specific gravity - 3.15
- Fineness - 8 %
- Compressive strength – 53 MPa

#### 2. Fine Aggregate

Laboratory test were conducted on fine aggregates to determine the different physical properties as per IS 2386 (part-3)-1963(Reaffirmed 2002). The fineness was obtained using the sieve analysis and the result was such that the fine aggregate was confirming to IS 383 – 1970. Artificial sand as well as Natural River Sand is obtained from a nearby quarry were used as fine aggregate, confirming to Zone-II of IS 383. The physical properties of fine aggregate when it is tested as per IS 2386-3 was found as below.

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**- Properties of Fine Aggregate:**

- a) Specific Gravity - 2.65
- b) Fineness modulus – 2.86
- c) Water Absorption - 1.8%

**3. Coarse Aggregate**

The coarse aggregate for the work was crushed stone. Angular shape aggregate of size was 20mm and below. The aggregates which were passes through 75mm sieve and retain on 4.75mm are known as coarse aggregate. The grading of coarse aggregates would be as per specifications of IS 383-1970. The fineness was calculated from sieve analysis and the result was such that confirming to IS specifications.

**- Properties Coarse Aggregate**

- a) Specific Gravity - 2.67
- b) Sieve Analysis As per IS code limit
- c) Water Absorption - 0.349

**4. Water**

The water would be fit for drinking. The water was used for mixing as well as for curing the samples. It would not have high concentrations of sodium and potassium and there was a danger of alkali-aggregate reaction. Natural waters that were slightly acidic were harmless, but water containing humic or other organic acids may be adversely affect the hardening of concrete. Such water as well as highly alkaline water would be tested. Water satisfactory for mixing was also suitable for curing purposes. However, it was essential that curing water should be free from substances that attack hardened concrete like free CO<sub>2</sub> etc.

**5. Zeolite**

Zeolites are porous crystalline alumina-silicates. The zeolite framework is consists of an assemblage of SiO<sub>4</sub> and AlO<sub>4</sub> tetrahedra, joined together in various regular arrangements through shared oxygen atoms to form an open crystal lattice containing pores of molecular dimensions into which molecules could be penetrate. Like most silicates the zeolites were based on TO<sub>4</sub> tetrahedra, where T is an aluminum or silicon atom. The vast 3-dimensional networks were a result of all four corners for the tetrahedra being shared, producing low density micro porous materials. Zeolite structures could be thought to exist of finite or infinite (chains, layers etc.) component units.

The oxides present in the zeolite was shown in below Table 1.

Table no. 1: Chemical Composition Percentage (%) of zeolite content chemical compound with various components

<b>SiO<sub>2</sub></b>	63.72
<b>Al<sub>2</sub>O<sub>3</sub></b>	11.40
<b>Fe<sub>2</sub>O<sub>3</sub></b>	2.73
<b>CaO</b>	3.29
<b>MgO</b>	0.05
<b>SO<sub>3</sub></b>	0.13
<b>Na<sub>2</sub>O</b>	1.02
<b>K<sub>2</sub>O</b>	2.83
<b>TiO<sub>2</sub></b>	0.29
<b>P<sub>2</sub>O<sub>5</sub></b>	0.03
<b>L.O.I</b>	14.20
<b>Total</b>	<b>99.69</b>

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### -Physical Property Zeolite

- a) Normal consistency - 38 %
- b) Initial setting time (min) – 55
- c) Final setting time (min) – 410
- d) Specific gravity - 2.98
- e) Fineness - 8 %

### 3.2 Concrete mixtures

The procedure of selection of suitable ingredients of concrete and determination of their relative amounts with the purpose of producing a concrete of the necessary strength, durability, and workability was termed as the concrete mix design. Mix ratio of 1: 2.5: 3 for water binder ratio of 0.4 was taken in the present investigation represents mix proportions of concrete for varying Zeolite replacements by weight of cement. The control concrete without Zeolite were also fabricated along with above mixes.

#### MIX DESIGN :M40 grade concrete

#### Mix design of control concrete AS per IS 10262-2009

Table No. 2: Mix proportions of zeolite concrete(0.004725m<sup>3</sup>)as per recommendations of IS – 10262:2009.  
Mix design of Zeolite powder replacement with cement with some percentage

Mix No.	Replacement Details	Zeolite (Z) (Kg/m3)	C.A (Kg/m3)	F.A (Kg/m3)	Cement (Kg/m3)	Water (Kg/m3)	Water-Cement Ratio
1.	5%	0.083	5.386	4.233	1.653	0.66	0.4
2.	10%	0.165	5.386	4.233	1.653	0.66	0.4
3.	15%	0.248	5.386	4.233	1.653	0.66	0.4
4.	20%	0.331	5.386	4.233	1.653	0.66	0.4
5.	25%	0.414	5.386	4.233	1.653	0.66	0.4
6.	30%	0.496	5.386	4.233	1.653	0.66	0.4



Fig.No.2. In above figure, 15% replacement of zeolite powder with cement block was been seen.

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It's mixing is done by using concrete mixer and after casting it is compacted on vibrator. This is the block having 15% replacement of zeolite having concrete mix design of grade M40 designed as per recommendations of IS – 10262:2009.

## IV. METHODOLOGY

### 4.1 Testing of Specimens

The Zeolite percentages are corresponding to 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. The test on fresh concrete such as slump cone test and compaction factor tests was carried out and were obtained as per code specifications. The compressive strength was then found for 7 and 28 days on cubes of 150mm dimension. Three trials were conducted for each above mentioned tests. Along this the carbon dioxide test were also carried out. For this cubes were casted and placed at different sites and after 7 days, 28 days the checking was done.

### 4.2 Carbon dioxide Absorption Test

Carbon dioxide absorption from the zeolite used concrete was compared with the conventional concrete. In this test weighing balance was used. Conventional concrete and zeolite used concrete were kept in water for curing. After 7 days weight of the cubes were taken. Similarly, readings were taken on pre-planned days on 7th, 14th, 21<sup>st</sup>, and 28<sup>th</sup> day. Then carbon dioxide absorption from the cubes was calculated,

In this study another test were conducted to determine the amount of CO<sub>2</sub> absorbed by the concrete block using zeolite.

#### - Test on zeolite block (CO<sub>2</sub> absorption test)

Aim- Test of CO<sub>2</sub> Absorption by Zeolite concrete block

Apparatus- Weighing Balance, Moulds of Size 15x15x15 cm.

Procedure:-

1. First, Take the Water, Cement, M sand, zeolite and aggregate in the required proportion.
2. Prepared blocks of dimension 15x15x15 cm for testing of CO<sub>2</sub> absorption.
3. By mixing suitable quantities of materials the concrete blocks were casted.
4. These blocks were then kept in water for curing.
5. Weight of the blocks were taken on pre-planned days up to 45<sup>th</sup> day

Calculation: (1) Carbon dioxide absorbed by cube = Final weight – Initial weight / Molecular weight of carbon dioxide.

Final weight = weight of zeolite cube on 45<sup>th</sup> day

Initial weight = weight of zeolite cube on 7<sup>th</sup> day

Molecular weight = 44 for carbon dioxide.

## 5 Compressive Strength Test

The strength in compression of concrete was determined from cubes of 15 cm x 15 cm x 15 cm. The cubes were tested for 7 days and 28 days. Compressive strength = P/A (N/mm<sup>2</sup>)

P = Load in N

A = Area in mm<sup>2</sup>

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(a) (b)  
Fig.No.3. compressive testing of zeolite powder replacement with cement having size of cube 150 \*150 \*150mm and it is tested on universal testing machine whose least count is 1 N/mm<sup>2</sup> after 7 and 28 day curing..

## V. EXPERIMENTAL RESULTS

- Results of compressive strength obtained from the CO<sub>2</sub> absorbing concrete blocks are as following:  
Table no.2:Results of Compressive testing of zeolite replacement with cement block 150mm cube size tested on universal testing machine after 28 days curing

Percentage of zeolite	Block no.	Compressive strength 7 days (N/mm <sup>2</sup> )	Average (N/mm <sup>2</sup> )	Compressive strength 28 days (N/mm <sup>2</sup> )	Average (N/mm <sup>2</sup> )
5%	1	22	23	32	34.67
	2	23		37	
	3	24		35	
10%	1	24	24	40	40.32
	2	25		38	
	3	23		43	
15%	1	24	24.33	47	44
	2	23		41	
	3	26		44	
20%	1	21	22.33	30	32
	2	23		34	
	3	23		32	
25%	1	18	16.67	25	27.3
	2	15		28	
	3	17		29	
30%	1	12	10.33	22	21.67
	2	9		20	
	3	10		23	

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Table no. 3: Results of CO<sub>2</sub> absorption of zeolite replacement with cement block 150mm cube size taking weight after 77day curing and 7 days curing and after 28 day open to atmosphere

Percentage of zeolite	Initial weight (7 days)	Final weight (28 days)	CO <sub>2</sub> absorption of blocks(moles)	CO <sub>2</sub> absorption of blocks(gms)
5%	8.497	8.66	0.0037	0.044
10%	8.729	8.782	0.0012	0.0144
15%	8.511	9.111	0.013	0.164
20%	8.511	8.998	0.011	0.133
25%	8.782	8.887	0.0023	0.0286
30%	8.38	8.8	0.0018	0.0218

## VI. CONCLUSION

- The concrete cubes that were replaced partially by zeolite powder which are placed in polluted environment showed increase in weight by absorption of CO<sub>2</sub>
- When partial replacement of zeolite powder with cement, maximum compressive strength was obtained at 15% replacement for 7 days and 28 days.
- The mix design was M40 and the maximum compressive strength obtained at 15% was 44 N/mm<sup>2</sup> after 28 day of curing.
- The CO<sub>2</sub> absorption was maximum for 15% of zeolite.

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