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ECONOMIC ANALYSIS OF RIGID PAVEMENT USING ZEOLITE AS A PARTIAL REPLACEMENT OF CEMENT

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Abstract: - Tremendous amount of CO2 ¬emission is carried out due various human activities. It is estimated that construction industry alone is responsible for emission of 50% of Greenhouse gases. Production of Cement emits about 7% CO2. Various researchers are contributing to reduce this CO2 emission. Zeolite is one of the various Supplementary Cementitious Material (SCM) which can be used as a partial replacement of Cement in concrete without deteriorating the strength of Concrete. In this paper, impact of Zeolite on Compressive strength of Concrete has been tested. Also economic analysis of zeolite as a partial replacement of Cement in Rigid pavement is carried out.

Keywords: Concrete, CO2, Pavement, Zeolite.

I. INTRODUCTION

Concrete is one of the most widely adopted materials for construction, due to its high ration of durability to cost. Though, when subjected to adverse environments, its durability can drastically decline due to corrosion of the inserted reinforcement steel and fibres and/or deprivation of the concrete. The most important factor on which concrete performance depends is the characteristics of cement consumed during concrete production. It is potential to accomplish environmental, social and economic profits with the addition of Pozzolanic mineral additives such as fly ash, GGBFS in Concrete production. The durability issues in concrete and reinforced cement concrete (RCC) structures open to destructive environment effects cause harms to the structures well before the anticipated service life. It is normally accepted that addition of pozzolan decreases the calcium hydroxide content in cement paste and increases the permeability of concrete.

Zeolites are crystalline alumina silicates with even pores, channels, and hollows. They hold special properties, such as ion exchange, molecular sieves, a big surface area, and catalytic activity, which make them a desirable material for various industrial applications. The Pozzolanic properties of Zeolite are mostly because of their reactive SiO_2 and Al_2O_3, which react with calcium hydroxide generated in the process the hydration of cement, and convert it into C–S–H gels and aluminates. As a result, the microstructure of hardened cement concrete is enhanced and the concrete becomes more impervious.

Addition of artificial zeolite to concrete has been tried in order to adsorb harmful substances chiefly contained in the automotive exhaust emission and to improve water quality. It can be said that the evaluation concerning with CO2 absorption of concrete with additional zeolite has not been done, though zeolite shows a very good adsorption characteristic for CO2 as well as for NOx.

In the present study, it is proposed to examine the effect of amalgamation of Natural zeolite in concrete. Compressive strength test has been carried out. Also effect of addition of Natural zeolite in terms of Economy is also been considered.

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II. LITERATURE REVIEW

Zeolite to improve strength shrinkage performance of high-strength engineered cementitious composite - Qing Wang, Jun Zhang, J.C.M. Ho, Construction and Building Materials 234 (2020) 1-9 Elsevier

Engineered cementitious composite (ECC) is high performance material gives high strength at the same time it gives multiple crack formation under tension. ECC is act as a binding mortar or repairing material for concrete cracks in existing structure. But one drawback of ECC is high shrinkage due to extra tensile stress that affects its durability. To decrease the shrinkage without sacrificing the strength we use zeolite. Following are different test conducted, replacement of zeolite by 15%, 20%, 30%.

1. Shrinkage.
2. Internal relative humidity.
3. Compressive strength.

The test result indicates that the 28 days autogenous shrinkage of ECC decrease reduction was 55% for 30% natural zeolite replacement. From shrinkage to strength ratio it with the zeolite replacement ratio. Using zeolite the maximum 28 days autogenous shrinkage shows that ECC with 30% zeolite yields the lower shrinkage per compressive strength .Zeolite replacement ratio>30% is used for future shrinkage reduction study.

Effect of chloride treatment curing condition on the mechanical properties and durability of concrete containing zeolite and micro-nano-bubble water - Moein Khoshroo, Ali Akbar Shirzadi Javid, Ali Katebi, Construction and Building Materials 177 (2018) 417-427 Elsevier.

In this research effect of chloride ion on properties of concrete is studied.

In this mixture that contains zeolite as a mineral admixture and also researchers have used the Micro-Nano bubble water to the concrete, under chloride curing condition.

1. Compressive strength test 2. Tensile strength test 3. Rapid chloride penetration test

Zeolite and micro-nano bubble in standard condition improved mechanical properties and durability of concrete. The mixture containing 15 per cent zeolite and 100 percent micro-Nano bubble water under chloride treatment condition, there was 45 percent increases the compressive strength and also tensile strength is increase 78 percent And also chloride penetration and water absorption were reduced by 83 percent and 49 percent respectively When 15 percent zeolite is used instead of cement and 100 percent Micro-Nano bubble water is used instead of water by using this material reduces the effect of chloride salt.

Interaction of treated industrial wastewater and zeolite on compressive strength of plain concrete in different cement contents and curing ages- Kami Kaboosi, Khashayar Emami, Case Studies in Construction Materials (2019)Elsevier

In this research paper the study was conducted to investigating interaction of three Level the of water quality (industrial waste water, tap water, mixture of equal ratio)

The substituting of cement by zeolite in concrete mix design (10%, 20%, and 30%) and plain then two levels of cement content 250 and 350kg used.

The natural zeolite in steady of cement in the concrete mix design then 10 to 30% of Cement by zeolite can decrease the global warming index.

The addition of a superplasticizer to concrete mix design then reduction of concrete Workability and zeolite maintain to the concrete slump.

Then the two-way interaction of cement content x zeolite% in the cement content 250kg then all levels of water reduction in compressive concrete.

Experimental investigation of mechanical properties of crumbed rubber concrete containing natural zeolite- Farnoosh Jokar, Mohammad Khorram, Gholamreza Karimi, Nader Hataf, Construction and Building Materials 208 (2019) 651-658 Elsevier

Crumbled Rubber Concrete improves mechanical properties of C.R.C by addition of natural Zeolite as partial replacement of cement. To improve cement-rubber bond, the surface treatment of rubber particle is carried out with 1M aqueous solution of NaOH. Crumbled rubber with size 1-6mm, 5, 10, 15% is replaced the C.A having maximum size 9mm. For reduction of the cement quantity and enhancing the concrete properties, replacement of 5, 10, 15% of cement with Zeolite. Following tests are examined such as-

1) Compressive strength
2) Brazilian tensile strength
3) Flexural strength

4) Specific weight

5) Modulus of elasticity of samples.

For M-30 concrete the design is carried out.

When we add all percentage of Crumbled rubber then mechanical properties reduced as compared to ordinary concrete. Only the concrete comprising 5% replaced crumbled rubber, flexural strength was enhanced as compared to other replaced percentages. The w/c ratio= 0.48 is constant all over. Addition of zeolite improves the compressive strength and flexural strength associated to samples containing 5% rubber, 15% zeolite and 5% rubber, 10% zeolite respectively.

III. CHARACTERIZATION OF MATERIALS

- *CEMENT*

Ordinary Portland cement of 53 Grade available in local market is used in the research. The cement used has been tested for various properties according to IS: 4031-1988 and found to be approving to various specifications of IS: 12269-1987 having specific gravity of 3.15.

- *AGGREGATES*
- *Fine Aggregate-*

Locally available well-graded, clean, natural river sand (or M- Sand) having fineness modulus of 2.6 following to IS 383-1970 was used as fine aggregate.

- *Coarse Aggregate-*

Crushed angular granite aggregate of size 20 mm obtained from local market with specific gravity of 2.60 was used.

- *WATER*

Potable locally available water following to IS 456 is used.

IV. MIX DESIGN OF CONCRETE

Various tests have been carried out on different constituents of Concrete viz. Specific gravity, water absorption, Fineness modulus etc. These values are used in the Mix design of Concrete using IS code method. Minimum grade of concrete used in rigid pavement is M30 so Mix design is carried for M30 grade concrete.

Following table 1 shows the quantity of material required to produce 1 Cum of Concrete.

Table 1: Mix Design of Concrete

CEMENT	FA	CA	Water
435.409	631.194	1215.273	203.430
1	**1.45**	**2.79**	**0.467**

V. RIGID PAVEMENT DESIGN

Traffic survey proposed National highway 166 is carried out to identify maximum wheel load. Design wheel load for the design is taken as 5100 kgs.

Following are outcomes from the pavement design:

Spacing of contraction Joint: 4.44 m

Spacing of Expansion Joint: 3.5 m

Pavement Thickness: 0.25 m

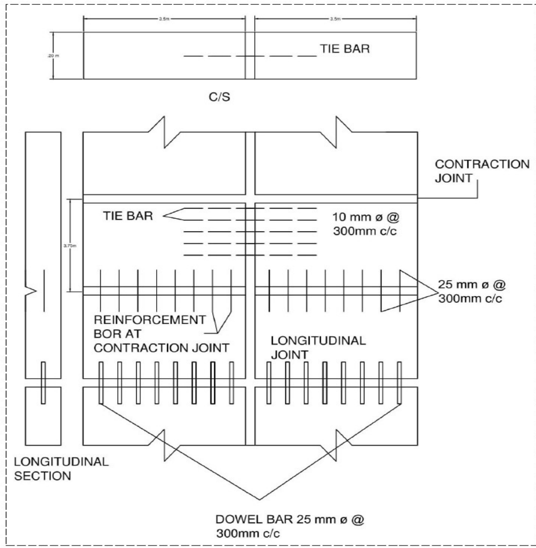

Figure 1: Design details of Rigid Pavement

VI. Testing of Concrete

Compressive Strength

For the testing purpose, four samples have prepared with different combinations of Zeolite replacement. Replacement percentage is 0, 10, 20 and 30% of weight of cement. Concrete Testing machine is used to test the samples of size 15cm x 15cm x 15cm.

Figure 2: Compressive test on concrete

For each group, three cubes are casted and cured for 3, 7 and 28 days. Following table 2 shows the results of compressive strength test carried on cubes at the end of 3, 7 and 28 days.

Table 2: Compressive strength for various mix proportions of concrete

Sr.No	Percentage of Replacement	Day of testing	Avg. Compressive Strength (N/mm2)
1	0% Zeolite	3	12.1
		7	18.2
		28	31.2
2	10% Zeolite	3	**13.6**
		7	**20.4**
		28	**34.9**
3	20% Zeolite	3	12.7
		7	19.6
		28	32.1
4	30% Zeolite	3	8.7
		7	16.8
		28	28.1

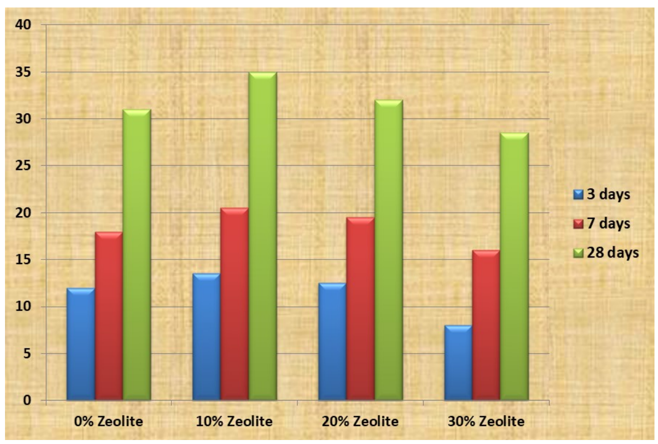

Figure 3: Compressive strength for various mix proportions of concrete

For the test carried out, it can be seen that with 10% addition of zeolite as a partial replacement of Cement in concrete, the concrete shows the significant increase in the compressive strength as compared to 20 and 30%.

Hence for the further calculations, 10% zeolite is considered to be most optimum and beneficial.

VII. Economic Analysis

Based on the mix design of M30 grade concrete, rigid pavement design, material calculation is carried out. Percentage replacement of cement with zeolite is kept to be 10%.

Following calculations are carried out for One Kilometer stretch of Four Lane National Highway with width of Single Lane as 3.5m. Thickness of pavement is calculated as 0.25m.

Table 3: Estimation of Pavement without Zeolite

MATERIAL	QUANTITY	RATE	UOM	FINAL AMOUNT (Rs.)
Cement	32237.5	348.46	per bag	**11233493.11**
Sand	1630.4	1575	m^3	**2567901.379**
Aggregate	2561.3	809.22	m^3	**2072632.96**
Steel	8400.0	43.543	kg	**365761.2**

Binding Wire	58.8	63.26	kg	**3719.688**
			Total Cost	**16243508**

Total material cost of Pavement comes out to be Rs**. 1.62 Crore per Kilometer**.

Table 4: Estimation of Pavement with Zeolite

MATERIAL	QUANTITY	RATE	UOM	FINAL AMOUNT (Rs.)
Cement	29013.8	348.46	per bag	**10110143.8**
Zeolite	161187.7	5	kg	**805938.4942**
Sand	1630.4	1575	m^3	**2567901.379**
Aggregate	2561.3	809.22	m^3	**2072632.96**
Steel	8400.0	43.543	kg	**365761.2**
Binding Wire	58.8	63.26	kg	**3719.688**
			Total	**15926098**

As per calculations carried out, it can be seen that due to addition of Zeolite there is total cost reduction of Rs. 3.17 Lakhs per Kilometer.

VIII. RESULTS AND DISCUSSION

Following are the key results of this research:

1. Mix Proportion of M30 grade of Concrete is **1:1.445:2.27**
2. Pavement thickness for design wheel load of 5100 kg comes out to be 0.25 m
3. Cost reduction of Rupees 3.17 lakhs per kilometer is observed in material cost.

IX. CONCLUSION

Zeolite which can be used as Supplementary Cementitious material in concrete has many advantages. Basic Advantage of using Zeolite is reduction of CO_2 emission mostly occurs in the process of Cement Manufacturing.

Zeolite addition in concrete not reduces the cost of Concrete but also with 10% replacement of Zeolite, Compressive strength of concrete is found out to be more than the conventional concrete.

REFERENCES

[1] Qing Wang, Jun Zhang, J.C.M. Ho, Zeolite to improve strength shrinkage performance of high-strength engineered cementitious composite - Construction and Building Materials 234 (2020) 1-9 Elsevier.

[2] Moein Khoshroo, Ali Akbar Shirzadi Javid, Ali Katebi,, Effect of chloride treatment curing condition on the mechanical properties and durability of concrete containing zeolite and micro-nano-bubble water - Construction and Building Materials 177 (2018) 417-427 Elsevier.

[3] Kami Kaboosi, Khashayar Emami , Interaction of treated industrial wastewater and zeolite on compressive strength of plain concrete in different cement contents and curing ages-, Case Studies in Construction Materials (2019)Elsevier

[4] Farnoosh Jokar, Mohammad Khorram, Gholamreza Karimi, Nader Hataf, , Experimental investigation of mechanical properties of crumbed rubber concrete containing natural zeolite- Construction and Building Materials 208 (2019) 651-658 Elsevier

[5] Bárbara Belén Raggiotti, María Josefina Positieri, Ángel Oshiro, Natural zeolite, a pozzolan for structural concrete- Procedia Structural Integrity 11 (2018) 36–43, Elsevier