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EXPERIMENTAL STUDY ON ABSORPTION OF CO_2 BY M40 GRADE CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY ZEOLITE

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Abstract:

An experimental investigation was carried out to evaluate the mechanical and durability properties of concrete mixtures containing Natural Zeolite (NZ) in binary blended system up to 30% replacements. In order to serious climate change, deep reduction in CO_2 emission will be required in coming decades. CO_2 absorption is one of the key technologies to control the global Warming. Global warming is caused by sharply increased greenhouse gases emission by human activities. In Construction industry, CO_2 emission mainly comes from cement production.

Capturing of CO_2 from a point source, from ambient air and reducing atmospheric CO_2 concentration by using Zeolite powder and Zeolite sand can be done. Concrete with Zeolite as a supplement material can absorb large quantity of CO_2. Introducing Zeolite material into the concrete absorbs CO_2 from the atmosphere hence it will be eco-friendly. Absorption of CO_2 reduces the air pollution and keep environment clean and full of oxygen. Zeolite, a type of natural Pozzolanic material, is abundantly deposited in China and is easy to quarry. It is widely used in producing blended cement and concrete structural elements. The direct partial replacement of cement by Zeolite resulted in the decrease of compressive strength, especially the early strength and tensile splitting strength. Silica fume was incorporated to enhance the strength performance of zeolite. It was found that the ternary blended cement (zeolite plus silica fume and cement) concrete performed better than the binary blended cement (zeolite and cement) concrete. Study of effect of zeolite on the strength of concrete

made in this study by Choosing M40 Grade of Concrete and Replacement of Cement With 0%, 10%, 20% and 30% of zeolite and also test were done on concrete to know the strength properties like Compressive Test, Flexural strength.

Keywords:Natural Zeolite (NZ), Global Warming, Pozzolanic material, etc.

1.Introduction:

Global warming resulted from the emission of greenhouse gases has received widespread attention. Among the greenhouse gases, CO_2 contributes more than 60% to global warming because of its huge emission amount. The CO_2 concentration in atmosphere now is closed to 400 ppm which is significantly higher than the preindustrial level of about 300 ppm. To mitigate global warming, Kyoto Protocol urges 37 industrialized nations and European Union to reduce their greenhouse gas emissions to a level of 5.2% on average lower than those of 1990 during the period of 2008 to 2012. Copenhagen Accord also requests the global temperature increase be limited to 2°C above the pre-industrial level by 2100. International Energy Agency (IEA) pointed out to achieve the ± 2°C goal, CO_2 capture and storage (CCS) technology is required and the contribution would be 19% in 2050. It is therefore essential to develop the CCS technologies to cope with the global demand of CO_2 reduction. Among these technologies, chemical absorption using aqueous alkanolamine solutions is proposed to be the most applicable technology for CO_2 capture before 2030. However, the alkanolamine aqueous solutions possess some drawbacks such as high equipment corrosion rate, high energy consumption in regeneration, and a large absorber volume required. As a result, solid adsorption processes are suggested and studied to overcome those inherent problems in chemical absorption. Impregnation or grafting of amines has been proposed to enhance the originally limited adsorption capacity and to promote the mass transfer rate of CO_2 into porous, or mesoporous adsorbents. The objectives of this paper is to review the technologies including chemical absorption and mesoporous adsorbents impregnated or grafted with amines for CO_2 capture for post-combustion power plants and regeneration processes concerning energy consumption.

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1.1 Carbonation of Concrete

Carbonation is known to improve surface hardness, strength, and durability of cementbased products by pore refinement of the cement paste matrix. Carbonation can be helpful in non-reinforced cement-based products. However, for reinforced cement-based products, as the pH of carbonated cement paste reduces due to carbonation, reinforcing steel loses its passivity and becomes vulnerable to corrosion. Carbonation in cement-based products can be defined as are action between the CO_2 dissolved in water and the cement hydration product $Ca(OH)_2$ in the pore water. This reaction produces calcium carbonate ($CaCO_3$) and water. Calcium silicate hydrates and calcium aluminate hydrates also react with CO_2 in the presence of moisture to produce calcium carbonate and hydrates of silicates and aluminates and water. CO_2 diffuses through the pores depending upon the pore structure and the degree of saturation of the pores in the cement paste matrix. CO_2 in gaseous phase does not react with cement hydration products; it has to dissolve in the pore water first to form carbonic acid ($H2CO_3$). Out of the hydrates in the cement paste, the one which reacts with CO_2 most readily is $Ca(OH)_2$. Other hydrates also react with dissolved CO_2, and hydrated silica, alumina, and ferric oxide are produced. When all $Ca(OH)_2$ becomes carbonated, the pH value of the pore solution is reduced from 12.5 to 8.3

1.2 Zeolite

- Zeolites are framework silicates, with a completely linked framework of tetrahedra, each consisting of 4 O2-surrounding a cat ion (usually Si4+ or Al3+).
- The framework contains open cavities in the form of channels and cages
- Channels and cages are occupied by H2O molecules and extra-framework cat ions (K+, Na+, Ca+ and others) that are commonly exchangeable.
- Channels are large enough to allow passage of guest species.
- In the hydrated phases, dehydration occurs at temperatures 400 $^{\circ}$C and is largely mostly below 400°C reversible.

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Zeolites are porous, hydrated Aluminosilicates. They may be natural minerals or synthetic materials. The general chemical composition of a zeolite is:

Fig 1.2 Zeolite Powder

2. Materials Characterisation:

2.1. Concrete

Concrete is a composite material that consists of a cement paste within which various sizes of fine and course aggregates are embedded. It contains some amount of entrapped air and may contain purposely-entrained air by the use of air-entraining admixtures. Various types of chemical admixtures and/or finely divided mineral admixtures are frequently used in the production of concrete to improve or alter its properties or to obtain a more economical concrete.

2.2. Concrete Making Materials:

2.2.1 Cement- Opc-43

Cement is a generic term that can apply to all binders. There is a wide variety of cements that are used to some extent in the construction and building industries, or to solve special problems. The chemical composition of these cements can be quite diverse, but by far the greatest amount of concrete used today is made with Portland cements.

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2.2.2 Coarse Aggregate

Aggregates generally occupy 70 to 80 percent of the volume of concrete and can therefore be expected to have an important influence on its properties. They are granular materials, derived for the most part from natural rock (crushed stone or natural gravels) and sands, although synthetic materials such as slag and expanded clay or shale are used to some extent, mostly in lightweight concrete. In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance. Aggregate classifications are made principally for the purpose of easier identification of particular aggregate lots, or to become familiar with the different types of aggregates. There are numerous ways of classifying aggregates. These classifications are made according to source of aggregate, specific gravity or unit weight of aggregate, size of aggregate particles, shape of aggregates, surface texture of Aggregates, mode of preparation of aggregates, geological origin of aggregates, and mineral composition of aggregate sand reactivity of aggregates. Aggregates are not generally classified by mineralogy; the simplest and most useful classifications are on the basis of source and specific gravity.

2.2.3 Fine Aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60. Locally available river sand conforming to Grading zone I of IS: 383 –1970.

Clean and dry rivers and available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens. Fine aggregate is defined as material that will pass a No. 4 sieve and will, for the most part, be retained on a No.200 sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

2.3 Water:

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Water is a key ingredient in the manufacture of concrete. It is also material on its own right. Understanding its properties is helpful in gaining and understanding of its effects on concrete and other building materials. Although water is an important ingredient of concrete little needs to be written about water quality, since it has little to do with the quality of the concrete. However mixing water can cause problems by introducing impurities that have detrimental effects on concrete quality. Although satisfactory strength development is of primary concern, impurities contained in the mix water may also affect setting times, drying shrinkage, or durability, or they may cause efflorescence. The water used for experiments was potable water. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. It should be free from organic matter and the pH value should be between 6-7.

3. Test Result:

3.1 Compressive Strength of Cube:

Compressive Strength Test results given in Table No.3.1

Sl. No	Percentage of replacement	No of days Cubes are tested	Average Compressive Strength inN/mm2
1	0%	7	36.04
		28	61.08
2	10%	7	36.40
		28	63.22
3	20%	7	38.077
		28	64.30
4	30%	7	28.07

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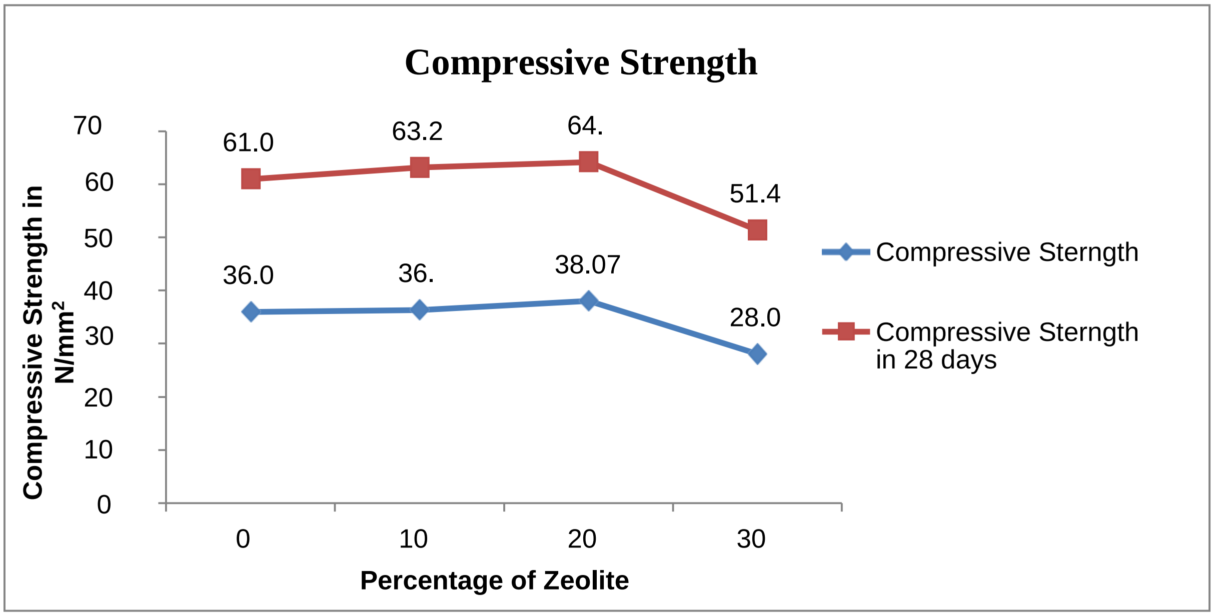
		28	51.42.



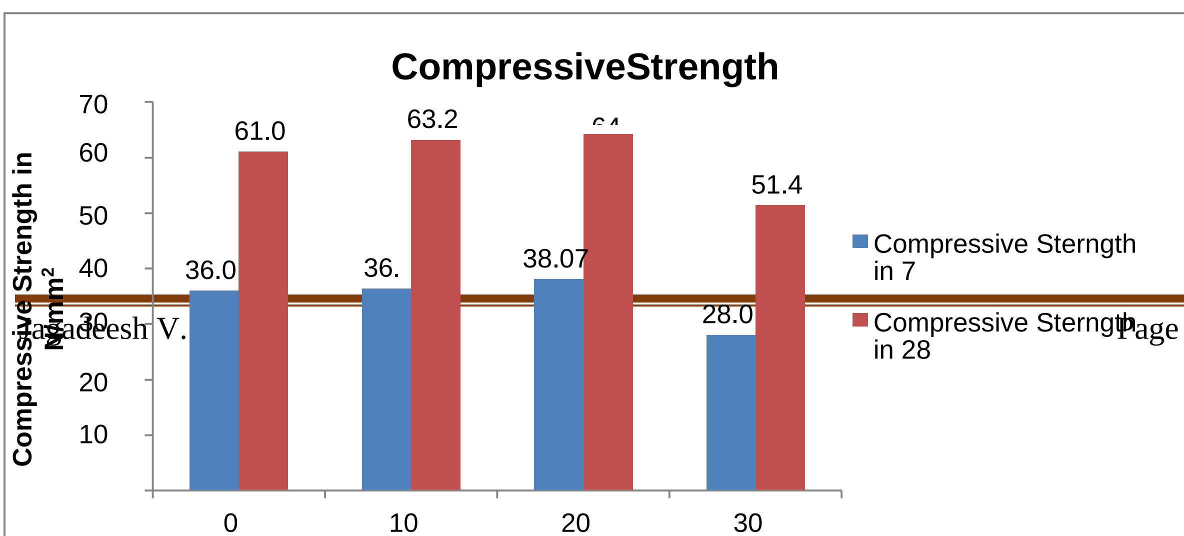


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Fig. 3.1 Graphical Representation of Compressive Strength Results

3.2 Flexural Strength:

Flexural Strength Test results given in Table No.3.2

Sl.No.	Percentage of replacement of zeolite	No of days Cubes are tested	Average flexural strength in N/mm^2
1	0%	7	2.45
		28	3.08
2	10%	7	2.6
		28	4.01
3	20%	7	2.86
		28	5.27
4	30%	7	1.82
		28	2.94

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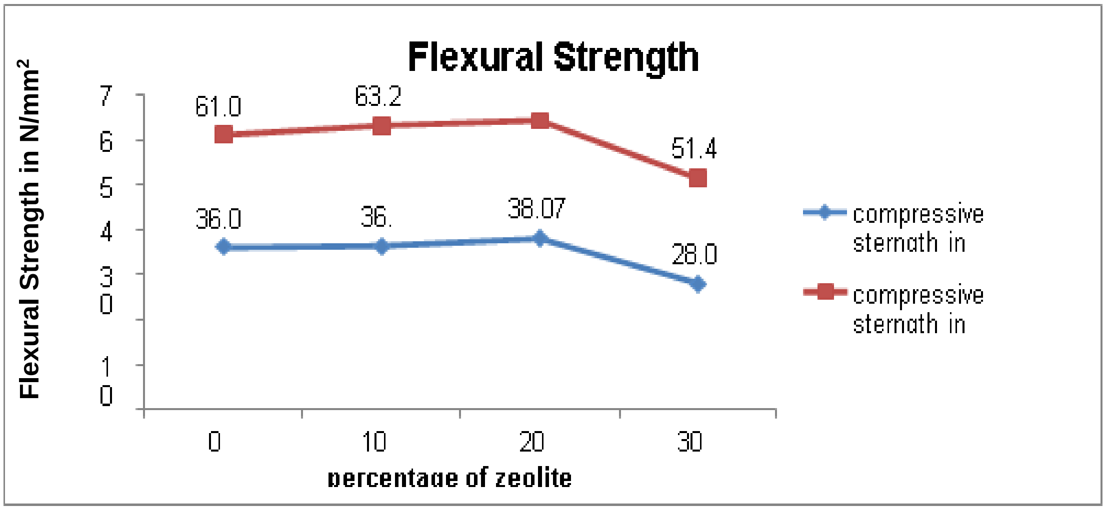

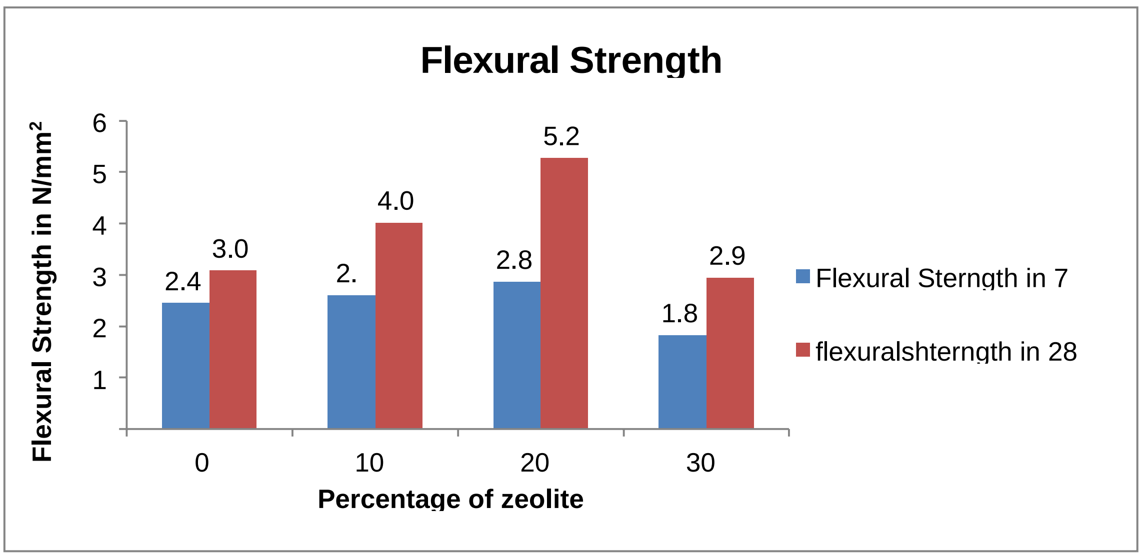

Fig. 3.2 Graphical Representation of Flexural Strength Test

3.3. Test on Zeolite Block:

Calculation of co$_2$ absorbed by blocks = (final weight – initial weight)/molecular weight of CO_2

CO_2 absorbed by B1 = 793-782/44 = 0.25 mole

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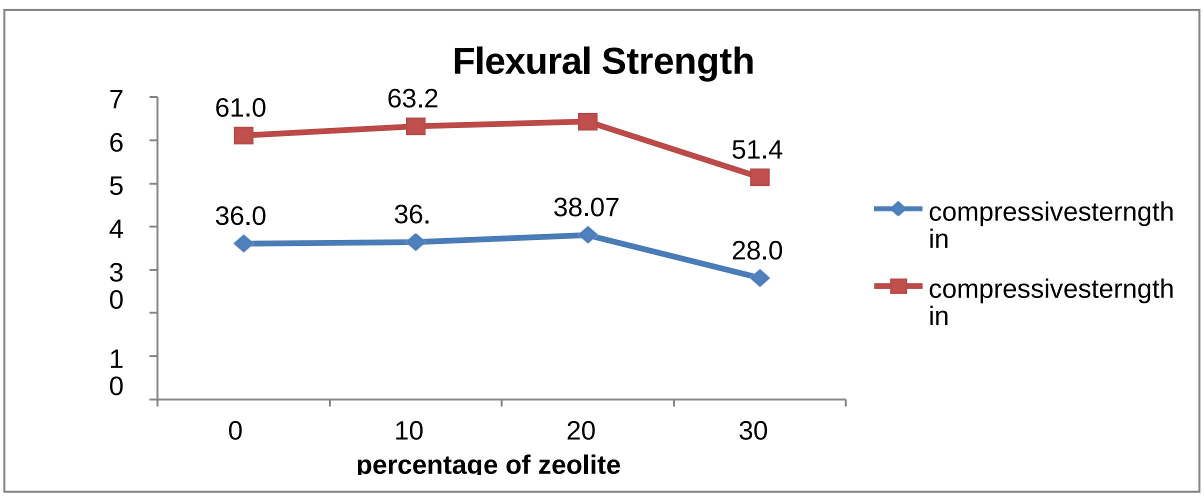
CO_2 absorbed by B2 = 872-820/44 = 1.18 mole

CO_2 absorbed by B3= 890-830 /44 =1.36 mole

Table No 3.3

Sl.No.	Block number	Amount of CO_2 absorbed(Mole)(After 28 days)
1	B0	0
2	B1(10% Zeolite)	0.25
3	B2(20% Zeolite)	1.18
4	B3(30% Zeolite)	1.36



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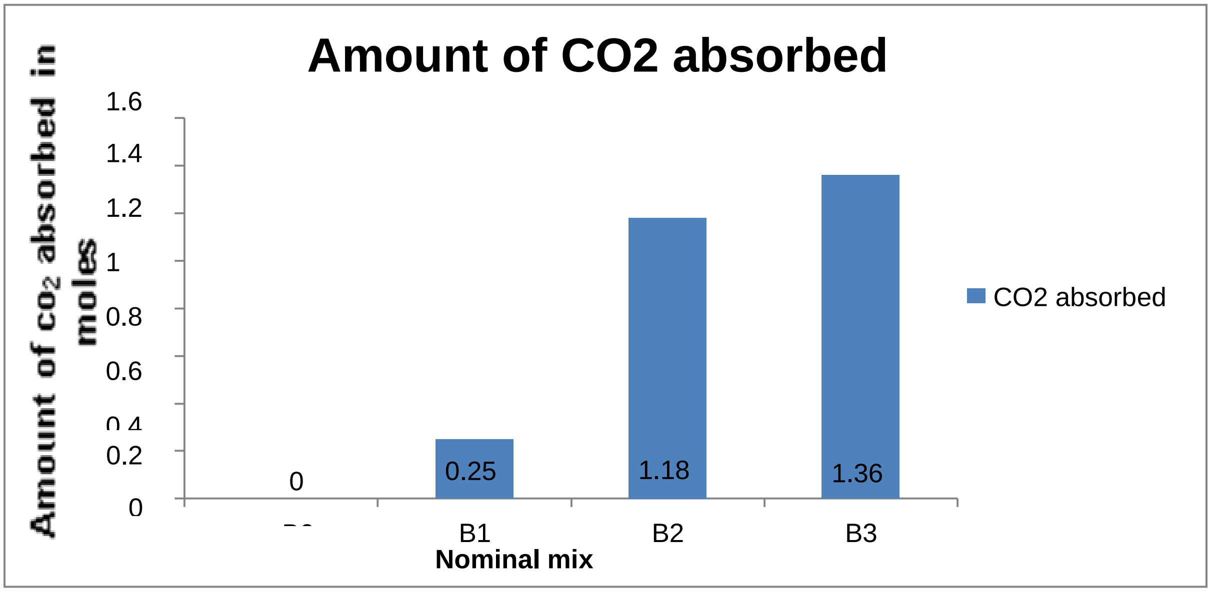

Fig. 3.3 Graphical Representation of Amount of CO_2 absorbed

4. Conclusions:

The findings of experimental investigations on the strength characteristics of concrete enhanced with Zeolite are reported. The following conclusions can be derived.

- The increment in compressive strength of CO_2cured cubes 36.40 N/mm^2 in duration of 7days.
- Precast building products which are cured in a controlled environment are more suitable for CO_2 curing as it would serve as appropriate technology with more efficientservice.
- The results would have been better on application of pressurized $CO_2$and moist temperature which is more favorable CO_2curing.
- Channelization of waste CO2 for curing of concrete in precast plants for its stable sequestration is a way of reducingpollution.
- The outlook of CO_2 as waste and pollutant would change as a resource for progressive construction. From this investigation the addition of zeolite up to 25% improves the strength properties of concrete. It becomes evident that cement based matrices zeolite

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with thus bringing new trends in composite materials. But to make this a reality, some conditions may have to bemet.

5. FutureScope:

- Similar investigation can be done on M_{50} or higher Grade Concretes and also for high strength concrete.
- As the Zeolite has good CO2 absorption properties as well as Strength properties, it can be used in Construction of Pavements.
- Similar investigations of different mix proportions can be done for flexure test.

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