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# Experimental Study On Partial Replacement Of Cement by Zeolite Powder in Concrete

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**ABSTRACT :**Concrete is used most preferably in construction field for their high compressive strength and its properties. In this field one of the disadvantages is carbon dioxide emission from the concrete and from manufacturing of cement. To overcome this issues zeolite material is introduced in concrete to absorb carbon dioxide from the environment and also to reduce the cement and natural river sand in construction**.** The influence of several kinds of synthetic zeolite as mineral admixtures on the workability and performance strength of mortars cement and concrete has been investigated This study focuses on the use of zeolite powder in concrete as partial replacement of cement. Encourage the supplement product as a construction material is the main objective of this work. Zeolite powder is a natural material which is being obtained during chemically reaction of volcanic ash mixed up with sea water. In this work, we used the I.S method for mix design and M30 grade for concrete. prepared concrete mixtures for making cubes with different proportion of zeolite powder ranging from-(5%ZP+95%C), (10%ZP+90%C), (15%ZP+80%C). It was curing was done for 7,14,28 days. From the above test result we found that after 7 days, the compressive strength of concrete was less than the compressive strength of conventional concrete. But compressive strength was increased as with increase the replacement level of cement with zeolite powder.

**KEY WORDS:** Zeolite powder,,Compressive strength, Split Tensile Strength, Flexural strength.

## I.INTRODUCTION

This projects report on the effect of using zeolite as a replacement of cement on the strength, workability, durability properties. Concrete is most popular, important and most economical construction material. Concrete is used very widely everywhere making architectural structure and infrastructure. Concrete is a mixture of different kind of materials which is composed of water, cement, coarse aggregate and fine aggregate. Cement is a most durable material of concrete. Nowaday's cement production is abundant which causes the reduction in the source of cement. To fulfill this gap created by cement, we can use zeolite powder as replacement material. We found that zeolite powder is a good substitute of replacement of cement. It can reduce the cost of construction.

Due to the production of cement the environment gets polluted and causes the source of CO2 emission. This entire process causes global warming and Global warming resulted from the emission of greenhouse gases has received widespread attention. In the sense of greenhouse gases, more than 60% to global warming caused due to contribution of CO2 because of its huge emission amount. According to latest scenario about 400 ppm CO2 concentration in atmosphere is measured.

There are several construction techniques as well as construction material used presently. Most of the materials used are detrimental to the environment which cause of several calamities. This detrimental material concludes cement, aggregate, sand and admixtures etc. Even now days we are preceding constructions with advance construction material like polymer rubbers as well as different sands etc.

Though we use advance material we are far away from dominating pollution intensity. That is only reason we are facing multitudinous problems. But still we are unable to reduce percentage emission of carbon dioxide. As it is been found that obtuse quantity of carbon dioxide get expelled from construction; impending it would definitely reduce the total percentage of carbon dioxide. An experimental investigation was carried out to evaluate the mechanical and durability properties of concrete mixtures containing natural zeolite .

**ZEOLITE POWDER:**

Zeolite mixtures have been widely used in constructions since in past times. Now a days there are 50 natural zeolite and 150 above artificial zeolite are used in industries. In construction many material are used for partial replacement cement with fiber glass, ash, etc. By using zeolite may reduce the consumption of cement in concrete.it reduces of production of co2 while production of cement in industries.

Natural zeolite as volcanic or volcano sediment material has a3D frame structure and is classified as a hydrated alumino silicate of alkali and alkaline earth cations. Crystals are characterized by a honeycomb like structure with extremely small pores .To eliminate 1 billion tonnes of CO2 per year. Through the concrete sector, approximately 50% of the clinker factor of 6 Portland cement must be replaced with materials produced with very low carbon dioxide emissions.

**SCOPE OF THE PROJECT:**

- To increase the strength and workability of concrete.
- zeolite is good and cost effective alternative.
- It is a more beneficial technology in utilization of zeolite
- The zeolite reduces the co2 emission.
- zeolite is reduces the self weight

## II.EXPERIMENTAL INVESTIGATION

### MATERIALS

### CEMENT:

Ordinary Portland cement (OPC) 53 grade of cement available in market manufactured by super tech was used for the experiment. The cement was tested for various properties as per: IS 12269:1970 properties such as consistency, specific gravity, setting time were determined. Cement is a binder, a substance used in construction that sets and hardened and can bind other material is together. Cement is a fine, grey powder. Cement is mixed with water and materials such as sand, gravel, and crushed stone to make concrete.

**Table 1 Properties of Cement**

| Properties of cement | | | | |
|---|---|---|---|---|
| **Standard consistency** | **Specific gravity of cement** | **Fineness test** | **Initial setting time** | **Final setting time** |
| 32% | 3.16 | 7.11% | 60 minutes | 400 minutes |

### FINE AGGREGATE:

Aggregate are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. They occupy about 70-80 percent of the volume of the concrete. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or combination of aggregates. They shall be hard, strong, durable, clear and free from veins and adherent coating; and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances.

**Table 2 Properties of Fine Aggregate**

| Properties of fine aggregate | | | | |
|---|---|---|---|---|
| **Sieve analysis of river sand** | **Sieve analysis of M-sand** | **Specific gravity of river sand** | **Sieve analysis of M-sand** | **Water absorption test** |
| 2.58 | 2.84 | 2.63 | 2.73 | 0.5% |

### COARSE AGGREGATE:

IS 383-1970 defines coarse aggregates as Aggregates most of which is retained on 4.75mm IS Sieve and containing only so much finer material are

1. Uncrushed gravel or stone which results from natural disintegration of rock,
2. Crushed gravel or stone when it results from crushing of gravel or hard stone
3. Partially crushed gravel or stone when it is a product of the blending of uncrushed gravel or stone and crushed gravel or stone

**Table 3 Properties of Coarse aggregate**

| Properties of coarse aggregate | | | | |
|---|---|---|---|---|
| **Sieve analysis of coarse aggregate** | **Specific gravity of Coarse aggregate** | **Water absorption test** | **Impact test** | **Abrasion test** |
| 7.33 | 2.65 | 0.98 | 10,28 | 10.8 |

**ZEOLITE POWDER:**

Zeolites are crystalline microporous aluminosilicates, which allow to adsorb water and other cations, thus filling the micropores. There are more than 40 different types of natural zeolites, and each has a slightly different composition that allows the adsorption of one or other molecules. They have a high capacity of cationic exchange facilitating the adsorption of water molecules, ammonium and heavy metal ions.

**Table 4 properties of zeolite powder**

| Specific gravity | Fineness moudulus | Water absorption |
|---|---|---|
| 2.7 | 3.0 | 1.5% |

**MIX PROPORTIONING:**

Concrete mix design in this experiment was designed as per the guidelines in IS 10262-2009. All the samples were prepared using design mix. M30 grade of concrete was used for the present investigation. Mix design was done based on I.S 10262-2009. The table 5 shows mix proportion of concrete (Kg/m$^3$).

**Table 5 mix proportion of concrete**

| | CEMENT | FINE AGGREGATE (River sand)(kg) | M-SAND | COARSE AGGREGATE | WATER | ZEOLITE POWDER |
|---|---|---|---|---|---|---|
| C.C | 425.73 | 647.11 | - | 1110.21 | 191.58 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| C.CM | 425.73 | 647.11 | 639.73 | 1110.21 | 191.58 | - |
| C.M.ZP 5% | 424.81 | 647.11 | 639.73 | 1110.21 | 191.58 | 0.916 |
| C.M.ZP 10% | 423.90 | 647.11 | 639.73 | 1110.21 | 191.58 | 1.829 |
| C.M.ZP 15% | 423.18 | 647.11 | 639.73 | 1110.21 | 191.58 | 2.544 |
| C.C= Conventional concrete , C.CM= Conventional concrete with M-sand, C.M.ZP= Conventional concrete with zeolite powder | | | | | | |

**FRESH CONCRETE PROPERTIES:**

The following tests were conducted to determine the fresh concrete properties.

**Test on fresh concrete**

1. Slump cone Test
2. Compacting Factor test

**Slump cone Test:**

This test is performed to measure the workability of fresh concrete as per IS 1199-1959. Slump cone test is the most commonly used method of measuring consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slump. The apparatus for conducting the slump test essentially consist of a metallic mould in the form of frustum of the cone having the internal dimension of bottom diameter 20cm, top diameter 10cm, and a height of 30cm. Slump cone = 30 cm height

Slump = 15 cm

**Fig 1: Slump cone Test**

**Compacting Factor test:**

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete as per IS1199:1959 Compaction factor test apparatus consists of two conical hoppers and a bottom cylinder which is arranged as shown in Fig, steel rod of1.6cm Diameter with a length of 61cm is used to tamp the concrete and a weightbalance is used to weight the concrete.

**Compaction factor = (W2-W1)/ (W3-W1)**

**Table 7 Workability of fresh concrete**

| **Workability** | |
|---|---|
| **Slump cone Test** | **Compacting Factor test** |
| 76 | 0.83 |

**Fig 2: Compacting Factor test**

## HARDENED CONCRETE PROPERTIES:

The various strength properties of M-sand concrete are discussed below.

**Test on Hardened concrete**

1. Compressive strength test
2. Split tensile strength test
3. Flexural strength test

**Compressive strength test**

150 mm cube specimens were tested under compressive load in the respective to the age of curing. All the specimens were tested in saturated surface dry condition, after wiping out the surface moisture. For each mix combination, three identical specimens were tested at the ages of 7, 14, 28 days using compression testing machine of 2000 KN capacity under a uniform rate ofloading of 140 kg/cm$^2$/min. and the compressive strength was calculated as per IS: 516 – 1959.

**Compressive Strength (f) = (P/A) N/mm$^2$**

Where,

P = Load at which specimen fails in Newton,

A = Area over which the load is applied in mm$^2$

f = Compressive Stress in N/mm$^2$

**Fig 3:Compressive strength test apparatus**

**Split tensile strength test**

This is an indirect test to determine the tensile strength of cylindrical specimens. Split tensile strength tests were carried out on 100 mm dia.x200 mm high cylindrical specimen at the ages of 28 days of moist curing, using compression testing machine of 2000 N capacity as per IS 5816-1999.

Split tensile strength (ft) is estimated from the expression

$$T = 2P / \pi DL \quad N/mm^2$$

Where,

T = Split tensile strength of concrete

P = Ultimate Load (Newton)

D = Diameter of cylinder (mm)

L= Length of cylinder (mm)

**Fig 4: Split tensile strength test apparatus**

**Flexural strength test**

In order to determine the flexural strength of concrete, prismatic specimens of a size 100 mm x 100 mm x 500 mm were cast with various proportions of all the concrete mixtures. After 28 days of moist curing the specimens were tested in flexural testing machine under a uniform rate of loadingof 180 $kg/cm^2$/min. Flexural strength of specimens expressed as the modulus of rupture (fb) is then calculated using the formula and procedure given in IS: 516- 1959.

When the distance between the line of fracture and the nearer support, measured on centre line of the tension side of specimen ('a' in mm) is greater than133 mm for prism of size 100 mm x 100 mm x 500 mm, the modulus of rupture (fb) is then calculated from the Equations.

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

For ‘a’ is less than 133 mm but greater than 110 mm for prismspecimen, then modulus of rupture is calculated from the formula.

$$(f_b) = 3Pa / bd$$

where,

b = Width of the specimen (mm)

d = Depth of the specimen (mm)

l = Length of the specimen (mm) on which specimen isSupported (span)

P = Maximum load (Newton) applied on the specimen

a = The distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen.


**Fig 5: Beam testing machine**

## III.EXPERIMENTAL PROCEDURE

The specimen of standard cube of (150mmx150mmx150mm) and standard cylinders of (200mmx100mm) and beam of (100mmx100mmx500mm) were used to determine the compressive strength, split tensile strength and flexural strength of concrete. Three specimens were tested for 7,14&28 days before crushing.

The following experiments are conducted on the specimen is the compressive strength test, split tensile strength test and flexural strength test.

## RESULTS AND DISCUSSION:

The normal concrete are tested for their performance by determining their compressive strength, splitting tensile strength and flexure strength development at different ages of 7$^{th}$, 14$^{th}$ and 28$^{th}$ days. The results obtained are discussed in detail in the following sections.

## COMPRESSIVE STRENGTH TEST:

Compressive strength test is done as Per IS 516-1959. The test is conducted on Compression testing machine of capacity 2000 KN. Mechanical behaviour of concrete was studied for M30 grade of cubes were casted and cured for 7,14 and 28days. using compression testing machine of 2000 KN capacity under a uniform rate of loading of 140 kg/cm2/min. and the compressive strength was calculated as per IS: 516 – 1959.

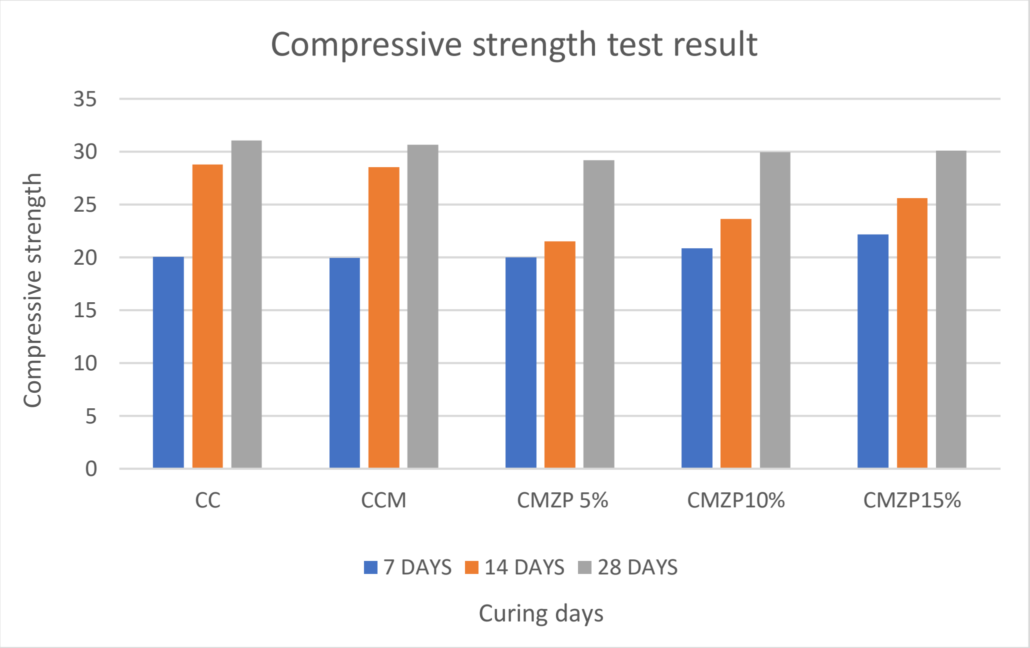
**Compressive Strength (f) = (P/A) N/mm$^2$**

Where,

P = Load at which specimen fails in Newton,

A = Area over which the load is applied in mm2

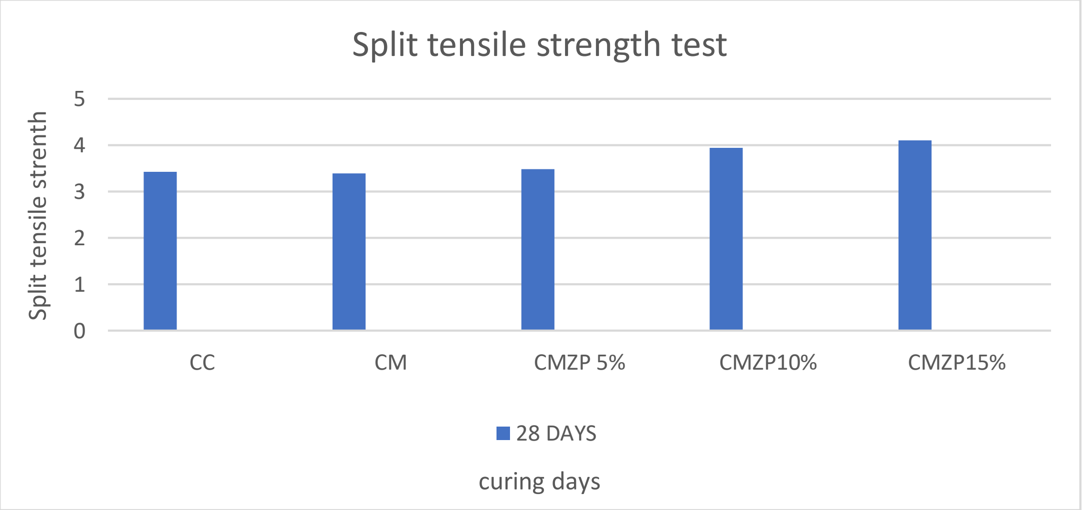
f = Compressive Stress in N/mm2




**Split Tensile Strength test result:**

This is an indirect test to determine the tensile strength of cylindrical specimens. Split tensile strength tests were carried out on 100 mm dia. x200 mm high cylindrical specimen at the ages of 28 days of moist curing, using compression testing machine of 2000 N capacity as per IS 5816-1999.

**T = 2P / πDL N/mm2**



**Flexural strength test result:**

In order to determine the flexural strength of concrete, prismatic specimens of a size 100 mm x 100 mm x 500 mm were cast with various proportions of all the concrete mixtures. After 28 days of moist curing the specimens were tested in flexural testing machine under a uniform rate of loading of 180 kg/cm2/min. Flexural strength of specimens expressed as the modulus of rupture (fb) is then calculated using the formula and procedure given in IS: 516- 1959.

When the distance between the line of fracture and the nearer support, measured on centerline of the tension side of specimen (‘a’ in mm) is greater than 133 mm for prism of size 100 mm x 100 mm x 500 mm, the modulus of rupture (fb) is then calculated from the Equations

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

For ‘a’ is less than 133 mm but greater than 110 mm for a100mm specimen, then modulus of rupture is calculated from the formula.

$$(fb) = 3Pa / bd$$

where,

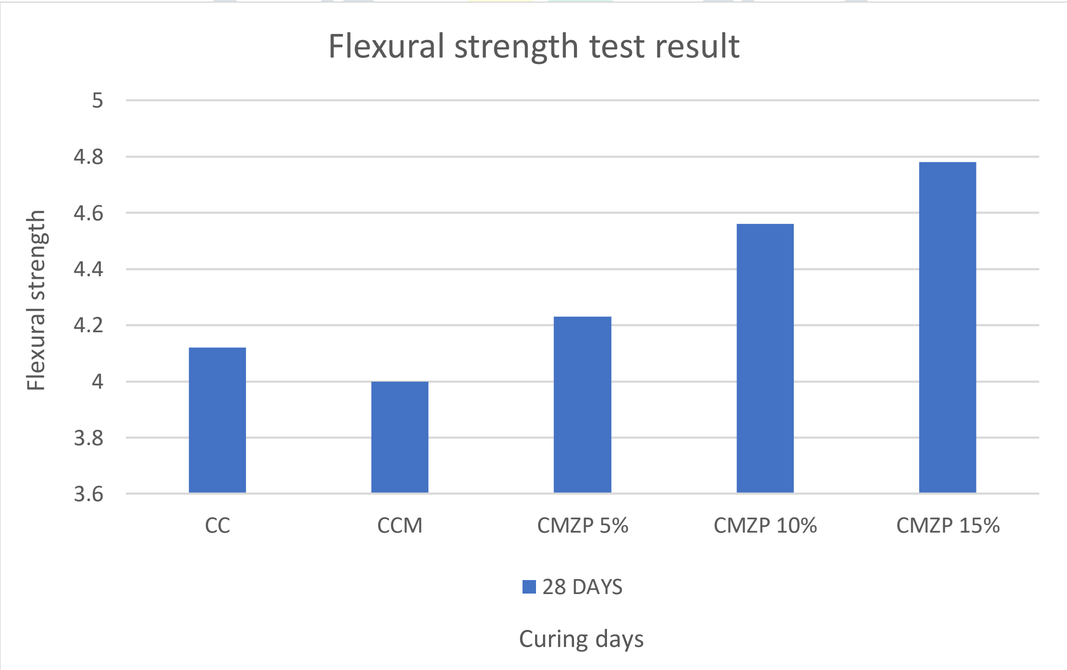
b= Width of the specimen (mm)

d= Depth of the specimen

l= Length of the specimen (mm) on which specimen is Supported (span)

P = Maximum load (Newton) applied on the specimen

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen




**SCANNING ELECTRON MICROSCOPE (SEM):**

The SEM technique can only be used for the evaluation of surface morphology like roughness, homogeneity of dispersion of nanomaterials in the polymer matrix. SEM is a method for high resolution surface imaging. The SEM uses electrons for imaging, much as light microscopy uses visible light. The advantages of SEM over light microscopy include greater magnification (up to 100,000X) and much greater depth of field. Different elements and surface topography emit different amounts of electrons; the varying amount of electrons are responsible for the contrast in the electron micrograph (picture).

Benefits of SEM testing include:

- Digital image resolution as low as 15 nanometers
- Magnification for all imaging is calibrated to a traceable standard. Image analysis for coating thicknesses, grain size determinations and particle sizing can be applied to the saved images.
- Qualitative elemental analysis, standardless quantitative analysis, x-ray line scans and mapping can be performed on both of the SEM systems.

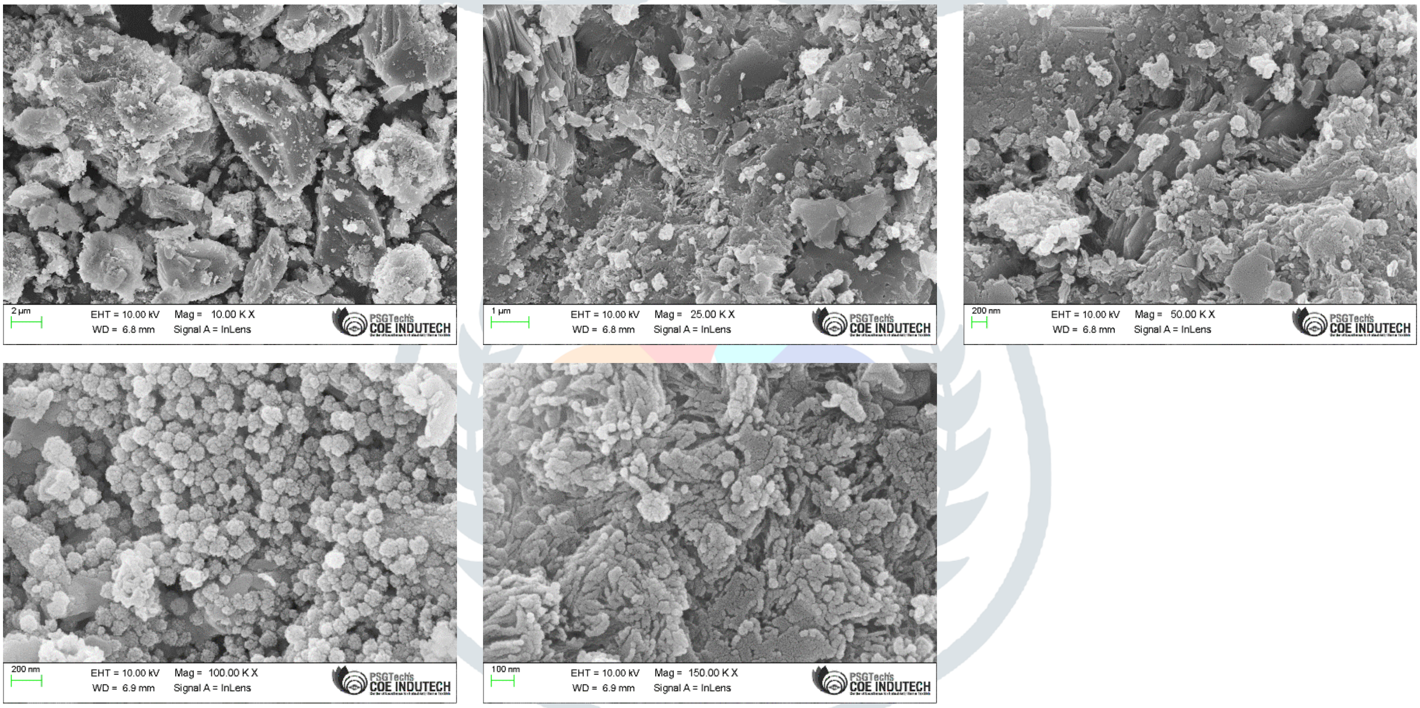



Figure SEM analysis ,these images are scanned in nano microscope(nm).

## IV.CONCLUSION

- The behavior of zeolite powder is different from cement. It helps for consuming the amount of CO2. The compressive strength of concrete was increasing as decrease in the replacement proportions of cement with zeolite powder. It balances the environmental issues and also acts as a substitute material.
- Concrete (By using zeolite) has the capacity of absorbing CO2 without any emission of it. The zeolite concrete block of size 15x15x15 cm has ability to absorb around (0.982) ,1 mole of CO2 in 35 to 40 days without affecting its strength and durability. Hence,
- it is required to look for ways to decrease carbon emissions from cement. In this regard, replacement of cement and its coarse aggregates in concrete by natural zeolites is one of the effective ways which is proven.
- Although they are abundant in nature,
- Zeolites are expensive, which limits the amount of zeolite that can be used to make it commercially available for everyone. They improve surface hardness, flexural strength, resistance to sulphates and

chlorides.

- Concrete incorporated with zeolite has the capability to absorb carbon dioxide from atmosphere making it eco-friendly.

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