A STUDY ON PROPERTIES OF CARBON DIOXIDE ABSORBING CONCRETE USING ZEOLITE AND SILICA FUME

Athul K N[1], Pushparaj A Naik[2]

[1] P G Student, Construction technology, NMAM Institute of Technology, Karnataka, India
[2] Assistant professor, Civil Engineering, NMAM Institute of Technology, Karnataka, India

ABSTRACT

Releasing of greenhouse gas results in global warming. In which cement production plants are also blamable for some quantity of carbon dioxide emission. Hence it is necessary to minimize the amount of carbon dioxide emission from cement production plants. So zeolite 4a powder and silica fume substituting for cement, investigation is carried out. Zeolite has the property of absorbing carbon dioxide up to certain percentage and silica fume used to keep the strength of the concrete. In this study grade of concrete used is M25 and cement is substituted by 5%, 10%, 15%, 20% of zeolite and silica fume combination. Concrete is checked for its carbon dioxide absorbing capacity, workability parameters and strength parameters.

Keyword - *Zeolite, Silica fume, greenhouse gases, and carbon dioxide absorption.*

1.INTRODUCTION

The enormous amount of problem on the earth because of increase of Carbon dioxide in the atmosphere which causes problem for the living beings. Portland cement industry is responsible for 7% of global carbon dioxide emission. This emission can be minimized to greater extent by introducing carbon dioxide absorbers in concrete blocks which is main constituent of construction. This can be made possible by using Zeolite powder and Silica fume as a partial replacement material for cement. Durability of concrete should be more as possible to maintain the strength of the structure up to a certain period. The durability of concrete in now a day is reduced due to the presence of carbon dioxide in the concrete structure. So the admixtures like fly ash, GGBS, are introduced to increase the strength of the concrete but they are not taking active part in the absorption of carbon dioxide. Hence the use of zeolite 4a and silica fume mixtures are combined in a certain proportion to replace cement to absorb the carbon dioxide content in the cement and it will also result in the increase in the strength of the cement. In this study grade of concrete used is M25 and cement is substituted by 5%, 10%, 15%, 20%, of zeolite, silica fume combination. Concrete is checked for its strength parameters and carbon dioxide absorbing capacity as well as its workability.

1.1 Drawbacks of carbon dioxide

Greenhouse Gas Emissions

Increase in Carbon dioxide and other greenhouse gases released into the atmosphere results in the increase in temperature and this rise cause severe droughts and powerful storms.

Toxicity

High levels of Carbon dioxide could lead to severe health effects, even death. When it reaches or exceeds permissible level, then individuals usually begin to demonstrate signs of carbon dioxide poisoning, including a rapid pulse rate, loss of hearing, breathing difficulties and sweating and fatigue.

1.2 Materials Used

Cement: Portland Pozzolana Cement.

Fine Aggregate: River sand passing through 4.75mm IS Sieve.

Coarse Aggregate: Local quarry aggregates of 20mm down size and 12.5 mm down size.

Zeolite 4a: Zeolite is a rock composed of micro porous alumina silicates, and oxygen. It occurs naturally in several regions of the world where volcanic activity has occurred near water. Since they are unreactive and based on naturally occurring minerals, they are not believed to have any harmful environmental impacts. Zeolites having high degree of hydration and it has ability to absorb harmful gases.

Silica fume: Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolona. Concrete containing silica fume can have very high strength and can be very durable. Silica fumes are ultrafine material with spherical particles.
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Fig -1.1: Mixture of cement, zeolite, silica fume

2.LITERATURE REVIEW

T. Subramani et al. (2016) [1] have studied about partial replacement of cement by 25% of zeolite for the absorption of carbon dioxide by M30 concrete. He stated that addition of zeolite up to 25% improves the strength properties of concrete.

S. Subash et al. (2016) [2] have studied about partial replacement of zeolite with cement. The zeolite mixed concrete gives the grade of M30 concrete mix in both substitution of 10% & 30% of zeolite in concrete brings similar compressive strength. He observed that there are no changes in compressive strength and minimal use of zeolite reduces the construction cost.

Balraj More et al. (2014) [3] have studied about carbon di oxide absorbing concrete blocks and observed there is a reduction in pollution. In this experiment they have used a block of size 10x10x10 cm, which has the ability to absorb 1 mole of carbon di oxide in 50 days. And the property of zeolite doesn't lose the strength and durability. This type of blocks is affordable and hence can be used general purpose and it will be eco-friendly.

Krishna lekha R T et al. (2017) [4] have studied about zeolite addition a concrete sustainability natural zeolite has porous structure with porosity of 54.7%. The pore volume is increased there will be the finer porous presented in the zeolite. Use of these zeolite concrete that will reduce the global warming index compare to the conventional concrete which indicates the effectiveness of the consumption of the zeolite in concrete to make concrete more environmental friendly.

Anila Mary Jacob et al. (2017) [5] have studied about partial replacement of cement by zeolite to reduce global warming. The compressive strength, split tensile strength, flexural strength of concrete was found to be more at 25% of zeolite at the age of 28 days when compared with conventional concrete. The zeolite made concrete is capable of absorbing Carbon dioxide without any emission of it. The incorporation of natural zeolites in concrete tends to reduce the slump value of fresh concrete due to its cubical particle shape and rough surface.

Cirajudeen.A.H et al. (2017) [6] have investigated on effect of partial replacement of zeolite and observed workability of concrete goes on decreasing as the replacement of cement by zeolite increases. Higher compressive strength, Higher flexural strength, Higher shear strength for concrete may be obtained by replacing 5% cement by zeolite.

Syed Eashan Adil et al. (2017) [7] study on carbon dioxide absorbing concrete blocks and observed that zeolite powder based concretes have achieved a high strength for replacement of zeolite powder for 28 days when compared to conventional concrete. There is no effect on strength of block prepared by zeolite sand and powder as a substitute. The zeolite block can be used in the road pavements, Chimney of factory as well as at the faces of building.

Sabale V.D et al. (2014) [8] have Studied the Effect of Addition of Silica Fume on Properties of High Strength Concrete and observed that Replacement of cement up to 10% with silica fume leads to increase in compressive strength, splitting tensile strength and flexural strength of concrete and Beyond 10% there is a decrease in compressive strength, tensile strength and flexural strength for 28 days curing period. There is a decrease in workability as the replacement level increases, and hence water Consumption will be more for higher replacements.

Akshatha K. B. (2018) [9] was studied about Concrete using Silica Fume and concluded that compressive strength of concrete gets enhanced with the use of silica fume. The split tensile strength and flexural strength is also found with similar variation when silica fume was used. There is no particular trend of variation in modulus of elasticity of normal and silica fume concrete. The addition of silica fume to the concrete tends to decrease the workability of normal concrete. The density of the concrete with silica fume is similar to the normal concrete.

P. Vinayagam. (2012) [10] investigated on High Performance Concrete Using Silica Fume and Super plasticizer and concluded that the optimum percentage of cement replacement by Silica fume is 10% for achieving maximum compressive, split tensile and flexural strength and elastic modulus. The concrete mixes containing silica fume showed less value of pH as compared to concrete mix without silica fume. The percentage of saturated water absorption of the HPC mixes containing silica fume was lower when compared with that of HPC mixes without silica fume.

N. K. Amudhavalli et al. (2012) [11] have studied on effect of silica fume on strength and durability parameters of concrete and observed that Silica fume is having greater fineness than cement and greater surface area so the consistency increases greatly, when silica fume percentage increases the normal consistency increases about 40% when silica fume percentage increases from 0% to 20%. The optimum 7 and 28 day compressive strength and flexural strength have been obtained in the range of 10-15 % silica fume replacement level.

Mr.Mengal G A et al. (2018) [12] have studied on carbon dioxide absorbing concrete roads and stated that The zeolite made concrete is capable of absorbing CO_2 without any emission of it. Otherwise general concrete evolves huge amount of CO_2 into the atmosphere. The zeolite of bottle of size 10 cm diameter and 12 cm height has ability to absorb around 1 to 14 gm of CO_2i n 5 days.

Seung-jun kown et al. (2019) [13] have studied on optimization of the mixture design of low CO_2 high strength concrete using silica fume and observed that objects of lowest CO_2 emission and lowest cost cannot be achieved simultaneously.

Sudarsana Rao.Hunchate et al. (2014) [14] have studied about mix design of high performance concrete using silica fume and superplasticizer and concluded that as the silica fume content increases the compressive strength increases up to 15% [HPC] and then decreases. Hence the optimum replacement is 15%. And they also stated that the percentage replacement of cement by silica fume increases, the workability decreases.

Esraa Emam et al. (2017) [15] have studied about performance of concrete containing zeolite as a supplementary cementitious material and stated that for untreated concrete mixtures, the percentage of absorption was decreased as the percentage of zeolite incorporation increased, while for calcined concrete mixtures, the percentage of absorption was increased as the percentage of zeolite incorporation increased.

P. Ramu et al. (2017) [16] have studied on Experimental Study on Concrete using Zeolite Sand and Zeolite Powder as Partly Replacement for Fine Aggregate and Cement and concluded that The compressive strength at 28 days is found to be 6% more and split tensile strength is 10% more than conventional concrete when zeolite sand is 30% and zeolite powder is 10% replaced in concrete.

3. OBJECTIVES

- To determine the carbon dioxide absorbing capacity of concrete.
- To study the workability aspects of zeolite and silica fume blended concrete and conventional concrete.
- To study the variation in compressive strength, tensile strength and flexural strength of concrete using zeolite and silica fume, compared to conventional concrete.

4. METHODOLOGY

LITERATURE STUDY
COLLECTION OF MATERIALS
BASIC TESTS ON MATERIALS
MIX DESIGN AS PER IS CODE
PREPERATION OF CONVENTIONAL CONCRETE SPECIMENS
PREPERATION OF ZEOLITE-SILICA FUME MIXED CONCRETE SPECIMENS
DETERMINATION OF CARBON DIOXIDE ABSORBING CAPACITY OF THE SPECIMENS
DETERMINATION OF WORKABILITY OF CONCRETE USED FOR STUDY
DETERMINATION OF COMPRESSIVE, TENSILE AND FLEXURAL STRENGTH OF THE SPECIMENS
RESULTS AND CONCLUSION

5.BASIC TEST RESULTS

Table 5.1: Physical Properties of Cement

Physical Properties	Results
Specific Gravity	3.12
Fineness of cement	6.17%
Normal Consistency	32%
Initial Setting Time	95min
Final Setting Time	290min

Table 5.2: Physical Properties of Fine Aggregate

Physical Properties	Results
Specific Gravity	2.63
Grading Zone	Zone II
Water absorption	1.63
Fineness modulus	2.86

Table 5.3: Physical Properties of Coarse Aggregates

Physical Properties	Results
Specific Gravity	2.83 (20mm) 2.78(12.5mm)
Water absorption	0.604%(20mm) 0.806%(12.5mm)
Fineness modulus	7.37

Table 5.4: Physical Property of Zeolite

Physical Property	Results
Specific Gravity	2.32

Table 5.5: Physical Property of Silica fume

Physical Property	Results
Specific Gravity	2.23

Table 5.6: Quantity of materials per cum

Materials	Quantity (Kg/m^3)
Cement	435.23
Fine aggregate	746.00
Coarse aggregate (20mm)	534.30
Coarse aggregate (12.5mm)	525.92
Total coarse aggregate	1060.22
Water	211.37

Cement: FA: CA = 1:1.71:2.44

6.RESULTS

6.1 Carbon Dioxide Absorption Test Results

Table 6.1: Carbon Dioxide Absorption Test Results

zeolite %	Silica fume %	Initial weight in grams (A)	Final weight in grams (B)	Carbon dioxide absorption in mole (B-A)/44	Average Carbon dioxide absorption in mole
0	0	i) 8067 ii) 8086 iii) 8094	i) 8047 ii) 8068 iii) 8072	i) -0.45 ii) -0.41 iii) -0.41	-0.42
5	0	i) 8029 ii) 8037 iii) 8116	i) 8053 ii) 8063 iii) 8143	i) 0.55 ii) 0.59 iii) 0.61	0.58
0	5	i) 8113 ii) 8087 iii) 8079	i) 8120 ii) 8091 iii) 8085	i) 0.16 ii) 0.09 iii) 0.14	0.13
2.5	2.5	i) 8056 ii) 8047 iii) 8041	i) 8071 ii) 8063 iii) 8059	i) 0.34 ii) 0.36 iii) 0.41	0.37
10	0	i) 8080 ii) 8076 iii) 8063	i) 8107 ii) 8102 iii) 8093	i) 0.61 ii) 0.59 iii) 0.68	0.63
0	10	i) 8049 ii) 8100 iii) 8074	i) 8057 ii) 8107 iii) 8079	i) 0.18 ii) 0.16 iii) 0.11	0.15
5	5	i) 8048 ii) 8079 iii) 8084	i) 8067 ii) 8099 iii) 8102	i) 0.43 ii) 0.45 iii) 0.41	0.43

zeolite %	Silica fume %	Initial weight in grams (A)	Final weight in grams (B)	Carbon dioxide absorption in mole (B-A)/44	Average Carbon dioxide absorption in mole
15	0	i) 8101 ii) 8090 iii) 8072	i) 8133 ii) 8120 iii) 8108	i) 0.73 ii) 0.68 iii) 0.82	0.74
0	15	i) 8075 ii) 8075 iii) 8033	i) 8083 ii) 8084 iii) 8042	i) 0.18 ii) 0.20 iii) 0.20	0.19
7.5	7.5	i) 8047 ii) 8098 iii) 8086	i) 8068 ii) 8120 iii) 8106	i) 0.47 ii) 0.50 iii) 0.45	0.47
20	0	i) 8057 ii) 8088 iii) 8063	i) 8084 ii) 8113 iii) 8089	i) 0.61 ii) 0.57 iii) 0.59	0.59
0	20	i) 8096 ii) 8092 iii) 8074	i) 8103 ii) 8100 iii) 8081	i) 0.16 ii) 0.18 iii) 0.16	0.17
10	10	i) 8090 ii) 8072 iii) 8090	i) 8106 ii) 8088 iii) 8107	i) 0.36 ii) 0.36 iii) 0.39	0.37

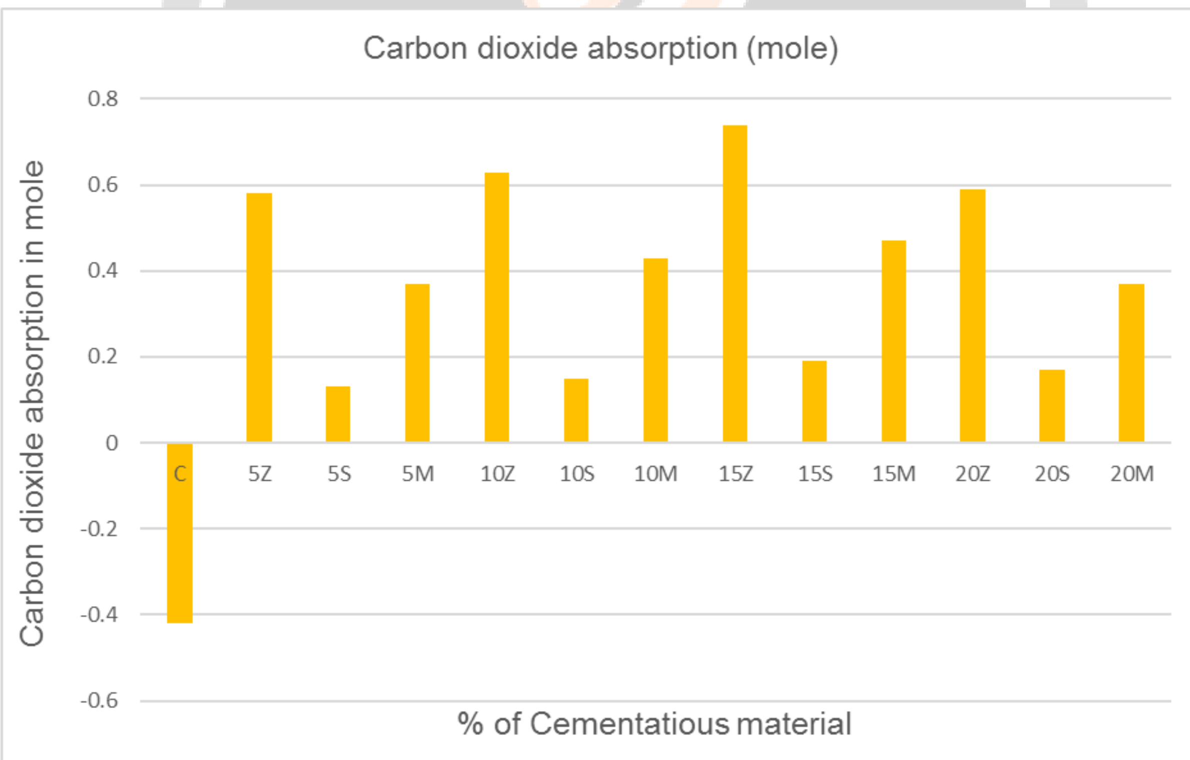

Chart -6.1: Carbon dioxide absorption in mole

6.2 Workability Test Results

Table 6.2: Workability Test Results

Zeolite %	Silica fume %	Slump (mm)
0	0	83
5	0	76
0	5	71
2.5	2.5	73
10	0	73
0	10	69
5	5	70
15	0	71
0	15	65
7.5	7.5	67
20	0	68
0	20	63
10	10	65

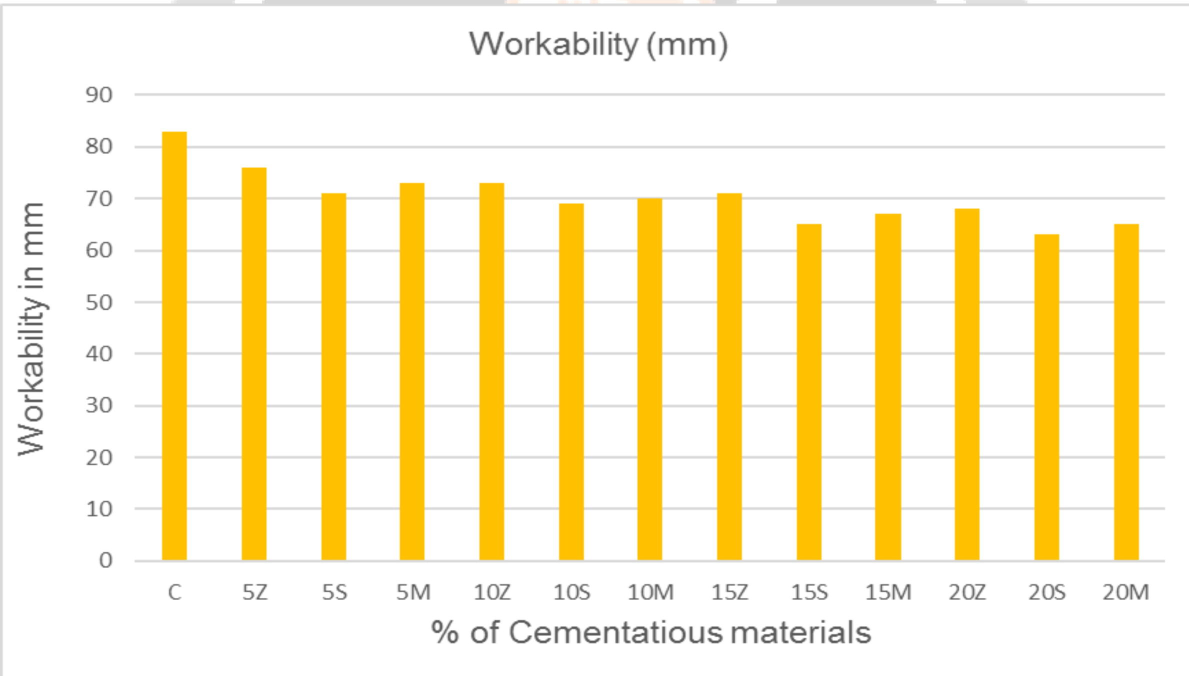

Chart 6. 2: Workability in mm

6.3 Compressive strength test results

Table 6.3: Compressive strength test results

Zeolite %	Silica fume %	Compressive Strength (N/mm^2) (1)	Compressive Strength (N/mm^2) (2)	Compressive Strength (N/mm^2) (3)	Average Compressive Strength (N/mm^2)
0	0	26.22	25.33	26.22	25.92
5	0	27.11	27.11	26.22	26.81
0	5	27.11	27.56	27.56	27.41
2.5	2.5	26.67	27.11	27.11	26.96
10	0	27.56	27.56	28.00	27.71
0	10	28.00	28.44	28.89	28.44
5	5	28.00	27.56	28.00	27.85
15	0	28.89	28.89	29.78	29.19
0	15	29.78	29.78	30.66	30.07
7.5	7.5	29.33	28.89	29.78	29.33
20	0	27.11	26.67	27.11	26.96
0	20	27.56	27.11	28.00	27.56
10	10	27.56	26.67	27.11	27.11

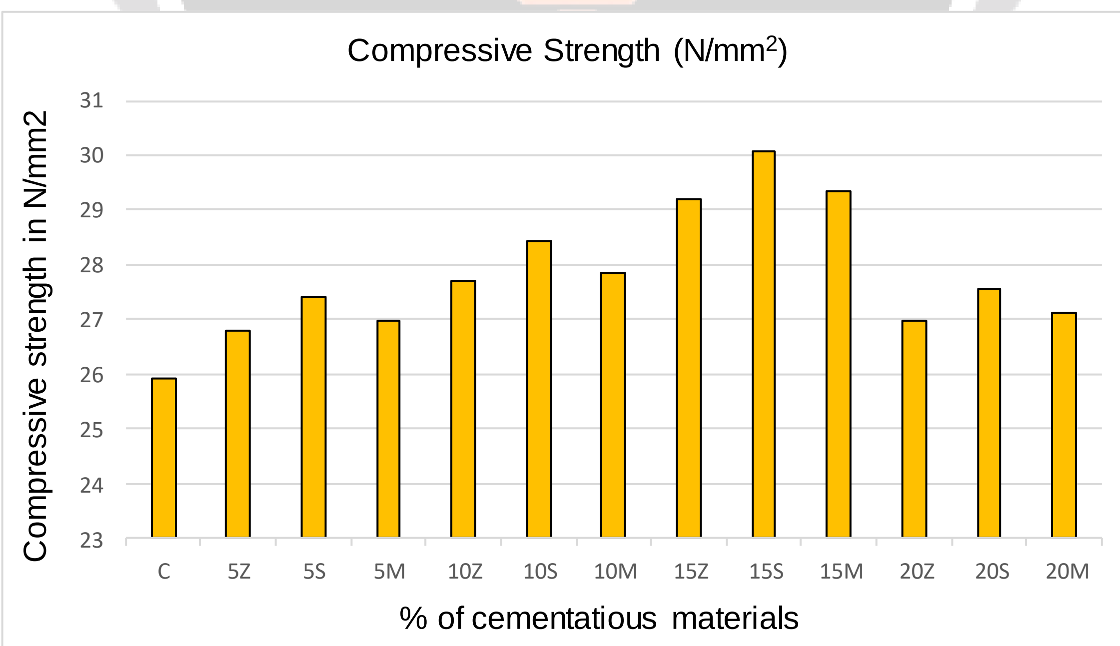

Chart 6. 3: Compressive strength in N/mm^2

6.4 Split Tensile Strength Test Results

Table 6.4: Split Tensile Strength Test Results

Zeolite %	Silica fume %	Average Tensile Strength (N/mm^2)
0	0	2.55
5	0	2.55
0	5	2.69
2.5	2.5	2.62
10	0	2.69
0	10	2.97
5	5	2.76
15	0	2.83
0	15	3.11
7.5	7.5	2.90
20	0	2.55
0	20	2.76
10	10	2.69

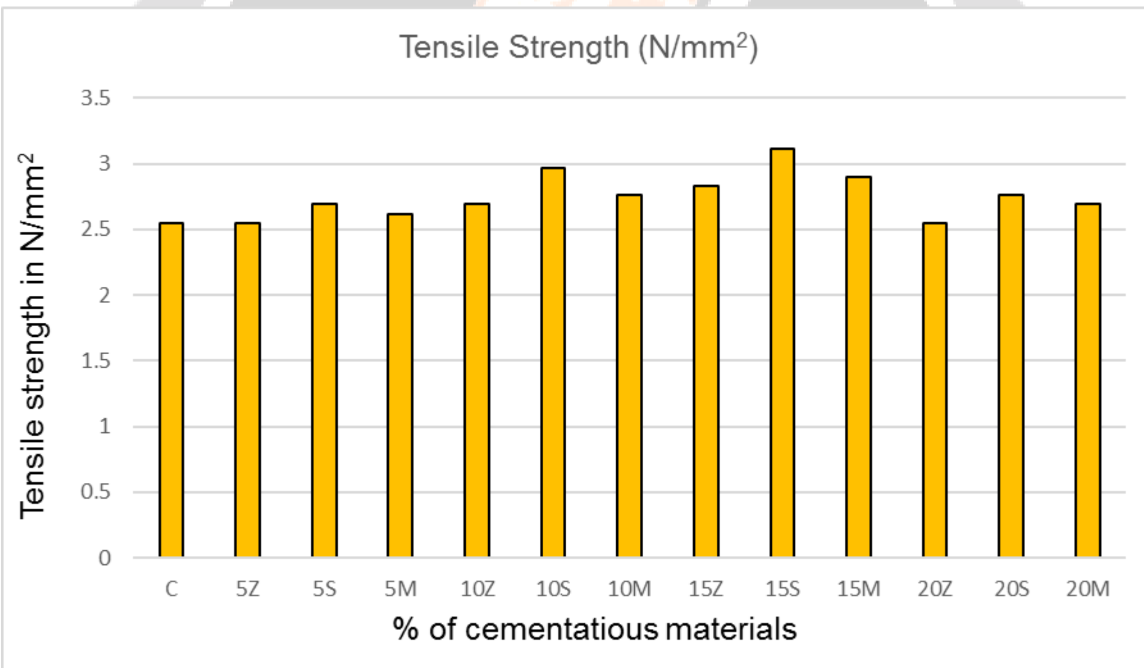

Chart 6.4: Split Tensile strength in N/mm^2

6.5 Flexural Strength Test Results

Table 6.5: Flexural Strength Test Results

Zeolite %	Silica fume %	Average Flexural Strength (N/mm^2)
0	0	3.85
15	0	4.70
0	15	6.55
7.5	7.5	4.90

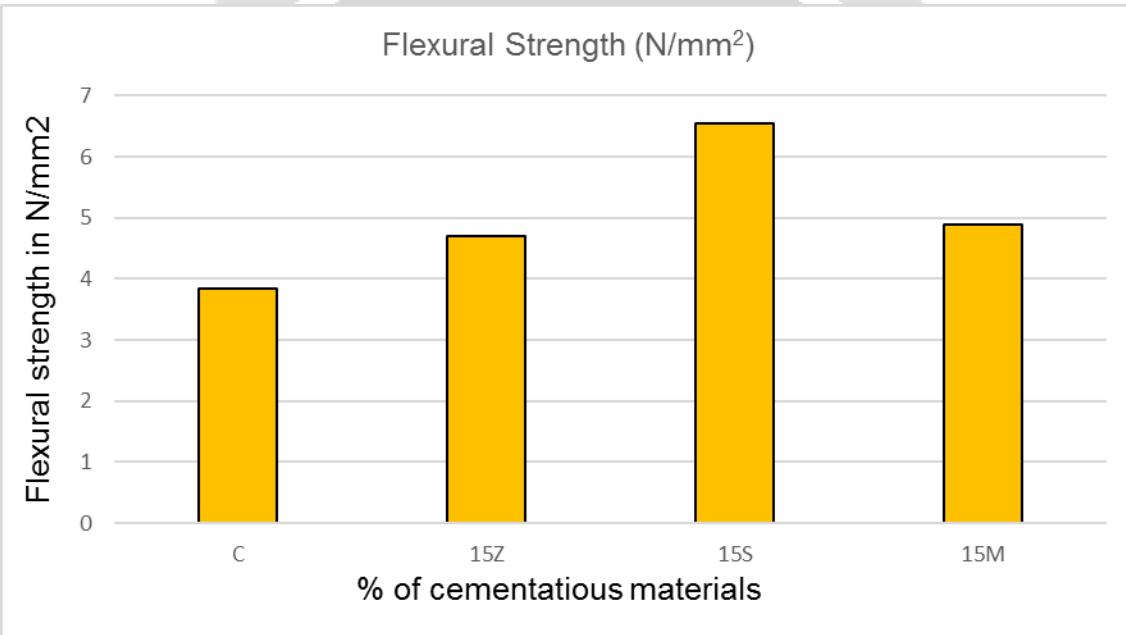

Chart 6.5: Flexural Strength in N/mm^2

7. CONCLUSIONS

- 15% Replacement of zeolite for cement gives the maximum Carbon dioxide absorption value due to its pozzolanic reaction.
- Workability of the concrete decreases with increase in zeolite and silica fume contents due to very small Nano particles which inhibit the flow of concrete.
- 15% Replacement of silica fume for cement gives the maximum compressive strength, Tensile strength and Flexural strength because of the high pozzolanic nature of the silica fume and its void filling ability.
- To achieve both carbon dioxide absorption and strength, we can choose the combination of 7.5% zeolite and 7.5% silica fume blended concrete mix.

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