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Experimental Investigation on Mix Proportion Design for Foam Concrete

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Abstract--- *An experimental investigation is done on finding the design mix proportion for foam concrete. Foam concrete is light weight concrete made with cement, fine aggregates and foam. Coarse aggregates are not used. It has excellent properties like low density, fire resistance. Using foam concrete in constructions, it reduces dead loads on structures and foundations and lowers labor cost during constructions. In foam concrete, the foam is produced from foam generator. The equipment which also helps in foam production is air compressor. In this right amount of foam density can be adjusted. The foam generator hassingle phase motorinside the machine and also it contains aninlet valve, an outlet valve, and pressure valve. The various mix designs are prepared using fine aggregate, cement and different percentages of foam. The foam is prepared using protein-based foaming agent. These foaming agents create air bubbles. These air bubbles reduce the surface tension. Various trial mixes are prepared and the compressive strengths are calculated. The right trial mix with more compressive strength is selected.*

Keywords--- *Foam Concrete, Light Weight Concrete, Protein-based Foam, Mix Design, Compressive Strength, Foam Generator, Air Compressor, Less Density.*

I. INTRODUCTION

Foam concrete is defined as cement slurry that is a mix of cement, water, sand and foams. It is lighter than normal concrete. Therefore, it can also be termed as light weight concrete and also aerated autoclave concrete. Foam is basically generated by using foaming agent, water and foam generator with air compressor. Air bubbles can be easily produced by using foaming agent which gives stability and also it protects the mixture from hardening physical and chemical properties.

Moulds will be filled with foam concrete to get the structure element. The nature of the foam allows the slurry to easily flow inti the moulds and this is because of thixotropic nature of the bubbles present in foam. Solidification takes 24 hours for the viscous materials. Bit if it is cured using steam in 70 C, it will take only 2 hours as it is the accelerated process. Once solidification is done, it is removed from the mould.

Foam concrete can be produced easily in a cost-efficient way and the product becomes inexpensive too. Because of this, it is named as the versatile material which can be used in all places. Foam concrete can be obtained in various densities with minimum 400 kg/m to 1500 kg/m based on the use. At present, no proper mix design for foam concrete has been found out in India. There also many defects in mix proportions which may affect the quality of foam concrete. Hence, a proper mix proportion has to be found out.

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The foam concrete also has environmental benefits. Foam concrete has best insulation properties.Which will reduce the heating costs in buildings, with consequent fuel savings of the building. Carbonation isless, the bubble structure of foam concrete gives it huge surface area. Buildings which are built with ordinary concrete over time, carbonation of materials is more.Foam concrete will reduce the emission of carbon dioxide.The main advantages of using foam concrete are: a)high thermal insulation than normal concrete b)compressive strength is lowc)higher drying shrinkage and higher creep d)Its modulus of elasticity is lower. e)higher absorption.

The elimination of coarse aggregate is done in order to decrease the density of concrete. Curing is also very important because it helps in gaining strength.

1. Materials Used

1.1 Cement

The cement used is Ordinary Portland Cement and its grade is Grade 53. It has 3 to 4% of gypsum. Both the properties like physical and chemical are in confirmation with IS 12269-2009. Various properties are tested and the results are, the specific gravity is 3.15. The normal consistency is 35%. The fineness of cement is 7%. The initial setting time is 50 minutes and final setting time is 600 minutes.

1.2 Fine Aggregate

The fine aggregate used in this project is M Sand. M sand is a replacement for river sand. Since M sand is obtained from crushed from granite rocks. The main advantage is, it is readily available. Hence, reducing the cost of transportation. It has fineness modulus 2.9 kg/m, specific gravity 2.25 and bulk density 1620 kg/m.

1.3 Water

Water is an integral part of the construction. By maintaining proper water cement ratio hydration of cement will be done properly. More amount of water will result in segregation.

1.4 Foaming Agent

A foaming agent helps in the production of foam. Under the specific conditions, the foaming agent can deliver foam in cement through compound and physical changes to shape shut or associated opening structures. It cannot just spare bond, decrease the density of concrete, consume less energy, yet in addition improve the working execution and cement's durability. There are different types of foaming agents like protein foaming agent, synthetic foaming agent, organic foaming agent.

Figure 1: Foaming Agent

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1.5 Foam Generator

The foam generator is a very integral machine which is used in the production of foam. This acts as medium which converts liquid chemical to stable form. It comes in different sizes. The size is chosen based on capability to hold liiquid. The features of foam generator is, it is adjustable. Automatic time setting to off the generator. It is easy to operate and easy to maintain.

Figure 2: Foam Generator

1.6 Air Compressor

An air compressor is a device which is used for conversion ofpotential energy. In the foam concrete mixtures manufacturing, compressed air is required to supply the mixture from the foam concrete machine. For this, an air compressor is usually used. Air compressors vary in performance, pressure, stability of operation in different environmental conditions, and in the type of design.Air compressors can be classified as stationary, operating in stationary work conditions and mobile - the most popular with consumers.

Figure 3: Air Compressor

II. METHODOLOGY

18 moulds of cubes for each trial mix design were prepared using M40 mix. The size of cube was 100 x 100 x 100mm. The water cement ratio adopted is 0.40 which gives satisfactory workability for the concrete. Foam is generated using protein based foaming agent. Foam is obtained by giving air pressure and adding foaming agent to

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the foam generating machine. Now 2 seconds of foam is taken and added to foam concrete mix. Vertical Pan mixer is used for the mixing purpose. De-moulding is done after 24 hours and undergoes water curing for 28 days.

Three trial mixes are taken. Compressive strength tests are done. Based on more compressive strength, the trial mix is selected.

Figure 4: Test Specimens

2. Mix Proportion

2.1 Trial Mix Proportion I

The trial mix proportion I is taken as following.

Table 1: Trial Mix I

Cement (kg/m³)	Fine Aggregate (kg/m³)	Water Cement ratio	Foaming Agent	Water in Foaming Agent
437.7	772.57	0.45	2% of total volume	12 litres in 1 litre of foam

2.2 Trial Mix Proportion II

The trial mix proportion II is taken as following,

Table 2: Trial Mix 2

Cement (kg/m³)	Fine Aggregate(kg/m³)	Water Cement ratio	Foaming Agent	Water in Foaming Agent
437.7	772.57	0.45	2% of total volume	10 litres in 1 litre of foam

2.3 Trial Mix Proportion III

The trial mix proportion III is taken as following.

Table 3: Trial Mix 3

Cement (kg/m³)	Fine Aggregate (kg/m³)	Water Cement ratio	Foaming Agent	Water in Foaming Agent
437.7	772.57	0.45	2% of total volume	8 litres in 1 litre of foam

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III. TESTING OF SPECIMEN

The compressive strength of foam concrete with different trial mixes is done is tested using compressive strength test.

Compression Strength Test

A compressive test was done for 140 specimens of 100 mm cubes. It is done on compression testing machine (CTM) of load capacity of 1000 KN.Gradual load is applied. The maximum load is the compressive stress. Compressive strength was examined as shown below shows the Air bubbles inside the failed specimen.

Figure 5: Testing of Specimen

IV. RESULTS AND DISCUSSION

The compressive strength test results are done for three different trial mixes. The test results for Trial mix I are as follows.

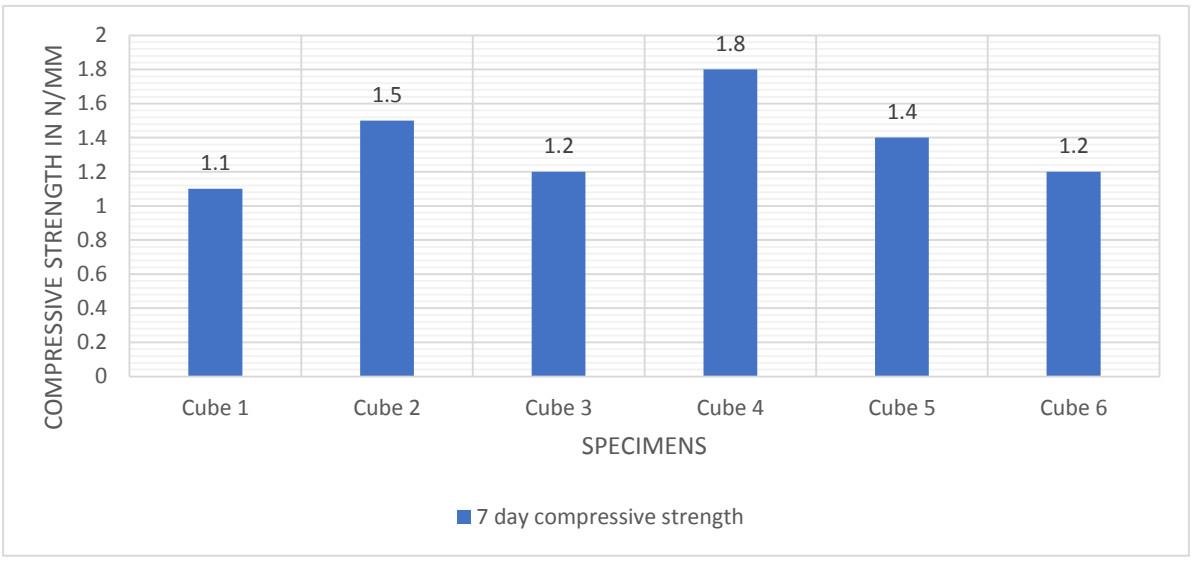

Chart 1: 7 days Compressive Strength for Trial I

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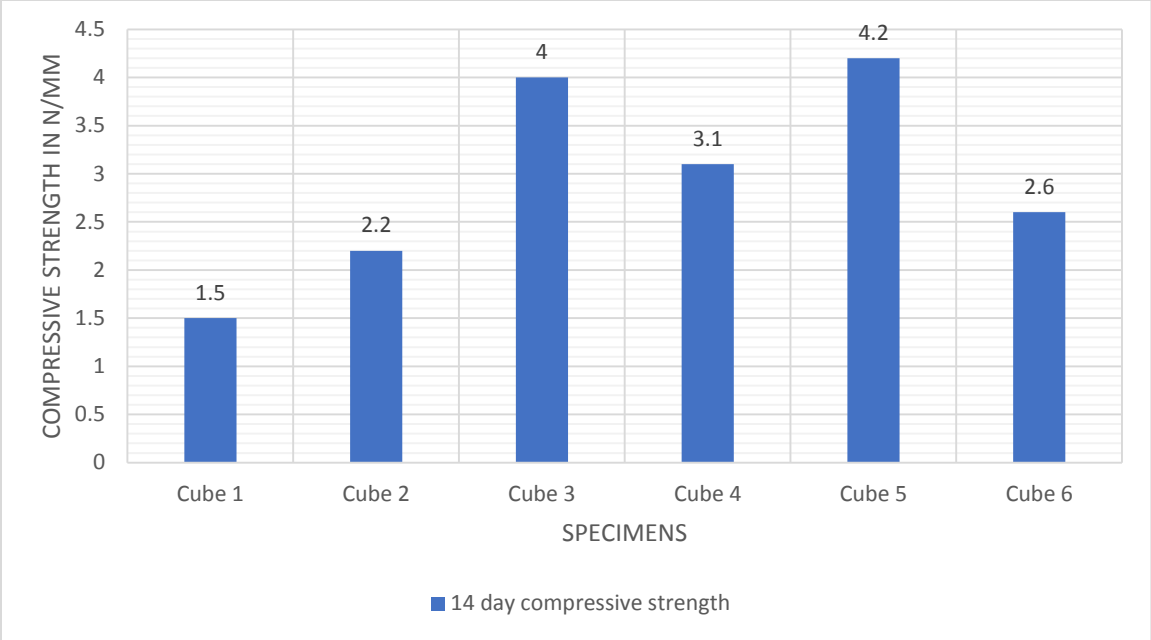

Chart 2: 14 days Compressive Strength for Trial I

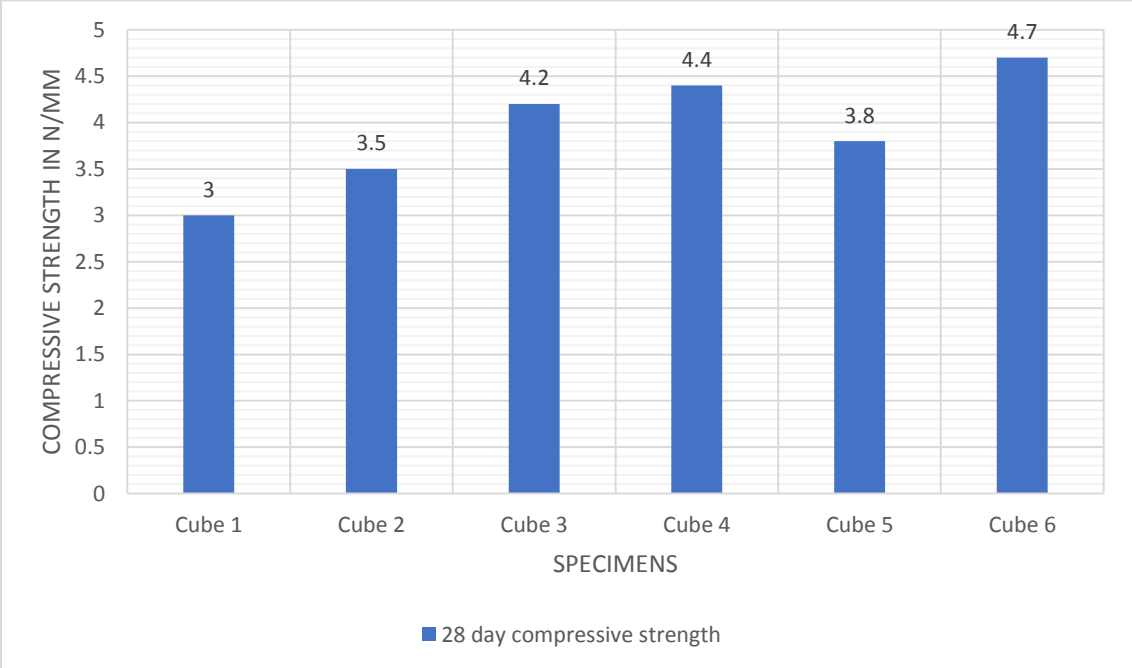

Chart 3: 28 days Compressive Strength for Trial I

Cube 5 has achieved maximum compressive strength result for 28 days. The cube 5 has 36 % more compressive strength than the Cube 1. Cube 1 has less compressive strength than the other cubes for 7 day, 14 day and 28 day. Cube 5 shows maximum compressive strength for 14 days. Cube 4 shows maximum compressive strength for 7 days than the other cubes. Therefore, the maximum compressive strength achieved for trial mix 1 is 4.7 N/mm².

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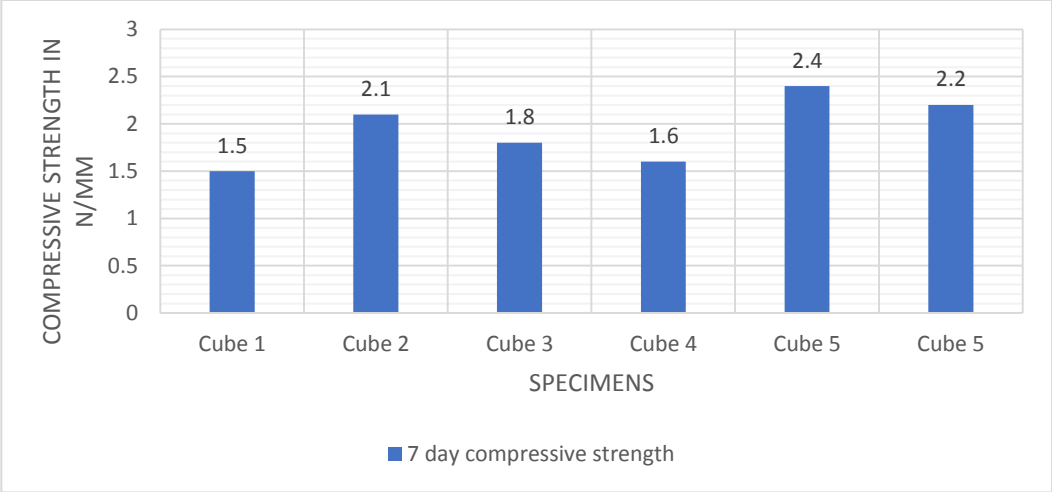

Chart 4: 7 days Compressive Strength For Trial II

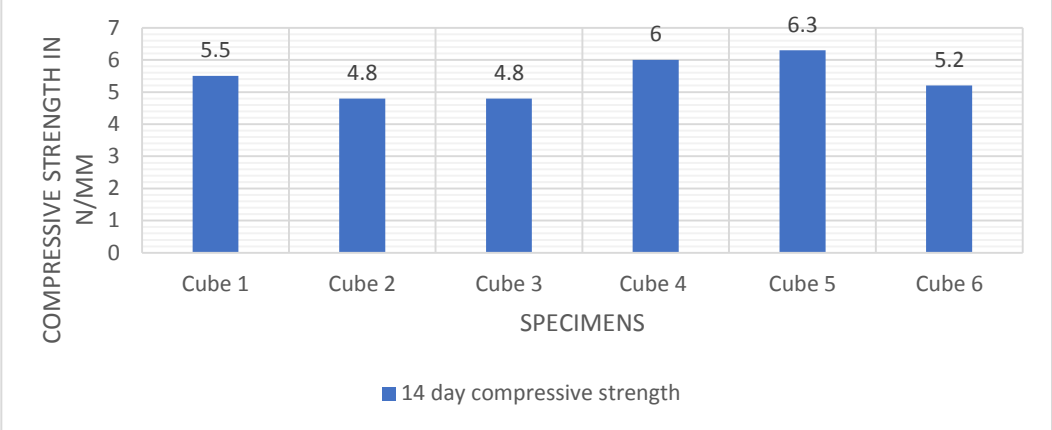

Chart 5: 14 days Compressive Strength for Trial II

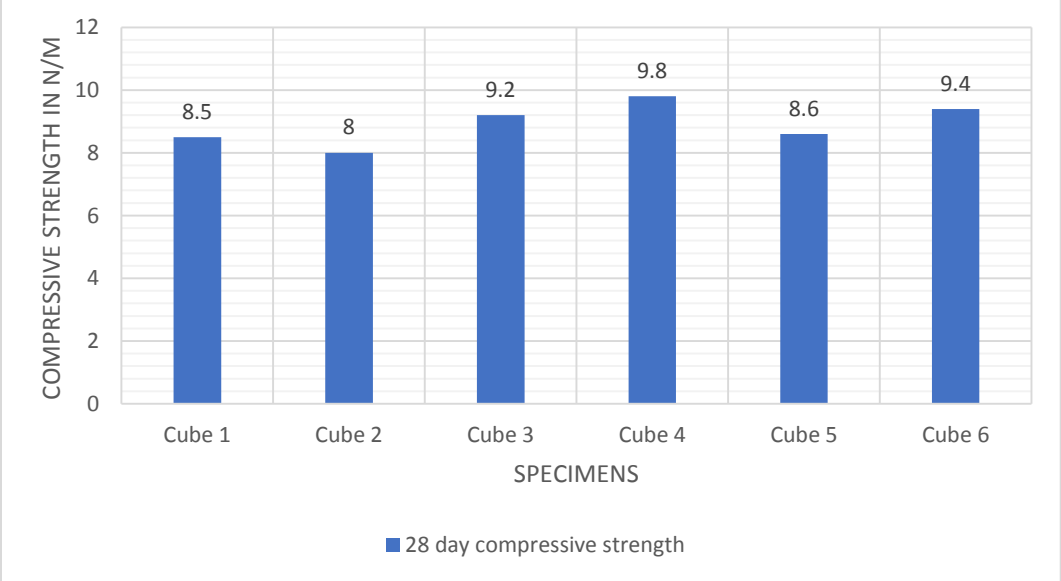

Chart 6: 28 days Compressive Strength for Trial II

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Cube 4 has achieved more compressive strength for 28 days than the other cubes. It has a difference of increase in 22 % from the lowest 28 day compressive strength result. Cube 5 also has more 7 day and 14 day compressive strength than the other cubes. Cube 1 has shown less compressive strength for 7 days than the other cubes. Similarly, Cube 2 and Cube 3 have shown less 7 day compressive strength results than the other cubes.

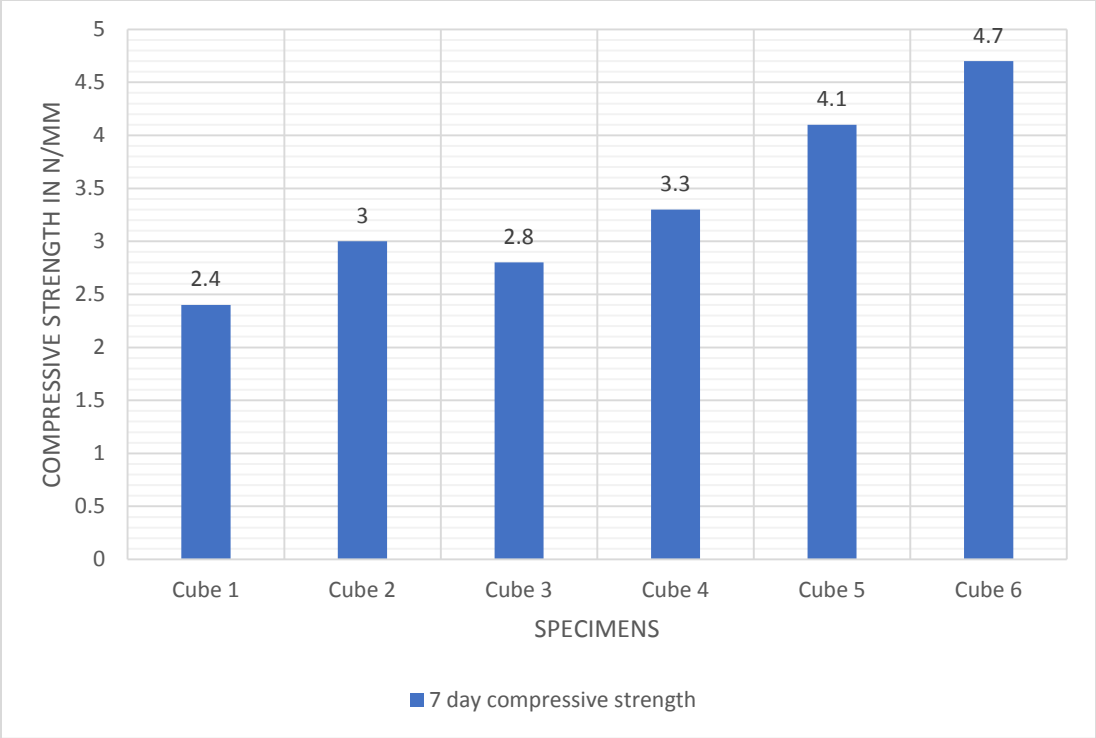

Chart 7: 7 days Compressive Strength for Trial III

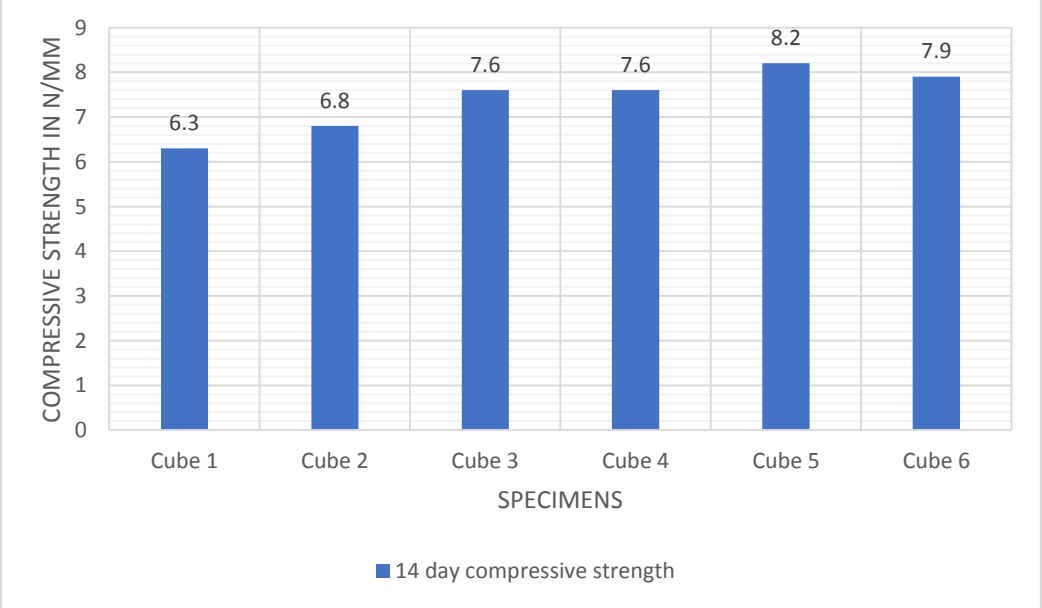

Chart 8: 14 days Compressive Strength for Trial III

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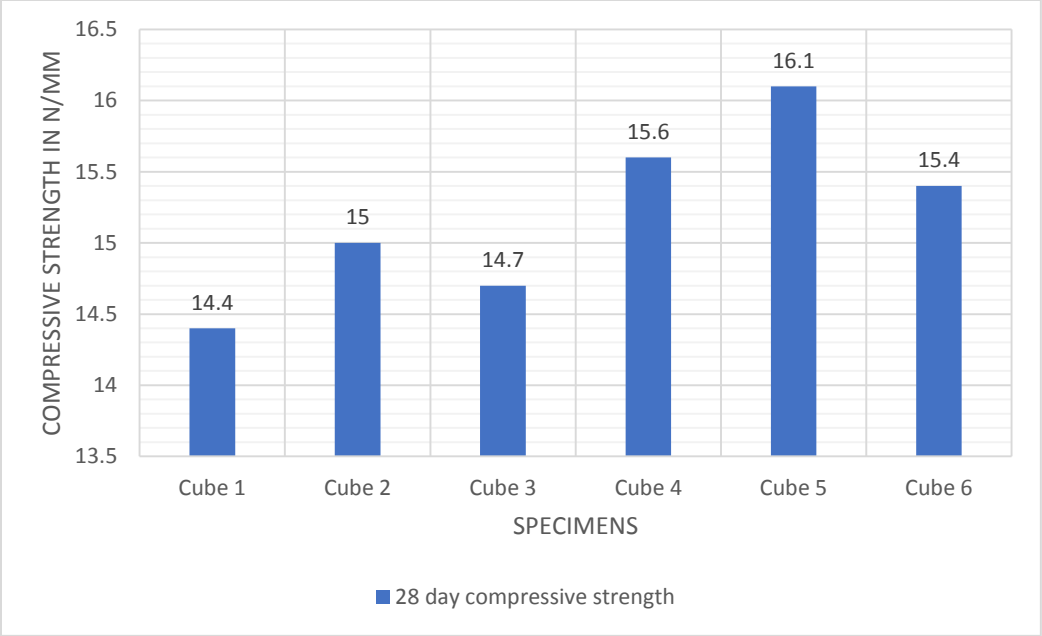

Chart 9: 28 days Compressive Strength for Trial III

Cube 5 has achieved more compressive strength than the other cubes for 28 days. It has shown an increase of 11% than the low compressive strength cube. Cube 5 has more compressive strength for 14 days than the other cubes. Cube 6 has shown more compressive strength for 7 days than the other cubes. Cube 1 has least compressive strength.

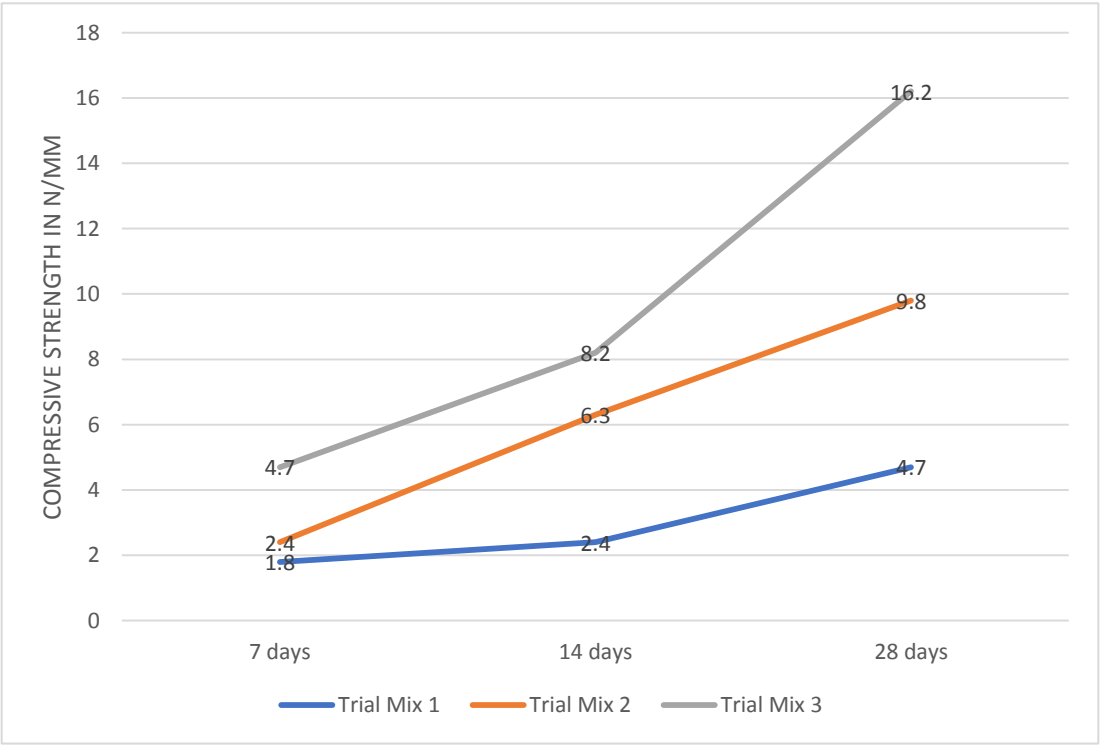

Chart 10: Comparison of Results

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For 28 days, the trial mix III have shown more compressive strength than the other two trial mixes. The trial mix III has shown an increase of 39% than the trial mix II. Similarly, it has shown an increase of 70% than the trial mix I. For 14 days, the trial mix III has shown more compressive strength than trial mix I and trial mix II. There was an increase of 40% and 70% than the trial mix II and trial mix I respectively. And for 7 days, the trial mix III has shown more compressive strength. It has an increase of 48% and 61% than trial mix II and trial mix I respectively.

Figure 6: Specimen after Load Failure

Figure 7: Air Bubbles Inside the Failed Specimen

V. CONCLUSIONS

- In this experimental study, trials are done for different mix proportions.
- Coarse aggregate is not used, and density of foam concrete is reduced compared to the conventional concrete.

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- The trial mix III shown more compressive strength i.e., 16.1 N/mm².
- The strength is less than 17 Mpa it cannot be used in structural elements.

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