

Experimental Investigation on Strength Properties of Foam Concrete

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ABSTRACT

Today, energy is at the forefront of issues that are critical to all governments. The ever increasing global population, along with expanding industry, has resulted in an inevitable increase in energy demand. Nowadays, in order to get desired benefits while using less energy, the issue of insulation has arisen, and thus the necessity of insulation has increased. Foamed concrete has properties such as a high strength-to-weight ratio and a low density. The use of foamed concrete minimizes dead loads on the structure and foundation, aids to energy saving, and saves construction labour costs. In this study the mechanical properties of foamed concrete was analyzed and the strength prediction of compressive was determined with the help of MATLAB. Interaction terms such as cement, flyash, marble sludge powder, water and foaming agent within a volume were inferred as a input and compressive strength is the output with training of 3 hidden layers were used to improve the efficacy of the predictive modeling of the foam concrete.

INTRODUCTION

A precise mixing foam concrete mixer is used to precisely mix cement, fly ash, or sand, water, and other additives into a slurry to create foam concrete without altering the material's original chemical or physical qualities. Concrete will provide structural materials with cellular densities of 300 kg/m³ to 1800 kg/m³ and compressive strengths of 1 MPa to 17 MPa. Controlled densities and strength of foam concrete are produced by the volume of air cells in the material. For casting blocks, panels, precast items, prefabricated homes, void fillers, roof insulations, floor screeds, and many more applications without any vibration or compaction, the finished mixture is either pumped or transferred manually.

Aerated light weight concrete includes foam concrete. It is seen as being comparatively homogeneous. The three methods of immersion in water, water spraying, and dry air curing have all been used to study the effects of curing foam concrete with saturated H₂SO₄ water solution. The compressive strength of low density concrete was shown to be highly affected and increased by relative humidity in the study that examined the impacts of various curing settings. In a different investigation, the samples that were treated with humidity had the maximum compressive strength after 28 days of being exposed to water, air, and humidity. The aim of this study is to establish patterns of influence of hardening accelerators on the mechanical properties of foam concrete mix and foam concrete.

LITERATURE REVIEW

E. Muthu Kumar., et.al. Investigated the Influence of Production on The Strength, Density and Water Absorption of Aerated Geopolymer Paste and Mortar Using Class F Fly Ash This research discusses the parameters that affect the qualities of aerated geopolymer concrete made with low calcium fly ash and activated with sodium-based alkalis at various curing temperatures. Utilising design of experiments, the parameters and their influence are statistically examined. By employing the alkaline solution, which is cooled to a lower temperature and contains sodium hydroxide (NaOH) and sodium silicate (Na-Si), the initial pace of reaction in the aeration process can be adjusted. The solution's conditioning at a lower temperature enabled more thorough mixing and longer placement times without impairing aeration. We looked examined the variables that affected fresh density, dry density, compressive strength, and water absorption, as well as how they interacted with one another. Compressive strength of aerated geopolymer paste is 55% higher than mortar for the given range of parameters. Addition of alkaline solution at 15°C prevented rapid aeration, which is essential for providing adequate mixing and casting time.

Bhagyashree Raj., et al, investigated the Mechanical and Durability Properties of Hybrid Fiber Reinforced Foam Concrete. This study examined the mechanical, functional, and long-term properties of hybrid reinforced foam concrete. Bottom ash is used in place of sand, and sample are designed to contain 1600 kg/m³. 0.3, 0.4, and 0.5 volume fractions of poly vinyl alcohol were added. RH foaming agent is the commonly used foaming agent. Foaming

agent/water concentration is 1:30. A study on shrinkage was conducted 3, 7, 14, 28, and 56 days following casting. A 76% increase in compressive strength is achieved. Concrete now has a 27% improvement in tensile strength. According to this investigation, Coir fibre mixtures had lower drying shrinkage and heat conductivity than PVA mixes.

Marcin Kozłowski and Marta Kadela et al, investigated the Mechanical Characterization of Lightweight Foamed Concrete. The purpose of the test was to evaluate the foamed concrete mix's mechanical characteristics. The indicated goal density is 400–1400 kg/m³. One uses fly ash. It uses a commercial foaming agent. The preparation process for specimens and the testing techniques utilised for regular concrete are covered in this study. Compressive strength, flexural strength, and modulus of elasticity tests are performed. Foam concrete has a 20% higher density than FCA. The specimen's resistance to freeze-thaw cycles is 15% weaker than average. When the density of the foamed concrete decreases, the compressive strength, elastic modulus, and flexural strength also drop. The compressive strength, flexural strength, and modulus of elasticity of foamed concrete are all decreased by 5% when fly ash is added.

Eva Namsone., et al, investigated the Durability Properties of High Performance Concrete. From this paper, we learned various information. When fly ash is used in place of sand, the dry density of the mixture decreases from 7% to 20% due to the addition of foam. Additionally, the compressive strength of 28 days increased from 10.7-1.23 MPa to 17.8-1.96 MPa for the percentages of 20% to 50%. Artificial foaming agent, 0.35 to 0.6% of cement weight. The production of more water-resistant and long-lasting foam concrete is made possible by the use of pozzolanic admixtures and turbulent mixing technologies.

SUMMARY OF LITERATURE REVIEW

- From the literature, studied that finding durability properties of foam concrete.
Thus, in our study, we are going to do an experimental investigation of mechanical properties of foam concrete.
- Although there are no standard methods for proportioning foam concrete, the general rules regarding w/c ratio, free water content and maintaining unit volume apply, but it is a specified plastic intensity that becomes a prime design criterion.
- The foam concentration of 1:20 is good for getting structural grade concrete foam concrete will produced in the laboratory using a standard inclined rotating drum mixer by the addition of performed foam to a mortar or paste.

Application of Foam Concrete

- Production of decoration application and partitioning walls, substitutions of current soil, raft foundation, soil steadiness.
- Rehabilitation of geotechnical application including road construction and soil settlement.

- Void filling, including old sewerage pipes, bore holes, basement and tunnels.
- Fabrication of masonry blocks, bricks for non- load bearing walls in building construction.
- Fabrication of load bearing application including floor screeds.
- Housing construction applications.
- Production of load bearing precast sandwich wall panels.

Materials Used

Cement

Various building materials can be joined together using cement as a binding agent. Portland cement and asphalt cement are the two varieties that are most frequently considered in the construction business. One of the most crucial components of concrete is Portland cement. Before water is added, it may be in a dry powdery state, or it may be in a paste that hardens and adheres to whatever it touches. In this work OPC grade of 53 was used.

Fly Ash

One of the naturally occurring byproducts of the burning of coal is fly ash. Combustion temperatures for coal in today's modern power producing plants are around 2800oF. Bottom ash and fly ash are produced naturally when coal is burned and consist of non-combustible materials. Bottom ash is a thin aggregate material that collects at the bottom of the boiler. The materials that are transported off by flue gases are called fly ash, and they can be collected and kept in silos for testing and beneficial use classification. In this work locally available flyash which is collected from thermal power plant, Tuticorin was used.

Marble Sludge Powder

One of the waste products of the marble industry is marble powder. It is obtained through the preserving and shaping operations. It is gathered as slurry not far from the industrial waste. It combines with the water and renders it unusable. Waste marble powder is a filler that can be used in concrete to lower the overall void content. Concrete's strength can be changed by adding waste marble powder as an additive. In this work locally available MSP which is collected from Pandiyan Granites, Sivakasi were utilized.

Foaming Agent

Foaming agents is also defined as air entraining agent. Air entraining agents are organic materials. When foaming agents added into the mix water it will produce discrete bubbles cavities which become incorporated in the cement paste. There are two types of foaming agent i.e., Synthetic-suitable for densities of 1000kg/m³ and above, Protein-suitable for densities from 400kg/m³ to 1600kg/m³. In this work synthetic based foaming agent were used. In this work synthetic based foaming agent of Sodium lauryl sulphate was utilized.

EXPERIMENTAL INVESTIGATION

Mix Proportion

The mix proportion of foam concrete as shown as below in Table 1.

S.No	Mix ID	Cement	Flyash	Marble Sludge Powder	Foaming Agent	Water
1.	FRC	3.24	3.24	-	0.23	4.6
2.	FRC1	3.24	3.078	0.162	0.23	4.6
3.	FRC2	3.24	2.916	0.324	0.23	4.6
4.	FRC3	3.24	2.754	0.486	0.23	4.6
5.	FRC4	3.24	2.592	0.648	0.23	4.6
6.	FRC5	3.24	2.43	0.81	0.23	4.6
7.	FRC6	3.24	2.268	0.972	0.23	4.6
8.	FRC7	3.24	2.106	1.134	0.23	4.6
9.	FRC8	3.24	1.944	1.296	0.23	4.6
10.	FRC9	3.24	1.782	1.458	0.23	4.6
11.	FRC10	3.24	1.62	1.62	0.23	4.6

Table 1: Mix Proportion for Cube Specimen

Preparation of Cube Specimen

The concrete cubes of size 150 x150 x150mm, are placed in water for curing for 7 day, and 28 days for conventional concrete. Measure the dry proportion of ingredients (cement, fly ash and marble sludge powder, water & foaming agent) as per the design requirements. The ingredients should be sufficient enough to cast test cubes. Thoroughly mix the dry ingredients to obtain uniform mixture. Add design quantity of water to the dry proportion and mix well to obtain uniform texture. Finish the top of the concrete by trowel & trapped well till the cement slurry comes to the top of the cubes.

Compression Strength Test

The compression test is used to determine the hardness of cubical specimens of concrete. Cube of size 150 x 150 x 150mm as per IS Code. The specimen should be given sufficient time for hardening of 25 hrs under water curing and then it should be cured for adequate time based on the type of concrete. After curing, it should be loaded in the compression testing machine and tested for maximum load. Compressive strength should be calculated by dividing maximum load by the cross sectional area. The load applied to opposite side of the cubes as cast. The maximum load was applied to the specimen until the failure recorded.

$$\text{Compressive strength} = P/A$$

Where

P = ultimate load

A = area of cube in mm²



Figure 1. Compressive Strength Test on Cube Specimen

RESULT AND DISCUSSION

The testing results on Compressive strength of foam concrete as shown in table 2.

S.No	Mix ID	Compressive Strength (MPa)
1.	FRC	5.21
2.	FRC1	5.62
3.	FRC2	5.96
4.	FRC3	6.83
5.	FRC4	7.25
6.	FRC5	8.15
7.	FRC6	8.68
8.	FRC7	7.92
9.	FRC8	7.66
10.	FRC9	6.83
11.	FRC10	5.57

Table 2. Test Results on Compressive Strength

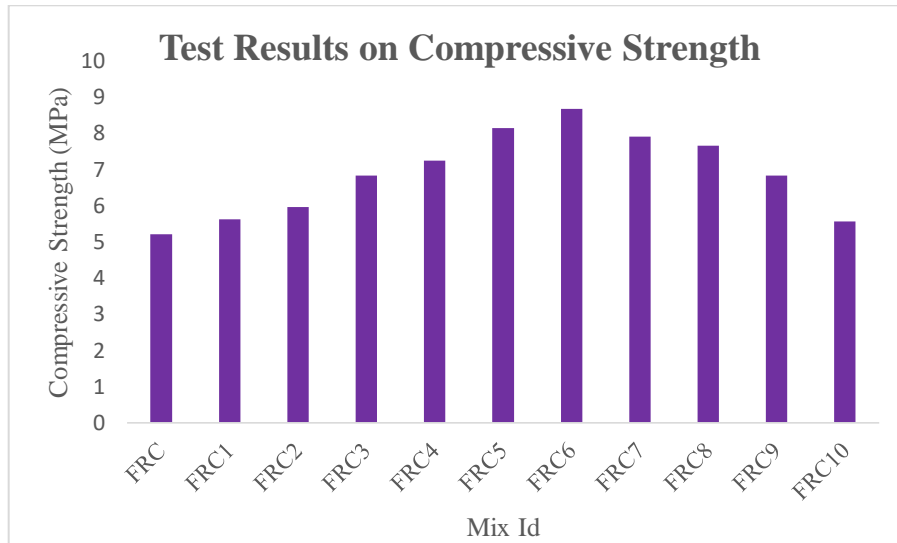


Figure 2. Test Results on Compressive Strength

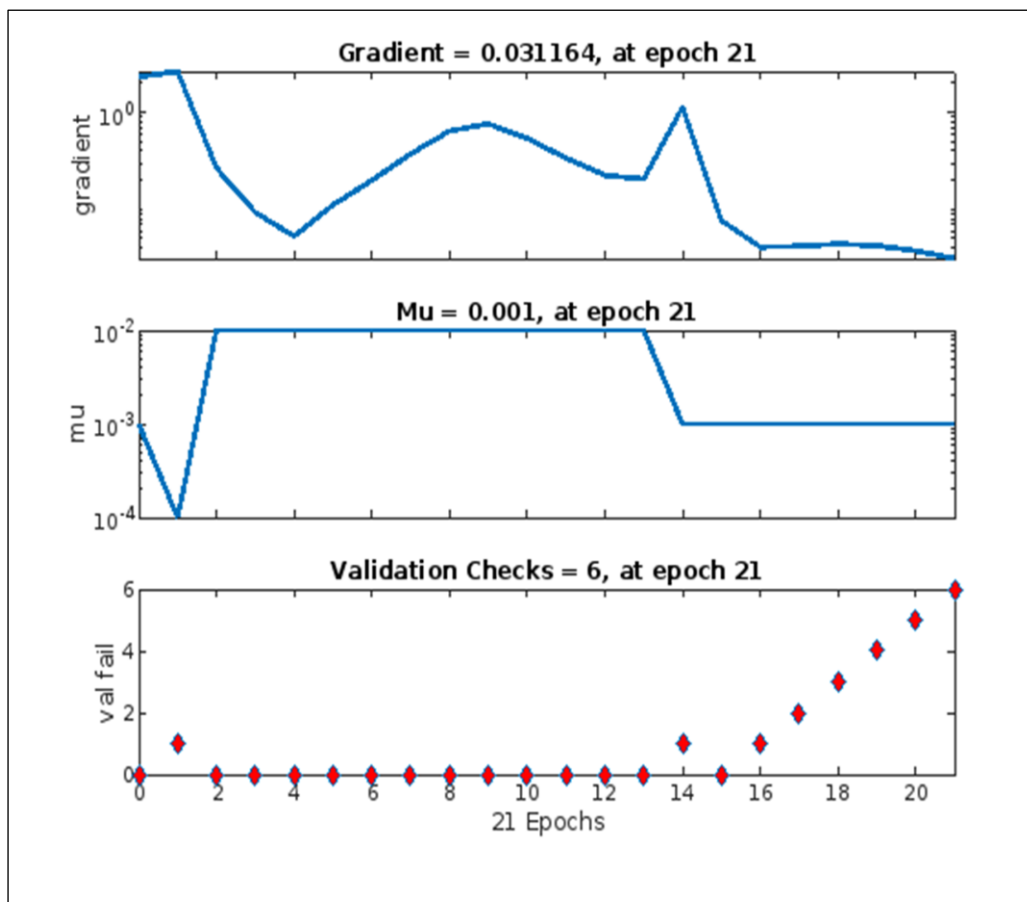


Figure 3. Performance state of Foam concrete

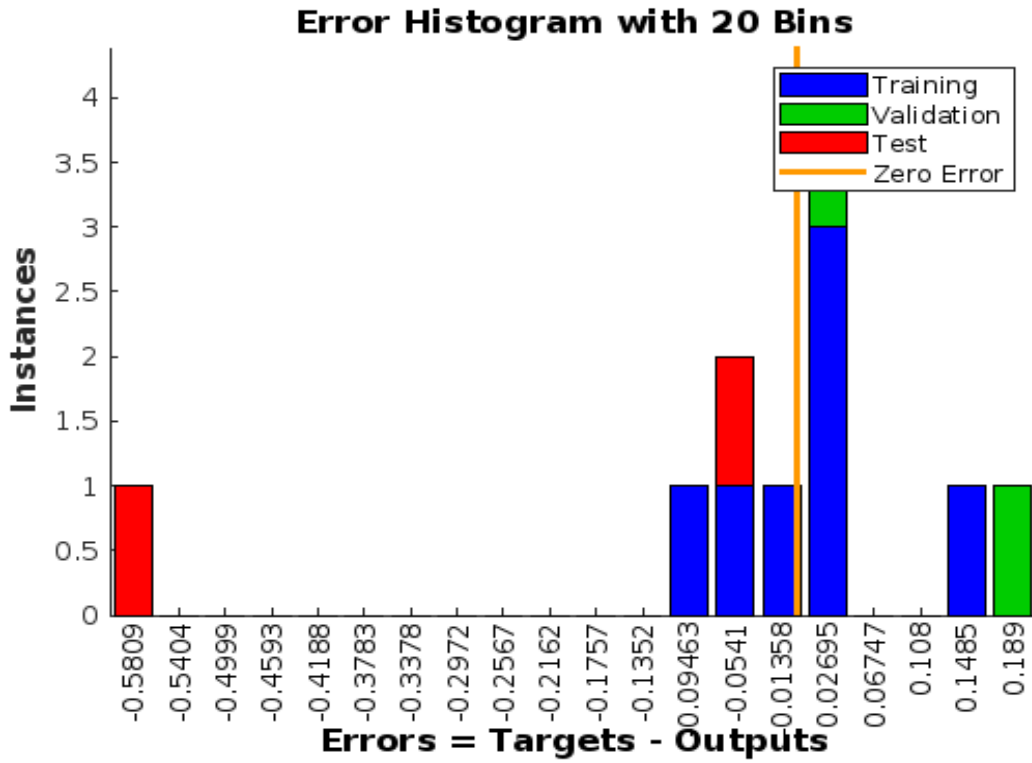


Figure 4. Histogram relation of Foam concrete

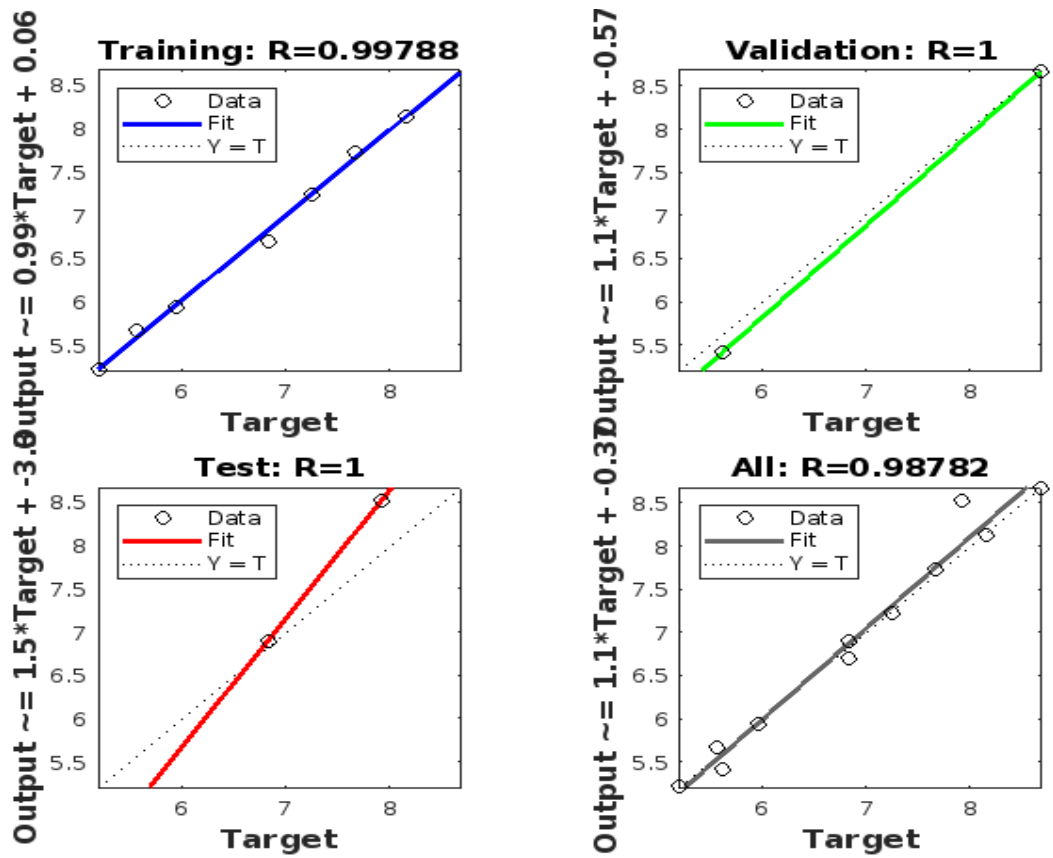


Figure 5. Model for compressive strength of FRC

Concrete strength using Regression Model

The design mix for foam Concrete is chosen mostly based on the trial mixes. To aid the mix design of FRC, this study attempts to provide predictive models using machine learning techniques such as non-linear regression on a database of experimental values are taken as samples, were taken. From the figure 5, shows that the 80% of the randomly chosen samples are used for training the model and the remaining 20% are used to test it. The Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), the statistical significance of the model coefficients, and the coefficient of determination are adopted as criteria to check the performance of the model on both the training and test data.

CONCLUSION

The following conclusions could be drawn from the present investigation, According to material study, all the ingredients are within the permissible limits. The concrete mixture generates the very slow heat of hydration which prevents thermal cracking in the foam concrete. The 28 days of compressive strength shows will achieved in FRC6 mix is high. FRC 6 Contains 65% of flyash and 25% of Marble sludge powder in the foam concrete. Strength and density is smaller compared to the conventional concrete. The regression model of compressive strength prediction gives the best value for the proper training set. The Therefore, the foamed concrete mixed proportion can be used for making partitions walls in buildings.

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