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Experimental Study of Foam Concrete by Using Different Mixes

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Abstract: Foamed concrete can also be termed as lightweight or cellular concrete. It consist of is a cementitious paste, fines, water and has coarse aggregate without voids. Voids are created by using foam. It creates more strength than plain foam concrete (PFC) by using admixtures like fly ash, silica and fibers in it . Under this research program, three different mixes were made: plain foamed concrete (PFC), polypropylene fiber reinforced foamed concrete (PPFC) and basalt fiber reinforced foamed concrete (BFC). Specimens were tested for compressive strength, splitting tensile strength, young's modulus and poisson's ratio, flexural strength and RFC (Reinforced foamed concrete) strength. This study showed that the use of optimum foam volume i.e. 20% gives a specific density of foam concrete 70 – 100 PFC and compressive strength of 3000 – 5500 psi. As the study of flexural and compression application eight different steel reinforced sandwich beams, sixteen compression column of witch eight are tested with and without reinforcement separately respectively. These sandwich beams of steel reinforcement were divided in four different sets as two of each, normal concrete - Styrofoam R-13 rating combination, normal concrete - PFC combination, normal concrete - PPFC combination and normal concrete – BFC combination. Likewise, for study of structural behavior of compression column the specimens were divided same as sandwich beams into different groups. The flexural strength of BFC specimen was 10 times more than PFC specimen. Among the RFC beam specimens, BFC has shown maximum load carrying capacity.
Keywords: Foam concrete, light weight concrete, strength, PFC, BFC and PPFC.

I. INTRODUCTION

A. Foam Concrete

Foam concrete is a form of lightweight concrete that is ingredients of cement, Fine aggregate or fly ash, water, coarse aggregate and the foam. Foam concrete is in the form of foaming agent or mix of cement, sand and water (mortar). Foam concrete can be defined as the cementations material that consists of minimum 20 percent of foam that is mechanically entrained into the plastic mortar. The density of foamed concrete may vary from 300 to 1600 kg/m3 in dry condition. The characteristics compressive strength (fck) of foam concrete determined at 28 days, ranges from 0.2 to 10N/mm2 or can gradually increase.

There is distinguished between foam concrete and air entrained concrete in terms of the volume of air that is entrapped. The air entrained concrete takes the air of 3 to 8 percent. It also differs from the retarded mortar and concrete in which air entrapped for the same reason of percentage.

II. OBJECTIVES OF THE RESEARCH

The main objective of this research is to develop structural fiber reinforced foamed concrete. The objectives include the following:

A. To obtain the optimum mix proportion design for the foamed concrete.
B. To optimize the mechanical properties such as compressive strength, modulus of elasticity and poisson's ratio, splitting tensile strength and flexural strength of plain foamed concrete (PFC), polypropylene fiber reinforced foamed concrete (PPFC) and basalt fiber reinforced foamed concrete (BFC).
C. To study the structural behavior of steel reinforced PFC, PPFC and BFC.
D. To assess the steel reinforced PFC, PPFC and BFC sandwich panels in compression and bending

III. MATERIALS FOR FOAM CONCRETE

A. Cement for Foam Concrete

Ordinary Portland cement is commonly used, but rapid hardening cement can also be used if necessary. Foam concrete can incorporate a wide range of cement.

Ordinary Portland Cement (OPC) of 53 grade conforming to IS12269: (1987) is used and its properties

Table 3.1 Properties of Cement

PROPERTY	EXPERIMENTAL RESULTS	LIMITING VALUES AS PER CODE (IS 12269 : 1987)
Fineness (Air permeability)	2465 cm 2 /gm	Not less than 225 m2 /K
Specific gravity	3.15	3.10 – 3.25
Standard Consistency	33%	26 % - 35%
Initial Setting time Minutes	48 minutes	Not less than 30 minute

Table 3.2 Chemical Properties of Cement

INGREDIENT	PERCENTAGE
Lime CaO	62
Silica SiO2	22
Alumina Al2O3	5
Calcium Sulphate CaSO4	4
Iron Oxide Fe2O3	3
Magnesia MgO	2
Sulphur S	1
Alkalies	1

B. Foam and Foaming Agent

The hydrolyzed proteins or the synthetic surfactants are the most common forms based on which foams are made. The synthetic based foam agents are easier to handle and are cheap. They can be stored for a longer period. Lesser energy is required to produce these foams. The protein based foam is costly but have high strength and performance. The foam can be of two types: wet foam and dry foam. Wet foams with densities lesser than 100 kg/m3 are not recommended for the manufacture of foam concrete. They have a very loosely place large bubble structure.

1) *Foaming Agent:* There are various types of foaming agents are available. Protein based standard foaming agents or hydrolyzed protein agents are made by protein hydrolysis from vegetables. This leads not only to unique variations in quality, due to the contradicting raw materials used in various batches. The lifetime of foaming agent under sealed condition is about 1 year. In this investigation we can use Synthetic based foaming agent.

Table 3.2.1 Properties of Foaming Agent

Appearance	Color less to pale yellow
Active matter%	28 min
pH (1% Aqueous solution)	6.5 – 8.5
Sodium Sulphate %	1.0 %
Sodium Chloride %	0.5 %
Un - Sulfated Matter %	1.00%
1 – 4 Dioxane ppm	30 max

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The foaming agent is added to the mixtures machine which produces the air voids in the concrete. The agents we used here is eco-conscious and un-contaminating . The foaming agent we used here is,

a) Polyethylene glycol, #6000
b) Dried N, N- Dimethylformamide
c) Sodium bicarbonate

- *Water:* The water is added to the mixture of cement and fine aggregate to get the homogeneous texture of concrete. The water used for construction should be neither acid nor alkaline (having a pH about 7). The deionised water is preferable while adding the chemical composition or chemical solution. The mineral content in water reacts with the chemical compounds and becomes inactive.
- *PolyethyleneGlycol, #6000:* Polyethylene glycol (PEG), it is generally considered as biologically inert and safe. PEG is also a non-toxic material. It is in irregular shape, in the form of pellets. When it exposed to the atmosphere, it changes its phase from solid to gas.
- *Dried N, N-Dimethyleformamide:* It is a liquid with water-white which is colorless. It is faint fishy in odor. The density of dimethylformamide should be less than water. It react with atmosphere and turns into pale yellow in color. It may causes irritation to eyes. When it combines with polyethylene glycol it acts as a foaming agent. Its solubility is miscible in water.

Fig 3.1Dried N, N-Dimethyleformamide

- *Sodium Bicarbonate:* Sodium bicarbonate (NaHCO3) is a white crystalline powder. It produce buffer because of maximum contents of hydrogen ions. Odourless in nature. When it added to water and mixed in high speed it will produce the foam in the form of bubbles.

Fig 3.2 Sodium Bicarbonate

C. Other Materials and Aggregate for Foam Concrete

The coarse aggregate or other replacement for coarse cannot be used. This is because these materials would sink in the lightweight foam. Manufactured (M-Sand) Sand it is used as a substitute of river sand. It is manufactured by crushing of hard granite stone. The M-Sand should be in the form of cubical in shape with light grounded edges. It is less than 4.75mm in size. The M-Sand is used in place of river sand due to the depletion and transporting cost and non availability of river sand. M-Sand is used because it is economical, easily available and manufactured in excessive quantity than river sand. To replace the m-sand in some percentage, we can use light weight material like thermocol and M sand

Properties of M Sand		
	Textural composition (%by weight)	
	Coarse sand (4.75-2.00mm)	28.1
	Medium sand (2.00-0.425mm)	44.8
1	Fine Sand (0.425-0.075mm)	27.1
2	Specific Gravity	2.63
3	Bulk Density (kN/m3)	15.
4	PH	10.11
5	Chemical composition of M sand	Si, Al, Ca, Mg, Na, K, Fe.

IV. MIX PROPORTION

The details of mix proportion for PFC, PPFC and BFC are given in the table below. For all mixes, water - cement ratio was maintained at 0.6 and volume of foam at 20 percent.

Table 4.1 Mix Proportion

	Constituents % by weight							
Sample	Cement	water	Foam	sand	Coarse Aggregate	Plastic Scrap	GLass Powder	Total
Mix1	20.57	9.25	-	30.23	49.2	-	-	100
Mix2	26.04	8.49	0.36	65.1	-	-	-	100
Mix3	26.04	8.49	0.36	61.21	-	0.62	3.25	100
Mix4	26.04	8.49	0.36	56.66	-	1.95	6.5	100
Mix5	26.04	8.49	0.36	52.11	-	3.25	9.75	100

A. *Specimen Preparation and Testing Procedure*

1) *Compressive Strength:* Compressive strength of foamed concrete is an important parameter because it indirectly gives other mechanical properties such as flexural strength, splitting tensile strength and modulus of elasticity. Standard size cylinders of size 4 x 8 inch were used for compression test. Three different batches: PFC, PPFC and BFC were cast with three specimens each for a given mix. Specimens were demolded after 24 hours of casting and kept in the curing room for curing. After 7 days, specimens were removed and air dried for at least 24 hours. Similarly, specimens which are needed to be tested after 28 days were removed from the curing room and dried for 24 hours prior to testing. The specimens were cut at the top to make the surface even as shown in Figure 42. ASTM C39 specification was followed for both casting and testing. The cylinders were tested in the compression testing machine as shown in Figure 43. Specimen size were adjusted in the machine, the rate of loading was maintained between 20000 - 30000 lb/min. Load carrying capacity (lb) and strength (psi) were recorded after the failure of the specimen.

Automatic Compression Testing Machine (MATEST s.r.l.)

2) *Modulus of Elasticity and Poisson's Ratio Test:* For conducting the modulus test, standard cylinders of size 6 inches diameter and 12 inches long were cast. After 24 hours of casting, specimens were demolded and kept in a moist curing room. After 28 days of curing, the specimens were air dried for 24 hours and made ready for testing. ASTM C469 specifications were used for casting and testing procedures. The specimen was then made to set – up with a compressometer. Horizontal and vertical dial gauges were mounted on a compressometer to determine lateral and longitudinal displacement. The set – up was later mounted on a universal testing machine. A load of up to 40 percent of the failure strength of the concrete mix were applied to seat the gauges and subsequently released. Before loading starts, the dial gauges were zeroed. A small load, approximately 10 percent of the 40 percent compressive strength (0.4) was applied, and then readings for both the vertical and horizontal dial gauges and applied load were recorded. The loads at which readings are taken were separated by convenient increments, up to 40 percent. At each load increment, readings for load and both gauges were recorded. The rate of loading was maintained as 5000-6000 lb/min.
3) *Splitting Tensile Strength:* Tensile test on concrete utilizes the split tensile strength, because direct tension test on ceramic based materials are difficult to perform, as there is no practical manner to grip the samples. Standard cylinders of size 6 inches diameters and 12 inches long were used for casting and testing the specimen. Three different batches PFC, PPFC and BFC were casted with three specimens each for the given mix. The specimen were tested on a Universal Testing Machines (UTM). The rate of loading was 8000-9000 lb/min and the maximum load was recorded. The specimens after casting were allowed to settle for 24 hours. After 24 hours of casting, the specimen were demolded and kept in the moist curing room. After 28 days of curing, the specimen were removed from the curing room and air dried for 24 hours. Specimen were casted and tested as per the specification provided as per ASTM C 496. The foamed concrete specimens were put into the Split tensile set up. Each concrete cylinders were laid in horizontal position, and load was applied to one of the long side which create uniform tensile stress in the cylinder.

$T=2P/\pi PL$

Where,

T = splitting tensile strength in psi

P = maximum applied load indicated by the testing machine in pounds

L = average sample length in inches

D = sample diameter in inches

Split tensile strength setup

4) *Flexural Beam Test:* Flexural test was conducted on the foamed concrete to investigate its flexural behavior. Standard Specimen of 4x4x14 inch were cast. Three different batches PFC, PPFC and BFC were cast with three specimen each for the mix. The casting and testing procedure as per the specification provided by ASTM C78 was followed. After casting the specimen, they were allowed to set for 24 hours. After 24 hours, the specimen was demolded and transferred to moist curing lab. The specimen were then removed after 28 days curing and air dried for 24 hours before testing. It was then ground in corners to prepare an even surface. The specimen were rested on the supports with the clear span of 12 inches. The testing was performed on Universal Testing Machine (UTM) at an average rate of loading 30-50 lb/sec.

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The Flexural Strength or Modulus of Rupture (fb) is given by

fb = Pl/bd2 (when a > 133 mm)

fb = 3Pa/bd2 (when a < 133 mm)

Where, **a** = the distance between the line of fracture and the nearest support, measured on the center line of the tensile side of the specimen (cm)

b = width of specimen (cm)

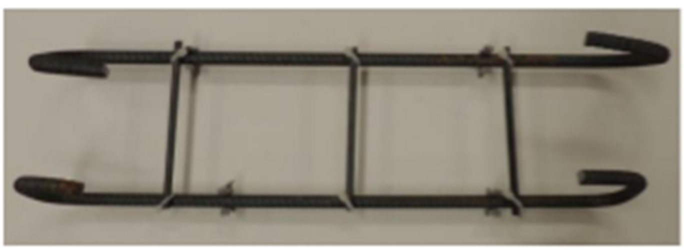
d = failure point depth (cm)

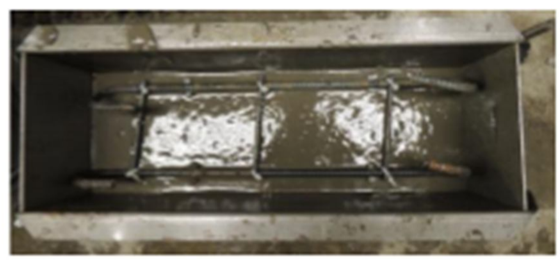
l = supported length (cm)

P = Maximum Load taken by the specimen (kg)

5) *Reinforced Foamed Concrete Test Beam:* The primary purpose of conducting such test is to study the performance of foamed concrete with steel reinforcement. Steel molds of size 6x4x20 inches were prepared as shown in figure below. Reinforced bars were used for and the reinforcement was provided only at the bottom of the cast. The reinforcing bars were supported laterally to keep them in place. Three different batches PFC, PPFC and BFC were cast with three specimen each for the mix. The mould were applied with oil to lubricate and later foamed concrete was placed. The specimen was allowed to set for 24 hours. After 24 hours, the specimen was demolded and kept in moist curing room. After 28 days of curing, the specimen was removed and air dried for 24 hours. Reinforced foamed concrete beam were tested under three point bending as per ASTM C78 specification.

Reinforcement and Framework for RFC Beam





V. RESULTS AND DISCUSSION

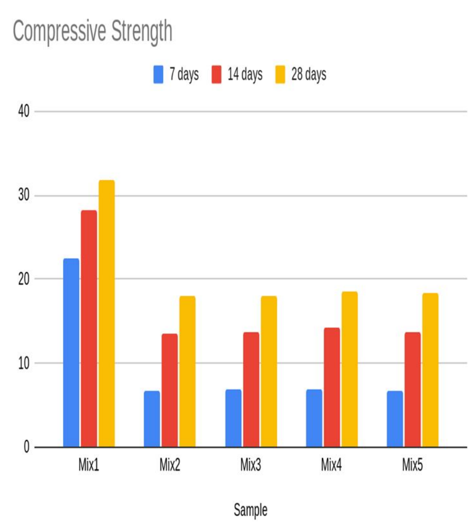
A. General

The mix proportion was presented in the chapter above and the comparison of results was done on parameters of compressive strength, flexural strength and split tensile strength.

B. Compressive Strength

Table 5.1 Compressive Strength of the Samples

Sample	Cross Sectional Area (mm2)	Average Compressive Strength (MPa)			Percentage of Variation with Mix 1 at 28 days
		7 days	14 days	28 days	
Mix1		22.51	28.21	31.84	-
Mix2		6.68	13.5	18.01	43.44% less
Mix3		6.82	13.64	18.04	43.35% less
Mix4		6.82	14.26	18.56	41.71% less
Mix5	22500	6.8	13.77	18.28	42.59% less



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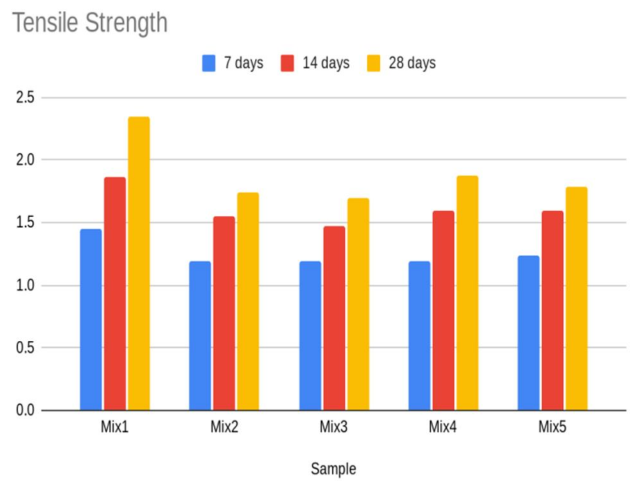
C. Tensile Strength

Table 5.2 Tensile Strength of Mix

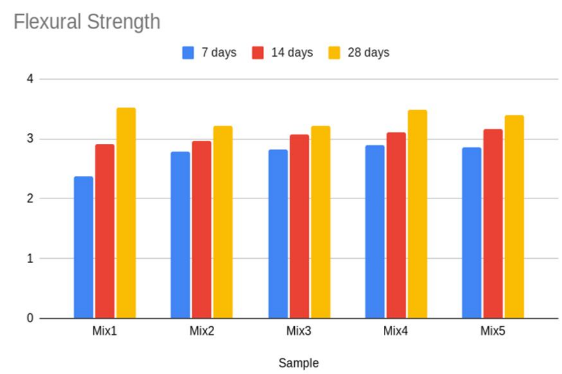
Sample	Cross Sectional Area (mm2)	Average Tensile Strength (MPa)		
		7 days	14 days	28 days
Mix1		1.45	1.86	2.35
Mix2		1.19	1.55	1.74
Mix3		1.19	1.47	1.7
Mix4		1.19	1.6	1.88
Mix5	50000	1.24	1.6	1.79



D. Flexural Strength

Table 5.3 Flexural Strength of Sample

Sample	Cross Sectional Area (mm2)	Average Flexural Strength (MPa)		
		7 days	14 days	28 days
Mix1		2.38	2.91	3.53
Mix2		2.79	2.96	3.21
Mix3		2.83	3.07	3.21
Mix4		2.9	3.1	3.48
Mix5	50000	2.85	3.17	3.4



VI. CONCLUSIONS

This research work investigates the feasibility of the foam concrete mixed with the combination of recycled plastic and glass waste. This research is focused on compressive strength, flexural strength and split tensile strength of foam concrete mixed with a combination of recycled glass and plastic waste. Based on the experimental results and analytical investigation, the following conclusion were drawn:

1) The compressive strength and durability of foam concrete increases with the age. But the compressive strength of concrete mix (i.e. CFPG-1, CFPG-2 & CFPG-3) was 41 to 44% lower than conventional concrete at 28 days.
2) The compressive strength of concrete mix (CFPG-2) was higher than concrete mix 1 (CFPG1) and Concrete mix 3 (CFPG-3). The compressive strength of concrete mix (CFPG-1) was 2.9% lower than concrete mix 2 (CFPG-2). So the sample CFPG- 2 gave the better compressive strength.
3) The tensile strength and flexural strength of this concrete mixes increases with age.
4) The replacement of 3% plastic & 10% glass as a filler in conventional foam concrete have 20% lesser tensile strength compared to conventional concrete at 28 days of curing. But the concrete mix (CFPG-2) gives 8% higher tensile strength than the conventional foam concrete (CFC).
5) The flexural strength of concrete mix (CFPG-2) was only 1.5% lower than the conventional concrete. The sample CFPG-2 have higher flexural strength than sample CFPG-1 and CFPG-3.

So overall the Sample CFPG-2 have higher compressive strength, tensile strength and flexural strength than sample CFPG-1 and sample CFPG-3. But sample CFPG-2 have lesser compressive strength, tensile strength and flexural strength than conventional concrete (CC).

REFERENCES

[1] Rokiah Othman, Ramadhansyah Putra Jaya, Khairunisa Muthusamy, MohdArif Sulaiman, Youventharan Duraisamy, Mohd Mustafa Al Bakri Abdullah, Anna Przybył, Wojciech Sochacki, Tomasz Skrzypczak, Petrica Vizureanu and Andrei Victor Sandu, [Relation between Density and Compressive Strength of Foamed Concrete], Materials 2021, 14, 2967.

[2] M.Ranjitham, S.Bharani Devi, J.Dhanusuya and S.K.Dharani, [EXPERIMENT AND CASE STUDY ON FOAMED CONCRETE], International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 08 Issue: 04 | Apr 2021.

[3] Jessie Deborah PJ and S.Kotteeswaran, [Study on Properties of Foam Concrete Using Fibers], International Journal of Research & Review, Vol.5; Issue: 5; May 2018.

[4] D.Kavitha and K.V.N Mallikarjunrao, [Design and Analysis of Foam Concrete], International Journal of Engineering Trends and Applications (IJETA) – Volume 5 Issue 3, May-Jun 2018.

[5] Dr.M. Shahul Hameed, A. Dhanalakshmi and B. Daniel Jeba Kumar, [Experimental Study on Foam Concrete], International Journal of Research in Engineering and Science (IJRES), Volume 9 Issue 6 ǁ 2021 ǁ PP. 53-58.

[6] S.Sidhardhan and A.Sagaya Albert, [EXPERIMENTAL INVESTIGATION ON LIGHT WEIGHT CELLULAR CONCRETE USING RECYCLED GLASS AND PLASTIC WASTE], constrution for the future construction",2020.

[7] Ravi Shankar S and Jijo Abraham Joy, [Experiment on Foam Concrete with Quarry Dust as Partial Replacement for Filler], International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS030595 www.ijert.org (This work is licensed under a Creative Commons Attribution 4.0 International License.) Vol. 4 Issue 03, March-2015.

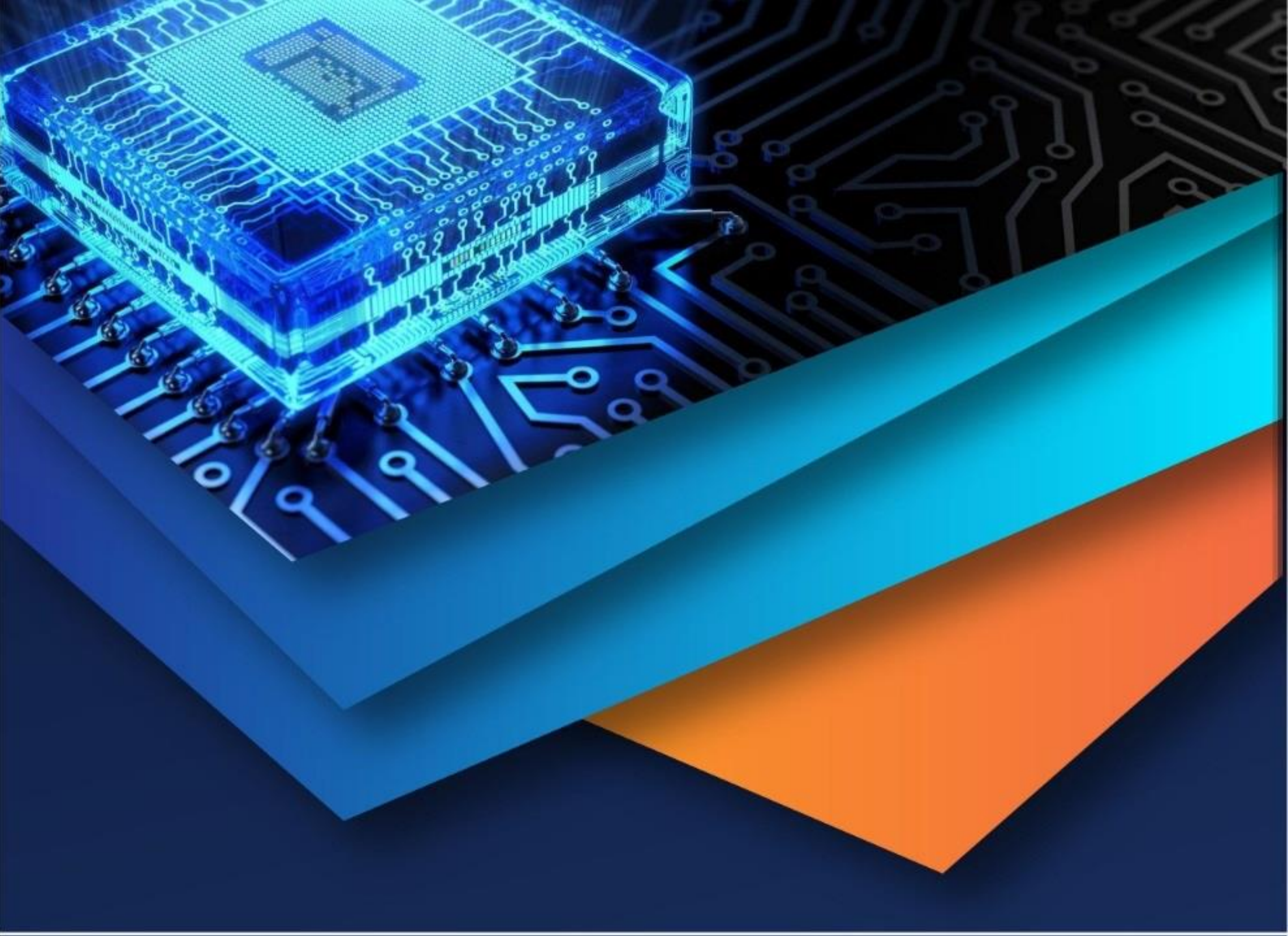
[8] Aswathy M, [Experimental study on light weight foamed concrete], Journal of Chemical and Pharmaceutical Sciences, April - June 2016.

[9] Sajan K Jose, Mini Soman and Sheela Evangeline Y, [Experiments on Foamed Concrete for the Development of Building Blocks], International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-5, January 2020.

[10] G.Mithra and S.Rajeshkumar, [A STUDY ON PROPERTIES OF FOAMED CONCRETE WITH FLY ASH AND MARBLE SLUDGE POWDER], International Journal of Scientific & Engineering Research Volume 11, Issue 3, March-2020 ISSN 2229-5518.

[11] Vishwanath Patil and Nikil Sunil, [Experimental Study on Foam Concrete], International Journal of Advance Research in Science and Engineering, Volume no 7, Special issue no 3, 2018.

[12] S.Yuvaraj, S.Karthik, M.Naveen Raj and S.S.Ridhu Pharan, [EXPERIMENTAL RESEARCH ON FOAM CONCRETE WITH PARTIAL REPLACEMENT OF SAND BY MSAND], International Journal of Advance Research in Science and Engineering, Volume no 3, Special issue no 1, 2015.



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