An Innovation on Properties of Foam Concrete with Different Admixture

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Abstract. With the expansion popular for structures which are light in weight, analysts and industrialist interest in frothed cement to be utilized in underlying applications is consistently expanding. Frothed concrete is as of now accepted to have a promising future. Frothed concrete was limited to use as segment divider, warm protection, making up for the shortcoming and restoration work previously. Over the most recent twenty years, with the comprehension of the peculiarity fundamental frothed concrete, specialists have concentrated on different boundaries that influences the presentation of frothed concrete with and without filaments, and endeavors have been made to involve frothed concrete in underlying application. The principle objective of the exploration is to research the mechanical and underlying properties of plain and fiber supported frothed concrete.

Frothed concrete otherwise called cell concrete or lightweight cement is a sort of cement with cementitious glue, fines, water and voids without coarse total. The voids are made by utilizing froth. The utilization of admixtures, for example, fly debris, silica smoke and filaments in the froth concrete give more strength than plain frothed concrete (PFC). Under this exploration program, three unique blends were made: plain frothed concrete (PFC), polypropylene fiber built up frothed concrete (PPFC) and basalt fiber supported frothed concrete (BFC). Examples were tried for compressive strength, parting elasticity, youthful's modulus and poisson's proportion, flexural strength and RFC (Reinforced frothed concrete) strength. This study showed that the utilization of ideal froth volume for example 20% gives a particular thickness of froth concrete 70 - 100 pcf and compressive strength of 3000 - 5500 psi. For the investigation of flexural application, eight different steel supported sandwich radiates were tried. For investigation of pressure application, sixteen pressure sections, eight of them with support and eight without support were tried. Steel built up sandwich radiates were separated into four unique sets, two of every, typical cement - Styrofoam R-13 rating blend,

ordinary cement - PFC mix, ordinary cement - PPFC mix and typical cement - BFC mix. Likewise, to concentrate on the underlying conduct of the pressure section, examples were isolated into various gatherings as that of sandwich radiates. The flexural strength of BFC example was multiple times more than PFC example. Among the RFC pillar examples, BFC has shown greatest burden conveying limit. Additionally, trial results show that typical cement - BFC mix has shown the most elevated burden conveying limit under bowing. Among the pressure section ordinary cement - PFC mix has shown the most elevated burden conveying limit.

Watchwords:

1.Introduction

1.1 Foam Concrete

Froth concrete is a sort of lightweight substantial that is made from concrete, sand or fly debris, water, and the froth. Froth concrete is as frothed grout or frothed mortar. Froth cement can be characterized as a cementitious material that comprises of least 20% of froth, that is precisely entrained into the plastic mortar. The dry thickness of frothed cement might fluctuate from 300 to 1600 kg/m3. The compressive strength of not entirely settled at 28 days, goes from 0.2 to 10N/mm2 or can go higher.

Froth concrete is separated from air entrained concrete as far as the volume of air that is entrained. The air entrained substantial takes in the demeanor of 3 to 8 percent. It likewise contrasts from the hindered mortar and circulated air through concrete for a similar explanation of level of air entrained. On account of hindered mortar frameworks, it is 15 to 22 percent. The air pockets are synthetically shaped on account of a circulated air through concrete.

Froth concrete is a combination of concrete, fine sand, water and froth which once solidified outcomes in a solid, lightweight cement containing a huge number of equitably circulated, reliably estimated air pockets or cells. Froth concrete is both fire and water safe. Sometimes sand is supplanted with quarry dust. It has high sound and warm protection properties. Froth concrete is like traditional concrete as it utilizes similar fixings. Notwithstanding, froth substantial contrasts from customary cement in that the utilization of totals in the previous is disposed of. A froth specialist is utilized to retain moistness however long the item is presented to the air, permitting the hydration interaction of the concrete to advance in its steadily proceeding with strength improvement.

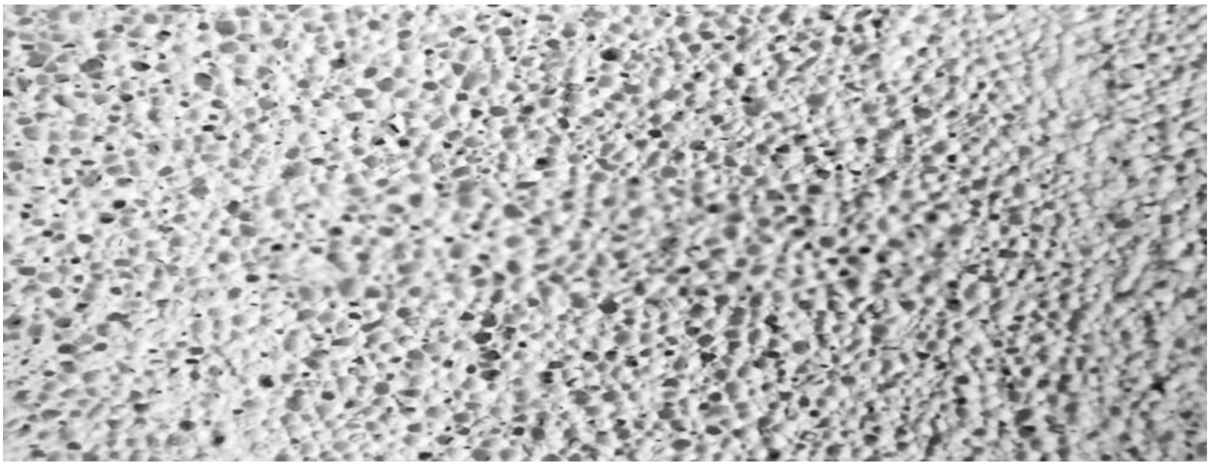

Fig 1.1 Foam Concrete

2. Materials for Foam Concrete

Cement for Foam Concrete

Ordinary Portland cement is commonly used, but rapid hardening cement can also be used if n ecessary. Foam concrete can incorporate a wide range of cement and other combinations, for e xample, 30 percent of cement, 60 percent of fly ash and 10 percent limestone. The content of cement range from 300 to 400 kg/m3.

Sand For Foam Concrete

The maximum size of sand used can be 5mm. Use of finer sands up to 2mm with amount p assing through 600 micron sieve range from 60 to 95%.

Pozzolans

The supplementary cementitious materials like fly ash and ground granulated blast furnace slag have been used widely in the manufacture of foam concrete. The amount of fly ash used rang es from 30 to 70 percent. White GGBFS range from

10 to 50%. This reduces the amount of cement used and economical. Silica fumecan be added to increase the strength; at an amount of 10 percentage by mass.

.**2.3 Foam Concrete Rating as per GBRS**

a) Water Efficient: Water required for Foam concrete is less as compare to normal concrete.

b) Energy and Atmosphere: Foam concrete has various excellent insulating qualities resulting in energy efficiency, Thermal insulation, Sound insulation, Fire resistance is the energy saving in buildings of Foam Concrete.

c) Materials and Resources: In India, the total production of fly ash is more than 100 million tons, but our utilization of fly ash is only about 5% of the production. Also the disposal of fly ash has become a serious concern to the environmental protection. Use of fly ash in foam concrete satisfies the GBRS.

d) Indoor Environmental Quality: An additional quality contributing to the sustainabilityof a building product is its ability to reduceand absorb noise or to improve or maintain indoor air quality.

3. Objectives of the research

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

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

4. Material and Properties

4.1 Cement

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

Table 4.1 Properties of Cement

PROPERTY	EXPERIMENTAL RE SULTS	LIMITING VALUES AS PE R CODE (IS 12269 : 1987)
Fineness (Air permea bility)	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 M inutes	48 minutes	Not less than 30 minute
Compressive Strength at 28 days (N/mm2)	55	Not less than 53 N/mm2

Table 4.2 Chemical Properties of Cement

Ingredient	Percentage
Lime CaO	62
Silica SiO2	22
Alumina Al2O3	5
Calcium Sulphate CaSO4	4
Iron Oxida Fe2O3	3
Magnesia MgO	2
Sulphur S	1
Alkalies	1

4.2 Fine Aggregate

MSand (Manufactured Sand) it is used as a substitute of river sand. It is manufactured by cru shing of hard granite stone. The M-

Sand is in the form of cubical in shape with edges grounded. It is less than 4.75mm in size. The M-

Sand is used instead of river sand due to the depletion and transporting cost and non availabil ity of river sand. M-

Sand is used because of its availability, economy and manufactured in large quantity than river sand. We used M-

Sand and some light weight material thermocol which is used as replacement for m-

sand in percentage.

Table 4.3 Properties of 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
	Fine Sand (0.425-0.075mm)	27.1
2	Specific Gravity	2.63
3	Bulk Density (kN/m3)	15.1
4	Ph	10.11

5	Chemical Composition of M Sand	Si, Al, Ca, Mg, Na, K, Fe.

4.3 Foaming Agent

There are several 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 on ly to infrequent variations in quality, due to the contradicting raw materials used in different b atches. The lifetime of foaming agent under sealed condition is about 1 year. Synthetic based f oaming agent is used in this investigation.

Table 4.4 Properties of Foaming Agent

Appearance	Colour 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

The foaming agent is added to the mixtures which produce the bubbles or air voids in the co ncrete. The agents we used here is eco-friendly. The foaming agent we used here is,

1. Polyethylene glycol, #6000
2. Dried N,N- Dimethylformamide
3. Sodium bicarbonate

- Water

The water is added to the mixture of cement and fine aggregate to get the homogeneous textu re of concrete.The water used for construction should not be less than or more

than 7 in pH. The water is neutral in nature. The demineralised water is preferable while addi ng the chemical composition or chemical solution. The mineral in water react with the chemica l 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 atmosph ere, it changes its phase from solid to gas.

- Dried N, N-Dimethyleformamide

It is a liquid with water-
white which is colourless. It is faint fishy in odour. The density of dimethylformamide is lesser than water. It react with atmosphere and turns into pale yellow in colour. 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 4.1Dried N, N-Dimethyleformamide

- Sodium Bicorbonate

Sodium bicarbonate is a white crystalline powder. It produce buffer because of excess of hydrogen ions. Odourless in nature. When it combines with water and mixed in high speed it will produce the foam in the form of bubbles.

Fig 4.2 Sodium Bicorbonate

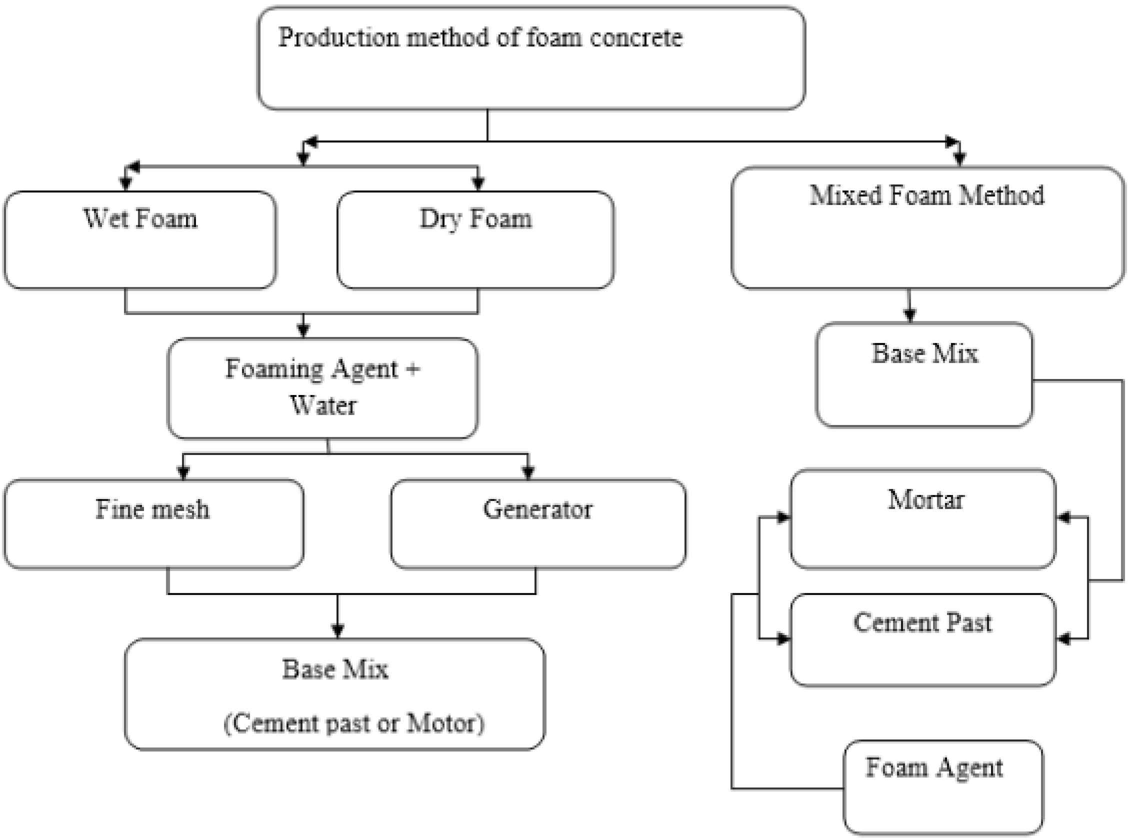

Fig 4.3 Production Method of Foam Concrete

5. Experimental Work

5.1 Mix Design

Various experiments were conducted to achieve optimum mix proportion. The standard mix desi gn was used for plain foamed concrete (PFC), polypropylene fiber reinforced concrete (PPFC) a nd basalt fiber reinforced foamed concrete (BFC).

5.2 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 5.1 Mix Proportion

Sample	Constituents % by weight							
	Cement	water	Foam	sand	Coarse Aggr egate	Plastic S crap	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

5.1.2 Mixing Procedure

The ingredients were mixed in the mixer as shown in figure below in the following sequence. At first, the ingredients such as cement, fly ash and silica fume were dry mixed in a concret e mixer. Super plasticizer was mixed in water. Later half of the water of the mix was added to the dry mix and the mixer was made to run until lumps were broken. Then, remaining hal f of the water was added and mixed for 2 minutes, foam was added and again mixed for 1 minute, the mix was made to rest for 3 minutes. For the mix design which consists of fibers, they were added at this point of time, again mixed for 2 min.

Fig 5.1 Concrete Mix

5.1.3 Casting and Demolding

Casting of foamed concrete specimens is an important step as the results indirectly depend on the output of specimen cast. Necessary steps were taken to ensure effective production of the s pecimens. Before casting, form oil was applied to the cylinders and molds to make sure concr ete will not stick to it. Since, foamed concrete is self - leveling and self – compacting, vibration was not required. After placing of concrete, the surface was leveled to get smooth finish. The specimens were then left to set for 24 hours. The specimens were dem olded after 24 hours with necessary tools and were transferred for curing to the curing room.

5.2 Specimen Preparation and Testing Procedure

5.2.1 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 inthe 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.

Fig 5.2 Specimen with cut surface

Fig 5.3 Compression Testing Machine

5.2.3 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 werecasted 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 removedfrom 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 specimen wereput 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 thecylinder.

T=2P/□PL

Where,

□ = splitting tensile strength in psi

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

□ = average sample length in inches

□ = sample diameter in inches

Fig 5.7 Split Tensile Strength Setup.

5.2.4 Flexural Beam Test

Flexural test was conducted on the foamed concrete to investigate its flexural behaviour. 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. Aftercasting 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 the removed after 28 days curing and air dried for 24 hours before testing. It was thenground in corners t o 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 r ate of loading 30-50 lb/sec.

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

fb = Pl/bd2 (when a > 13.3 cm)

fb = 3Pa/bd2 (when a < 13.3 cm)

Where, **a** = the distance between the line of fracture and the nearest support, measured on t he 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)

Fig 5.8 Flexural Beam Test Setup

5.2.5 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 asshown in figure b elow.Reinforced bars were used for and the reinforcement was providedonly at the bottom of t he 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 foamedconcrete 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 curingthe specimen was removed and air dried for 24 hours. Reinforced foamed concrete beam were tested under three point bending as per ASTM C78 specification.


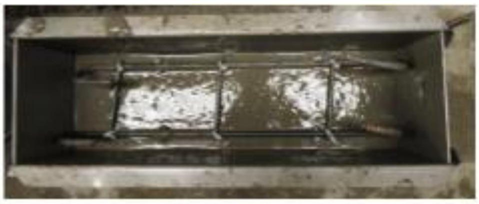

Fig 5.9 Reinforcement and Framework for RFC Beam

6. Conclusion

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:

- 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.
- 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.

- The tensile strength and flexural strength of this concrete mixes increases with age.
- 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).
- 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 con crete (CC).
- The starting of strength gain for foamed concrete was on higher side than thatof conventional concrete and strength gain beyond 28 days was faster than conventional concrete.
- The mixed proportion for foamed concrete used in this research report cannot be used for str uctural purpose, because the compressive strength is lower than conventional concrete. The var ious mix proportions in this research can be usedfor making of partition wall in building.
- The use of recycled glass and plastic in conventional foam concrete reduce theconsumption of fresh raw materials especially sand. It promotes the judicial andsustainable use of sand. So t he combination of recycled glass and plastic wastecan be used as a filler in conventional foa m concrete.

References

1. Rokiah Othman, Ramadhansyah Putra Jaya, KhairunisaMuthusamy, MohdArifSulaiman, YouventharanDuraisamy, Mohd Mustafa Al Bakri Abdullah, Anna Przybył, WojciechSochacki, Tomasz Skrzypczak, PetricaVizureanu 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.