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AN EXPERIMENTAL INVESTIGATION ON LIGHT WEIGHT FOAM CEMENT BLOCKS WITH QUARRY DUST REPLACEMENT FOR FINE AGGREGATE

T.Tharakarama[1] ,B.Veni[2], P.Bala Krishna[3]

[1]Student, KMM Engineering College
[2]Assistant Professor, Dept. of Civil Engineering, Sree Rama Engineering college
[3] Assistant Professor, Dept. of Civil Engineering, KMM Engineering college

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ABSTRACT- Foamed concrete is a versatile material which consists primarily of a cement based mortar mixed with at least 20-25% of volume air. It is non-load bearing structural element which has lower strength than conventional concrete. In the present investigation, an experimental study is carried on the influence of varying densities of foam in the quarry dust based foam concrete. The range of densities investigated are 800kg/m^3,1000kg/m^3,1200 kg/m^3,1400 kg/m^3 ,1600 kg/m^3,1800 kg/m^3.The density of concrete is varied by using synthetic foam called sodium lauryl sulphate,for 30 liters of water 1 liter of foam is used separately and the same is introduced into the fresh concrete during its mixing by controlling its concentration to its desired density of concrete is achieved

The focus of this project is to decrease the density of concrete by using optimum content of foam.The results are discussed elaborately with respect to compressive strength, split tensile strength, flexural strength and water absorption with varying densities of foam i.e, 800kg/m^3,1000kg/m^3,1200kg/m^3, 1400kg/m^3, 1600kg/m^3, 1800kg/m^3 and no foam. Foamed concrete has unique characteristics that can be exploited in civil engineering works. It requires no compaction, but will flow readily from an outlet to fill restricted and irregular cavities, and it can be pumped over significant distances and heights. Thus it could be thought of as a free-flowing, self-setting fill. This report provides a conspectus of foamed concrete covering its constituents, production, engineering properties and use.

Based on the test results it can be observed at 1200kg/m^3 will be the optimum density where upto 40% of density can be reduced compared to conventional concrete.

KEY WORDS: Foam concrete, Flexural strength, Split tensile strength, Compressive Strength, Compaction, Foam.

1.INTRODUCTION

One of the major challenges of the present society is the protection of environment. Some of the important elements in this respect are the reduction in the consumption of energy, natural materials and consumption of waste materials. Now-a-days these are getting considerable attention under sustainable development. The use of quarry dust as application in construction as an alternative to the natural aggregate. It conserves natural resources and reduces the space required for the landfill disposal.

Concrete is the second most widely consumed substance on earth, after water. In concrete construction, self-weight represents a very large proportion of the total load on the structure; hence there are clearly considerable advantages in reducing the density of concrete by using Light Weight Concrete (LWC). The chief of these are the use of smaller sections and the corresponding reduction in the size. Furthermore, with lighter concrete the form work needs to withstand a lower pressure than would be the case with ordinary concrete, and also the total weight of materials to be handled is reduced with a consequent increase in productivity. LWC also gives better thermal insulation than ordinary concrete. The practical range of densities of lightweight concrete is between 3.00 and 18.50 KN/m3. One such LWC is foamed concrete. Foam concrete is a very fluid, lightweight cellular concrete fill material, produced by blending a cement paste (the slurry or mortar), with a separately manufactured, pre-formed foam. The density of foam concrete is determined by the ratio of foam to slurry and densities range typically between 300 and 1800 kg/m3.

2. APPLICATIONS OF FOAM CONCRETE

Pre-Cast Lightweight Blocks

The most widespread use of foamed concrete in India is for making pre-cast lightweight blocks. These blocks are used to construct non-structural walls in apartments, hotels and offices. Foamed concrete is lightweight which means that the loading on the building is reduced. Therefore the amount of structural steelwork and structural concrete is also reduced resulting in significant cost savings. The thermal insulation properties of foamed concrete mean that there will be greater comfort and reduced air-conditioning and heating costs for tenants.

Cast In-Situ Lightweight Walls

In order to reduce the time and labour needed to make pre-cast blocks, it is possible to cast lightweight foamed concrete walls in-situ. Heights of up to 1m can be cast in a single pour. Normal formwork suitable for concrete can be used. Casting in-situ foamed concrete walls is currently gaining popularity in India.

Void Filling

Foamed concrete does not shrink, is free flowing and fills every gap, even beneath overhangs. It can be placed quickly in large quantities through narrow openings, which means void filling can be tackled with minimal disruption. Both planned and emergency void filling are regularly carried out using foamed concrete. Using traditional methods, the repair would have taken three weeks to be completed, including the dismantling and re-assembly of the road structure, which consisted of pavers bedded in mortar. Using foamed concrete, the whole job was completed and the road re-opened in 48 hours.

Ground Stabilization

The lightweight nature and excellent load spreading characteristics of foamed concrete mean that it is ideal for ground stabilization. During construction of an expressway on a hillside in Japan, traditional granular fill materials were used to construct a large embankment. A landslide caused the embankment to fail. Instead of using traditional fill materials to reconstruct the embankment, a lightweight material needed to be used.

Environmental Benefits

Foamed concrete saves on the use of other materials. It directly saves on material usage since it can be made using fly ash, which is a bi-product of energy generation. Indirectly, since it is lightweight and does not impose large loadings, it reduces the amount steel work and structural concrete required in building construction and civil engineering projects. The most obvious environmental benefit of foamed concrete is its ability to provide thermal insulation

Road Sub-Base

Foamed Concrete can be used to make road structures less heavy. This helps solve the problem where the traditionally heavy road structures cause severe settlement of the road, particularly in areas of soft ground. By constructing the road sub-base from as light weight material, the overall weight of the structure can be greatly reduced. As Foamed Concrete is very versatile, with a wide range of densities, it has proved to be an ideal, cost effective material for solving this problem.

Wall Construction

Foamed Concrete can be used for cast in-situ walls. These can be made either by using traditional shuttering or hollow polystyrene moulds. This provides a quick and cheap method of building, with the added advantage of excellent thermal insulation. A wall made from 1200kg/m^3 density foamed concrete provides the same level of thermal insulation as would a wall made from dense concrete that was 5 times as thick and made from 10 times the quantity of materials as the foamed concrete wall. Tunnelling

Ground Works

Foamed Concrete can be used in various types of ground projects, including stabilizing embankments after landslides, highway widening schemes, land reclamation and filling in of harbors. As it does not sink into soft subsoil, redevelopment can begin much sooner after application than can using traditional methods. For similar reasons, it is also ideal for road foundations.

Fire Breaks

The excellent fire resistant properties of Foamed Concrete makes it an ideal material for fire breaks in buildings where there are large undivided spaces. It is used to prevent flame penetration through the services void between floor and ceiling in modern construction, and also to protect timber floors in old houses.

Sound Insulation

Foamed Concrete reduces the passage of sound, both from background noise and due to impact. It is, therefore, an ideal material for internal walls and suspended floors in multi-storey buildings, especially ones with communal use.

3. SCOPE OF THE PROJECT

The scope of this project:

- Review and research of concrete properties using quarry dust based foamed concrete.
- Casting of concrete specimens by using different densities of foam concrete using quarry dust.
- Testing on concrete specimen prepared using foam concrete with different densities.
- Analysis of test results and recommendation for further research area.

4. MATERIALS

The materials used in experimental investigation are:
1. 53 grade Ordinary Portland Cement (OPC)
2. Quarry dust
3. Foaming agent
4. Potable water

The properties of the materials are presented in following sections.

4.2.1 Cement

Portland cement grade 53 is used in this test. It is the basic ingredient of concrete, mortar and plaster. Cement is an amorphous (glassy) powdered siliceous material that responds to the alkali content in cements to react with lime in the high pH environment in concrete to form additional CSH (calcium silicate hydrate) binder within the pore structure of the concrete. Pozzolana is effective as minus 325 mesh powders. Much of the chemistry associated with certain Pozzolana, such as sulfides, carbon, sulfates, and alkalis can be quite deleterious to the long-term durability of concrete. The properties of cement were within limits as per IS 8112:1989. The properties are shown in Table 3.1.

Table 4.1. Physical Properties of 53 Grade Ordinary Portland Cement

S.No.	Property	Result
1.	Fineness	2.7%
2.	Specific gravity	3.12
3.	Normal Consistency	30.5%
4.	Setting time(min) Initial Final	 80 min 305 min

4.2.2 Quarry dust

Quarry dust is a by product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. The quarry dust used in the investigation is obtained from the quarry at Chandragiri near Tirupati Andhra Pradesh. Locally available quarry dust confirming to IS specifications was used as the fine aggregate in the concrete preparation.

The properties of Quarry dust were analyzed in accordance with the procedure and were presented in Table4.2

Table 4.2 Properties of Quarry dust

S.No	Property	Result
1	Specific Gravity	2.52
2	Fineness modulus	3.2
3	Grading of sand	Zone-11
4	Density of Quarry Dust	1653kg/m^3

4.2.3. Foaming agent

A foam is a substance formed by trapping pockets of gas in a liquid or solid. A bath sponge and the head on a glass of beer are examples of foams. In most foams, the volume of gas is large, with thin films of liquid or solid separating the regions of gas.

Solid foams can be closed-cell or open-cell. In closed-cell foam, the gas forms discrete pockets, each completely surrounded by the solid material. In open-cell foam, gas pockets connect to each other. A bath sponge is an example of an open-cell foam: water easily flows through the entire structure, displacing the air. A camping mat is an example of a closed-cell foam: gas pockets are sealed from each other so the mat cannot soak up water.

Foams are examples of dispersed media. In general, gas is present, so it divides into gas bubbles of different sizes (i.e., the material is polydisperse) separated by liquid regions that may form films, thinner and thinner when the liquid phase drains out of the system films.When the principal scale is small, i.e., for a very fine foam, this dispersed medium can be considered a type of colloid. Foam can also refer to something that is analogous to foam, such as quantum foam, polyurethane foam (foam rubber), XPS foam, polystyrene, phenolic, or many other manufactured foams.

Foaming agent used in the investigation is sodium lauryl sulphate.

Foaming used in the study was manufactured by Acuro Organcs Ltd, New Delhi Bee Chemicals. Specifications of foaming agent as given by the supplier are given in the following table.

The properties of foaming agent were analyzed in accordance with the procedure laid down and were presented in Table 4.3.

Table 4.3 : Properties of Sodium lauryl sulphate

Parameter	Values
Physical state	White colour
pH	9 - 10
Specific gravity	1.05
stability	Stable under normal conditions

5.RESULTS AND DISCUSSION

5.1 RESULTS

The results of the experimental investigation are presented in this chapter. The significance of the results were assessed with the reference to relevant IS codes.

5.2.1 Compressive Strength

The results of compressive strength of foam concrete for different densities of foam are presented in Table 5.1. and Fig.5.2.

Table 5.1. Test Results of Compressive Strength of Concrete

Foam density(kg/m3)	Average Compressive Strength (MPa)				
	3 days	7 days	28 days	56 days	90 days
800	1.2	4	7.2	15.4	18.5
1000	1.32	4.56	9.86	16.2	18.8
1200	1.67	5.1	12.4	17.3	20
1400	3.25	7.1	16.3	19.4	22.6
1600	3.8	7.7	16.9	22.6	29.5
1800	4.23	8.8	18.3	26.3	29.9
No foam	8.91	15.8	21.5	29.3	30.4

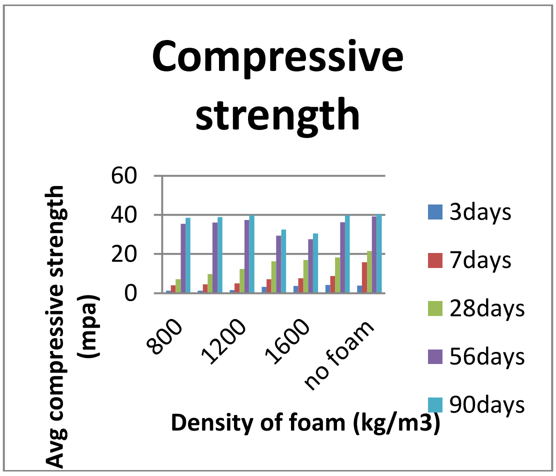

Fig:5.1

The variation of the cube compressive strength of size 150x150x150 mm with different densities of foam concrete is shown in Fig.5.1 and strength at different ages is shown in fig5.2. The cube compressive strength indicates the average of three test results for 3,7,28,56 and 90 days.The results shows that with increase of density the strength is increasing. Compare to the present results at 1200 kg/m^{3}the strength is 12.36 MPa. For 3 days the compressive strength for the 800kg/m^3 ,1000 kg/m^3,1200kg/m^3 densities of foam concrete the strength is more over the same with small variations .For 90 days at 800kg/m^3 and 1000kg/m^3 the strengths are nearly equal again at 1600kg/m^3 and 1800kg/m^3 the strengths are nearly equal.Without using any foam the strength at 90 days is 30.4 MPa. At no foam condition the strength at 56 days and 90 days is nearly equal i.e, 29.3MPa,30.4MPa.

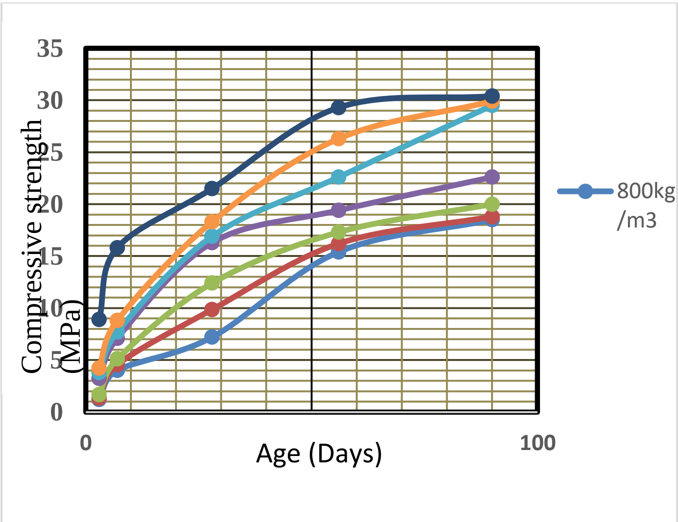

Fig.5.2.Compression strength of foam at different ages

If the change is more than 10% ,it is significant, otherwise it is insignificant. Considering the maximum compressive strength of brick 7.0MPa ,the compressive strength of foam concrete at different ages are varied by 2.87%,40.5%,50.2% at the densities of 800 kg/m³ ,1000 kg/m³,1200 kg/m³ respectively.

The percentage change is insignificant at at 800 kg/m³,whereas the percentage change for other densities it is significant. If the variation of strength is more than 10% with respect to reference mix it is considered as significant. otherwise it can be considered as in -significant

5.2.2 Split Tensile Strength

The Split Tensile Strength test was carried according to IS 5816-1999. The results of Split Tensile strength using different densities of foam concrete presented in Table 5.2.

Table 5.2. Test Results of Split Tensile Strength of foam Concrete

Density of foam((kg/m3)	Split Tensile Strength for 28 days (MPa)
800	1.08
1000	1.46
1200	1.85
1400	2.18
1600	2.23
1800	2.54
No Foam	3.225

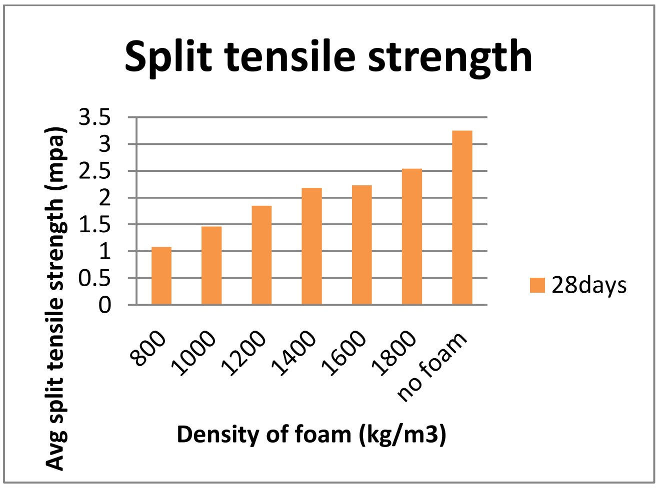

Fig.5.3. Variation of Split Tensile Strength with Different densites of foam

Cylinders of 150 mm diameter and 300 mm height with varying densities of foam were casted and tested the strength at 28 days for its split tensile strength is shown in fig 5.3. Compare to the present results at 1200 kg/m³ the split strength is 1.75 MPa..At 1400kg/m³ and1600kg/m³ the split tensile strength is nearly equal i.e,2.18MPa and 2.23 MPa.

If the change is more than 10% ,it is significant, otherwise it is insignificant.Considering the maximum split tensile strength of brick ,the split tensile strength at different ages are varied by 5.87%,39.5%,47.2% at the densities of 800 kg/m³ ,1000 kg/m³,1200 kg/m³ respectively.

The percentage change is insignificant at at 800 kg/m³,whereas the percentage change for other densities it is significant. If the variation of strength ,is more than 10% with respect to reference mix it is considered as significant. otherwise it can be considered as in -significant

5.2.3 Flexural Strength

The Flexure Strength test was carried according to IS 516-1959. The results of Flexure strength of varying densities of foam concrete are presented in Table 5.3.

Density of foam((kg/m³)	Flexural Strength for 28 days (MPa)
800	1.84
1000	2.26
1200	2.54
1400	2.97
1600	3.08
1800	3.31
NO FOAM	3.74

Table 5.3. Test Results of Flexure Strength of Concrete

The variation of flexural strength with different densities of foam of Concrete Beams of size 500 mm Length and 100mm × 100 mm cross section are cast and the results are shown in fig5.3. Compare to the present results at 1200 kg/m³ the Flexure strength is 2.5MPa which is more than the strength of brick .

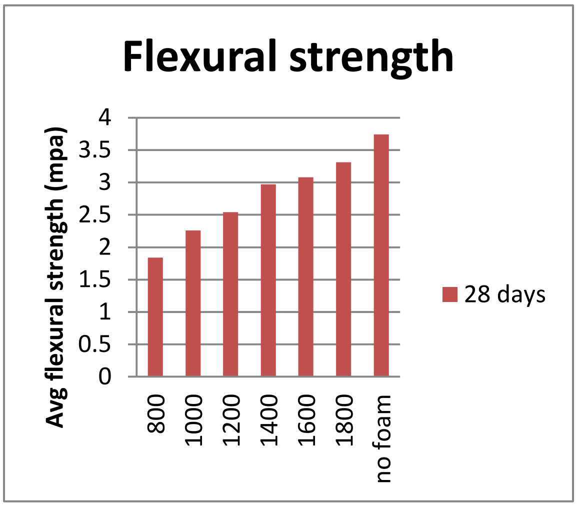

fig5.4 Variation of Flexural Strength with Different densites of foam

The percentage change is insignificant at at 800 kg/m³,where as the percentage change for other densities it is significant. If the variation of strength ,is more than significant. otherwise it can be considered as in –significant.

At 800 kg/m³,the flexural strength is 1.84 MPa and for 1000 kg/m³ ,1200 kg/m³ it is near about equal i.e,2.26 and 2.54MPa and it drastically increases at 1600 kg/m³ ,and for no foam concrete it increases to 3.74 MPa.

Hence optimum density of 1200 kg/m³ is considered

5.2.4.WATER ABSORBTION

Three full size blocks shall be completely immersed in clean water at room temperature for 24 hours. The blocks shall then be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth, the saturated and surface dry blocks immediately weighed. After weighing all blocks shall be dried in a ventilated oven at 100 to 1150C for not less than 24 hours and until two successive weighing at intervals of 2 hours show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen.

The water absorption calculates as given below:

Absorption, percent =(A-B)/B * 100

Where,
A=wet mass of unit in kg.
B = dry mass of unit in kg.

Table 5.4. Test Results of water absorption for foam Concrete

Density of foam (kg/m3)	% of water absorption
800	11.87
1000	11.51
1200	11.37
1400	10.96
1600	9.98
1800	8.91
No foam	8.21

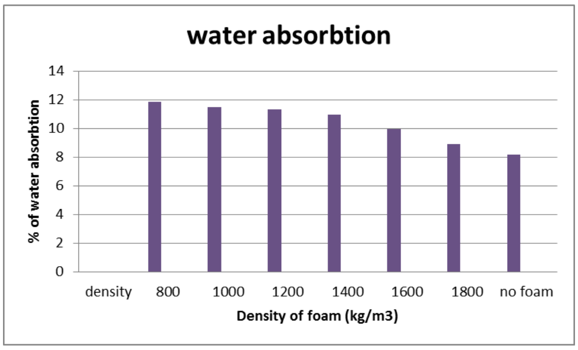

Fig.5.5. Variation of water absorbtion with different densities of foam

With increasing of density, the water absorption is decreasing.At 800kg/m³ ,1000kg/m³,1200kg/m³ the water absorption is nearly the same. From 1600 kg/m³ and above the water absorption is less than 10% is observed. However, at the optimum mix of 1200kg/m³, the water absorption is 11.6%. Water absorption of almost 12% is observed for 800kg/m³ density.

If the change is more than 10% ,it is significant,otherwise it is insignificant.Considering the water absorbtion of brick 15% ,the water absorbtion at different ages are varied by 26.6%,18.5%,15.2% at the densities of 800 kg/m³ ,1000 kg/m³,1200 kg/m³ respectively.

The percentage change is insignificant at a 800 kg/m³,where as the percentage change for other densities it is significant.If the variation of strength ,is more than 10% with respect to reference mix it is considered as significant.other wise it can be considered as in –significant.

6. CONCLUSIONS

Based on the test results of the present investigation, the following conclusions are drawn.

- As no coarse aggregate is used it can be used as precast in-situ elements.
- From the test results it can be arrived that at 1200 kg/m^3 density,compresssive strength,split tensile strength,flexural strength and water absorbtion is taken as optimum with strengths 12.4 MPa,1.85MPa,2.54MPa and11.37%
- Brick has compressive strength of 3-7 Mpa at 1900kg/m^3, compared to our results at 1200kg/m^3 the strength is 12.36 Mpa which is 50% more than that.
- The water absorption for 1st class brick is 20% but in case of foam concrete at 1200kg/m^3 the water absorption is 11.37%.
- By selecting 1200kg/m^3 as optimum density we can reduce the density by 40%
- Using the test results, it can be concluded that the percentage of cement content will be reduced to half by using quarry dust so that CO_2 emissions from the cement will be reduced .
- Per unit quantity of work,foam concrete is more cost effective besides eco friendly.

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6.2 SCOPE FOR FUTURE WORK

The work can be extended for:

- The tests on Durability, creep, shrinkage properties of foam concrete.
- Use of foam concrete for high Strength by using admixtures.
- Study on properties of foam concrete at various densities of foam by using different combinations of various puzzolanic materials.

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