International Journal of Research in Advanced Engineering and Technology
ISSN: 2455-0876
Impact Factor: RJIF 5.44
www.newengineeringjournal.in
Volume 4; Issue 2; May 2018; Page No. 15-20

Use foam concrete in construction works

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Abstract
Foam Concrete can be defines as a type of aerated lightweight concrete; it doesn't contain coarse aggregate (gravel) and can be regarded as an aerated mortar. Foam Concrete can be produce by two methods (Inline Method and Pre-foam Method) where the Foam liquid is added to slurry to form the Foam. The function of Foam liquid is to create an air bubbles in cement–based slurry. The Foam is generated separately by using Foam generator, where the Foaming agent is diluted with water to create the Foam. The Foam Concrete mixture becomes too stiff with lower content, causing bubbles to break, whereas the mixtures becomes too thin to hold the bubbles with high water content, leading to the separation of bubbles from the mixture, water-cement (w/c) ratio usually ranges from (0.4–1.25). The Foam Concrete can be designed to have any density within the dry density range of (300–1850 kg/m3). This project includes study many application of form concrete in construction works.

Keywords: foam concrete, lightweight concrete, cement–based slurry, foam generator

1. Introduction

Foam concrete is the concrete that can be used for a variety of purposes and in different locations of the building and its lightweight concrete because of its low density. One of the most important characteristics of Foam Concrete, its high ability to prevent the leakage of heat, sound and fire through the slab, walls and floors and lack of absorption of water in addition to being cheaper than normal concrete and it will reduce the overall density of building.

Foamed Concrete can have a range of compressive strengths (1-15) Mpa and its typically consists of slurry of cement, water with fly ash or fine sand may be added at a uniform rate for the purpose of obtaining specific density, compressive strength and according to the purpose used for it although some suppliers recommend pure cement and water with the Foaming agent for very lightweight mixes. This slurry is further mixed with synthetic aerated Foam in a concrete mixing plant. The Foaming agent used must be able to produce air bubbles with a high level of stability, resistant to the physical and chemical processes of mixing, placing and hardening. Water is an important element in foam the Foam Concrete, its mixes with materials and reacts to obtain a foam cement mixture, and is added to the concrete after several tests to ensure that the (W/C) ratio is (50-60%). water can be increased or decrease in the mixture depending on materials additives that used. Foam Concrete mixture may be poured or pumped into the molds or directly into the structural elements.

2. History

The history of Foam Concrete dates back to the early of (1920 s) and the production of autoclaved aerated concrete, which was used mainly as insulation [2]. Initially, Foam Concrete was used in the Netherlands for filling the voids and for ground stabilization also it used in Sweden as a 1923 invention for use as a dielectric, and its use was limited in this area until 1954. A detailed study on Foam concrete concerning on the composition, physical properties and the production of Foamed Concrete was first carried out in the (1950 s -1960 s). [3, 4, 5] Following this research, new admixtures were developed in the late (1970 s) and early of (1980 s), which led to the commercial use of Foamed Concrete in the construction projects.

3. Advantages and Disadvantages of Foam Concrete

3.1 Advantages

1. Using Foam Concrete walls in the superstructure, the weight will reduce and cause decrease in the amount of steel reinforcements that required for slabs, columns, beams and foundation due to lesser load.
2. Using Foam Concrete walls in multi-story buildings, Earthquake resistant will be lessening due to lesser weight of building that built from lightweight Foam Concrete.
3. Foam Concrete suitable for buildings in the hurricane, cyclone and flood affected areas as the damage caused by Foam Concrete walls and roofs are minimal compared to conventional concrete based structures.
4. Foam Concrete material reduced the cost of raw materials, by adding air, enclosed in Foam bubbles, the volume of concrete can be increased at very low cost [6].
5. Cost reduction for transportation because of lightweight materials, very efficient Foam concentrate.
6. Foam Concrete faster for construction by using the cast-in-situ application
7. Foam Concrete improved the thermal insulation: it's can achieve the same insulation results as compared with normal concrete with only (20%) of the weight and (10%) of raw materials.
8. Foam Concrete improved the fire protection: for example, a wall of (130 mm) thickness and (1,250 kg/m³) can withstand a fire for (5 h) also a wall of (100 mm) thickness

and only (400 kg/m³) achieves the same result, due to the air enclosed in the cellular concrete.
9. Foam Concrete has low investment: Just one simple machine required.
10. Foam Concrete has high flowing capability: Can fill hollow spaces.
11. Foam Concrete has low water absorption: Only (10–15)%, if the specific Foaming agents are being used in combination with silicon oil in the cement slurry, the water absorption rate can be decreased to only 1% [6].

3.2 Disadvantages [7]
1. Foam Concrete very sensitive with water content in the mixtures
2. Foam Concrete difficult to place and finish because of the porosity and angularity of the aggregate. In some mixes, the cement mortar may separate the aggregate and float towards the surface
3. Mixing time of lightweight Foam Concrete is longer than normal concrete to assure proper mixing

4. Types of Foam Concrete Properties as [9]
1. Fresh state properties to be familiar with the consistency and stability
2. Physical properties to recognize the drying shrinkage, air-void system and density
3. Mechanical properties to identify the compressive strength, flexural and tensile strengths and modulus of elasticity
4. Thermal properties to classify the thermal conductivity, thermal expansion, specific heat and flammability
5. Strength prediction models
6. Durability of Foamed Concrete such as permeation characteristics and resistance to aggressive environment
7. Functional characteristics for instance thermal insulation, acoustical properties, and fire resistance.

Lightweight Foamed Concrete depends on many characteristics for its different applications in the building construction. There are some guidelines on production and processes to produce the best lightweight Foamed Concrete.

The Strength of Lightweight Foamed Concrete Can Be Increase By [9]
1. By decreasing the porosity (less foam),
2. By using finer sand (Fine Aggregate), less than (5 mm)
3. By introducing or providing small air bubbles between (0.1 mm and 1.5 mm) with uniform distribution
4. By using the fly ash and silica fume for pozolanic reaction,
5. By air curing (compared to sealed/ water curing)
6. usage of polypropylene.

Table 1: Typical properties of Foamed Concrete based on British Concrete Association (BCA)

Dry Density (kg/m3)	Compressive strength (N/mm2)	Thermal Conductivity (W/mK)	Modulus of Elasticity (kN/mm2)	Dry Shrinkage (%)
400	0.5 – 1.0	0.10	0.8 – 1.0	0.30 – 0.35
600	1.0 – 1.5	0.11	1.0 – 1.5	0.22 – 0.25
800	1.5 – 2.0	0.17 – 0.23	2.0 – 2.5	0.20 – 0.22
1000	2.5 – 3.0	0.23 – 0.30	2.5 – 3.0	0.15 – 0.18
1200	4.5 – 5.5	0.38 – 0.42	3.5 – 4.0	0.09 – 0.11
1400	6.0 – 8.0	0.50 – 0.55	5.0 – 6.0	0.07 – 0.09
1600	7.5 – 10.0	0.62 – 0.66	10.0 – 12.0	0.06 – 0.07

5. Production Methods
Foaming admixtures is based on (BS8443: 2005). Barnes 2009 and Ramamurthy 2009 discussed the method of producing the Foam, known as Wet method and Dry method [9].

A. Wet Foam has a large loose bubble structure. Although the stable, isn’t recommended for the production of Foamed Concretes with densities below (1000 kg/m3). It involves spraying a solution of the agent and water over a fine mesh, leading to Foam with bubbles of size between (2 – 5) mm
B. Dry Foam is extremely stable. The stability is a characteristic that has become increasingly important as the density of the Foamed Concrete reduces. It’s produced by forcing a solution of Foaming agent and water through restrictions whilst forcing compressed air into the mixing chamber. The resulting bubble size is smaller than wet foam, i.e. less than (1 mm) in diameter.

After the Foam is stable, it can be mixed into the concrete by two methods (Barnes 2009), i.e. the inline method or pre-foam method [9].

i) Inline Method
Cement, fine aggregate (sand) and the water are placed into a same unit where they are blended together with the Foam. The mixing process is more controlled and greater quantities can be easily produced. There are two types of processes depending on whether the wet method or dry method is used.

In wet method, the base materials are the same as those used in the pre-foam system but are generally wetter. The base material and the Foam are fed through a series of static inline mixers where the two are mixed together. The Foam and the base materials are blended together and continuously monitored by an on-board density monitor. The output volume isn’t governed by the size of the pre-mix concrete truck but by the density of the Foamed Concrete, where (18 m3) delivery of base material can produce (35 m3) of a (500 kg/m3) Foamed Concrete [9].

ii) Pre-Foam Method
In pre-Foam method, pre-mix concrete truck delivers the base materials to site and then the pre-formed Foam is injected directly into the back of the truck whilst the mixer is rotating.

The advantage of this method is that, relatively small quantities can be ordered. However, it does rely on the mixing action of the concrete truck. Densities in the range of (300 to 1200) kg/m3 can be achieved. Typically Foamed air in this method is in the range of (20% to 60%) of air [9].

6. Foam concrete can be classified according to its density

1. Foam concrete density (300-600) kg / m3 used in thermal insulation, sound and soil replacement and support and installation are also used in the floors and ceilings and settlement and fill of blanks and bridges and supports instead of soil and the rules of subways and in the applications of drilling and mining.
2. Foam concrete density (600-1200) kg / m3 used in the production of lightweight blocks and the production of finished panels and in the decoration and decoration of the gardens.
3. Foam concrete with density (1200-1600 kg / m3) used in the production of prefabricated panels and in the works of floors and walls loaded and sound barriers are also used as boards in highways and walls of walls and bullet proof Figure 4 shows some applications of foam concrete.

7. Application of Foam Concrete

Foam concrete has several and always increasing applications in all types of construction work. Generally the application of foam concrete is depend on its density. The application are commonly for constructions, houses, highway constructions, blinding, void filling, footing, tunnel lining, trench reinstatement, roof insulation and others.

In Practice, Applications of Foam Concrete Can Be Divided Into Three Uses

1. **Precast Units:** Foam concrete is poured directly into molds or in metal casings. After the foam is poured, the molds are removed and concrete molds are left to dry. This method is used in wall and ceiling panels. The excellent insulation properties of low-density foamed concrete (foam concrete containing a large amount of bubbles) are of great use for buildings, where the light weight of walls and panels is very suitable for roofs and surfaces. The various sizes of foam concrete are used extensively for walls and facades and are easy to use.
2. **Building Blocks:** Block is a known form of foam concrete in its production. Foam concrete can be poured directly into the molds of the small size block. The bricks can also be poured into large molds and then cut off after casting them from the molds. Desired sizes.
3. **Site Casting (Floors, Insulating Ceilings and Wall Fillings):** Foam concrete is suitable for use as an additional layer of flooring, as it helps to level the floors in addition to noise insulation. Foam concrete mixtures are also used as a heat insulating layer for flat roofs.

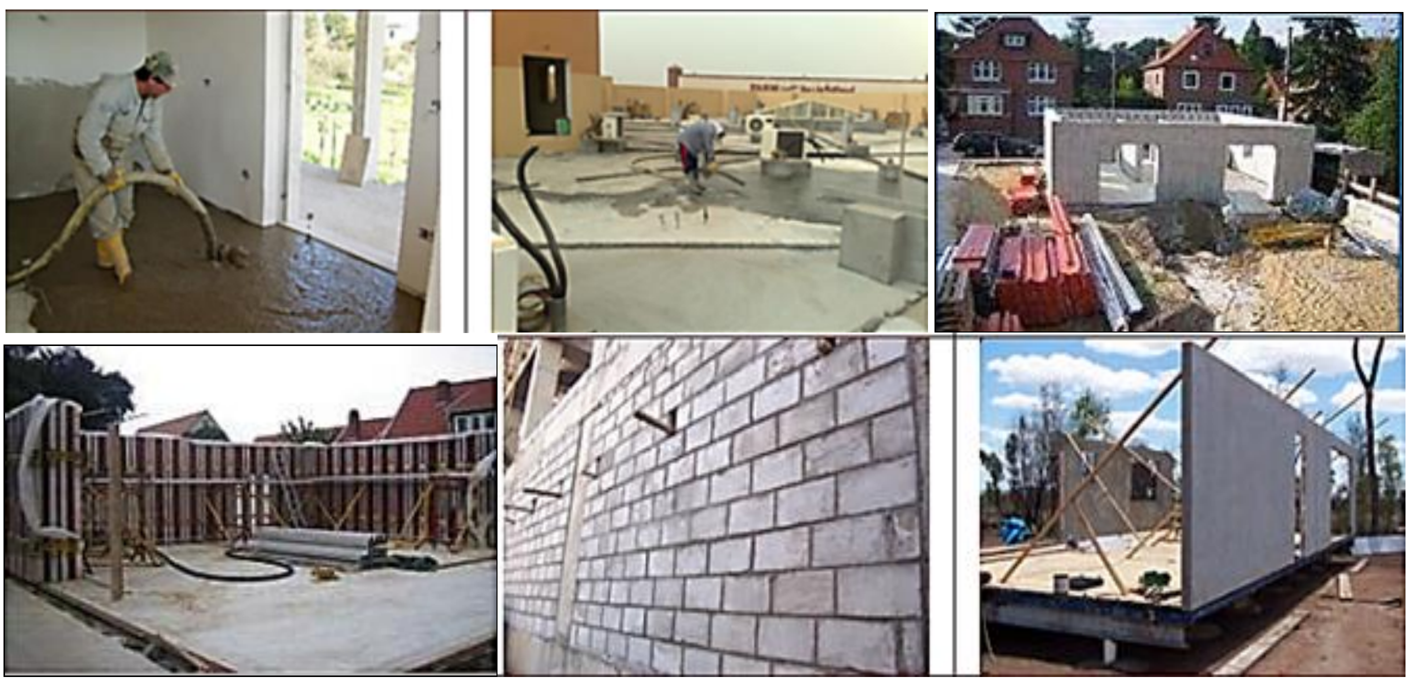

Fig 1: Different applications of Form Concrete

8. Case Study

8.1 Use foam concrete in the project of the city of residential architecture in the province of Maysan in southern of Iraq.

Details of project

1. The project consists of (800) houses
2. Building area of one house (60 m2)
3. A (10 cm) thick cleaning layer was casted
4. (Ø 12) and (Ø 8) steel reinforcement was used in the Raft foundation
5. A solid base (Raft foundation) of (40 cm) was casted above cleaning layer
6. Iron (BRC) was used in the casted the walls
7. The iron (BRC) was connected with the base (Raft foundation) by reinforcing steel (Dowels)
8. Two layers of Wire mesh were used in casting the walls
9. (20 cm) thickness of each wall
10. The molds are placed to form a full house where the house is casted as one section
11. The molds remain for (20 days) and then are opened
12. Fibers were used to increase concrete resistance

Fig 2: Details of steel reinforcement and casted the foundation

Fig 3: Put the Molds before the casting

Fig 4: Casting the house

Fig 5: Open the Molds after (20 days)

Oven-Density in KG/m³			400	600	800	1.000	1,200	1.400	1.600	2.316 Conv.concr.
Sand	(kg)		-	210	400	560	750	950	1.100	1.815 gravel+sand
Cement	(kg)	+	300	310	320	350	360	380	400	320
Water in mortar	(kg)	+	110	110	120	120	140	150	160	180
Quantity of Foam	(Ltrs)		(800)	(715)	(630)	(560)	(460)	(370)	(290)	-
Water in Foam	(kg)	+	64	57	50	45	37	30	23	-
Wet Density	(kg/m³)		474	687	890	1.075	1.287	1.510	1.683	2.315
Foaming Agent use	(kg)		1,5	1,4	1,2	1,1	0,9	0,7	0,6	-
Water/Cement Ratio			0,58	0,54	0,53	0,47	0,49	0,47	0,46	0,56
Maximum Strength in N/mm²			~ 1	~ 2	~ 3	~ 4	~ 8	~ 12	~ 18	40 +
Average Lambda (W/m x K)			0,096	0,18	0,21	0,32	0,405	0,450	0,550	2,10

(Achieved strength at the lab with optimum sand and cement qualities) More cement will increase strength. Using lightweight aggregate in matrix of Cell. Concrete increases strength up to 500% in overall densities below 1.000 kg/m³

GENERAL REMARKS

Recommended weight of foam	Minimum 80 g/ltr
Crushed Sand might mechanically destroy part of the foam	
Water to process foam	Potable, if possible below 25°C
Dilution of foaming agent	1 part of Neopor to 40 parts of water
Recommended Cement	Portland CEM I 32,5R or higher grade, or similar
Recommended Sand	Washed river sand, Density/Sieve :Up to 1.000/up to 2mm; Minimum 15-18% fines; Up to 1.200/up to 4 mm; Up to 1.400/up to 5 mm; Up to 1.600/up to 6 mm

1 kg of Neopor foaming agent, diluted in 40 parts of water yields approx. 510 litres of foam at 80 grams/litre

Captive densities are oven-dry (24h at 100°C)
Appr. 25% of the total volume of water (in mix and in foam) in relation to the weight of cement used will crystallize and therefore will have to be added to the dry-weight of the cement and sand used to reach the "oven-dry" density.

Fig 6: Details of Form Material used in Maysan project

8.2 Production of Bricks from Foam Concrete

1. The use of bricks made of foam concrete will contribute to reducing the use of cement in construction by up to 40%. The components of this type of bricks are 40% of cement, 40% sand, 10% foam and 10% special materials. The cost of producing bricks is very low, as it is limited to 40% of cement.
2. Other advantages of this type that it will be insulating to heat, fire, humidity, salts and sound, which reduces the consumption of electricity, by reducing the work of cooling and heating devices and the use of expensive and multiple condoms,
3. This type of bricks do not drown in water, but floats on the surface of the water, whatever the size of the block
4. This type of brick is characterized by high durability and strength of hardness 20 kg / cm 2 at density 600 kg / m 3 to 300 kg / m 3 at the density 800 kg / m 3.

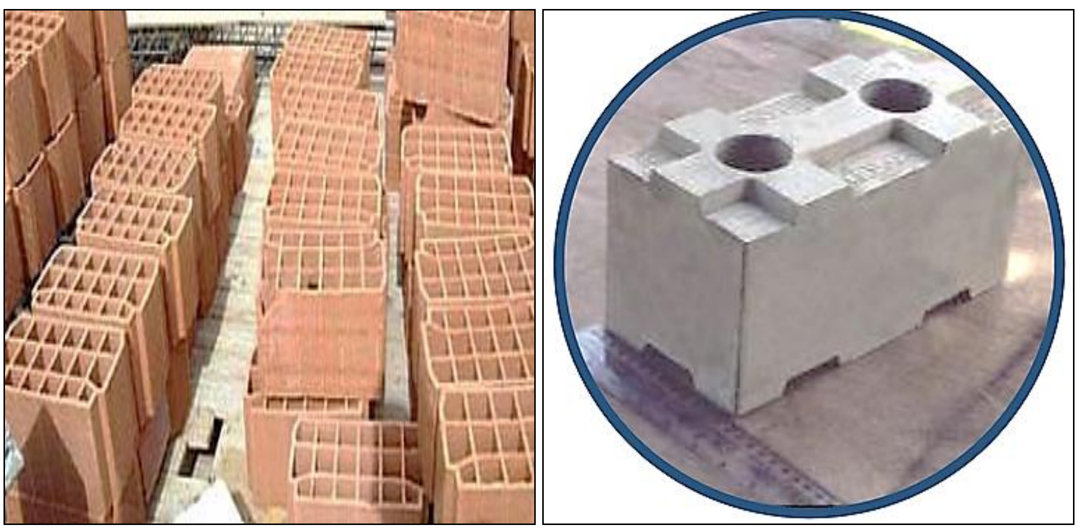

Fig 7: Blocks product from Foam Concrete

8.3 Use the Foam Concrete in the Waffle Slab

Recently, most countries in the world has used the Waffle slab instead of the traditional slab. A blocks are product from foam concrete of low density are used as a stuffing of the roof nerves resulting from ordinary concrete in order to reduce the load on columns and foundations of buildings in addition to reducing the costs of these slab and for the benefit of the property thermal and acoustic insulation of these concrete blocks.

9. Conclusions

1. The Density of Foamed Concrete is inversely proportional to the percentage of foam that is added to the mortar.
2. Foam Concrete is an economical material because it reduces the total cost of the concrete used in the building because Foam Concrete is cheaper than normal concrete
3. The use of Foam Concrete in the construction works helps to reduce the load on the foundations, columns and beams because of its density ranges from (300 - 1600) kg / m3 while the density of normal concrete ranges from (2200 - 2600 kg / m 3)
4. The Compressive Strength and Density of Foam Concrete increases with the age
5. The Compressive Strength of Foamed Concrete increases

with increase in the Density.

6. The Strength gain for foamed concrete is higher than that of normal concrete because used the Fiber

10. References

1. Vikram Kaintura. [M.Tech Student, Department of Civil Engineering, Faculty of Technology, Uttarakhand Technical University, Dehradun, India], Sangeeta Dhyani, [Head of the Department (HOD), Department of Civil Engineering, Faculty of Technology, Uttarakhand Technical University, Dehradun, India]
2. Sach J, Seifert H. Foamed concrete technology: possibilities for thermal insulation at high temperatures. CFI Forum of Technology, DKG. 1999; 76(9):23-30.
3. Valore RC. [Cellular concrete part 1 composition and methods of production, ACI j. 1954; 50:773-96.
4. Valore RC. [Cellular RC, Cellular concrete part 2 physical properties. ACI J. 1954; 50:817-36.
5. Rudnai G. [Lightweight concretes]. Budapest, Akademikiado, 1963.
6. Ecowall Project (http://ecowall.ecocrete.eu/EN_2_0.htm), Retrieved, 2015.
7. Lee Kun guan. [performance of foamed concrete using laterite as sand replacement], universiti malaysia pahang, November, 2010.
8. [Lightweight concrete (types and applications)], Nawaz Sabah Nadir, http://keu92.org/uploads/Search%20engineering/Awaz%20Sabah%20Nader.pdf
9. Kamarul Aini Mohd Sari1. Abdul Rahim Mohammed Sani2, [Applications of Foamed Lightweight Concrete], Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 1963.