Advanced material foam concrete

A Report Submitted by Building construction engineer

Shagul Yaseen Rostam (KEU ID No.: 8944)

to Promote

"Consultant Engineer"

Date: February/2024

Contents

Table of contents...2

ABSTRACT 3

Advanced material foam concrete..4

INTRODUCTION 4

HISTORY 5

WHAT IS FOAM CONCRETE 5

MANUFACTURE OF FOAM CONCRETE...............................6

PROPERTIES OF FOAM CONCRETE...................................9

Flexural and tensile strengths.......................................10

Durability of foam concrete..10

Resistance to aggressive environment................................11

Functional characteristics 11

.

FOAM CONCRETE APPLICATIONS......................................12

ADVANTAGES OF FOAM CONCRETE.................................14

DISADVANTAGES OF FOAM CONCRETE...........................14

Foam Concrete Mix Design 15

References and Resources 16

ABSTRACT. This paper will explain the history, development and applications of foamed materials, definition of the material, along with typical properties including strength, density and thermal characteristics. The various methods of production from established methods to future ones are presented as well as mix designs, and the effect foaming chemicals and types of foam have on the material. A number of case studies are detailed including the use of foamed concrete on Highways works, bridges, tunnels and large void infills.

Advanced material Foam concrete

INTRODUCTION

Foam concrete, is also known as **air Crete**, **foamed concrete foam-Crete cellular lightweightconcrete** or **reduced density concrete.**

- **It is defined as a cement-based slurry, with a minimum of 20% (per volume) foam entrained into the plastic mortar.**

- **As mostly no coarse aggregate is used for production of foam concrete the correct term would be called mortar instead of concrete; it may be called "foamed cement" as well.**

- **The density of foam concrete usually varies from 400 kg/m³ to 1600 kg/ m³. The density is normally controlled by substituting fully or part of the fine aggregate with foam.**

- **Foam concrete is differentiated from air entrained concrete in terms of the volume of air that is entrained.**

• The air entrained concrete takes in the air of 3 to 8 percent. It also differs from the retarded mortar and aerated concrete for the same reason of percentage of air entrained.

• In the case of retarded mortar systems, it is 15 to 22 percent.

• The bubbles are chemically formed in the case of an aerated concrete.

HISTORY

• Foamed concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material.

• The first comprehensive review on foamed concrete was presented by Valore in 1954 and a detailed treatment by Rudnai and Short and Kinniburgh in 1963, summarising the composition.

•Significant improvements over the past 20 years in production equipment and better-quality surfactants (foaming agents) has enabled the use of foamed concrete on a larger scale.

WHAT IS FOAM CONCRETE?

Foam concrete is a cement-bonded material made by blending an extremely fluid cement paste (slurry), into which is injected a stable, pre-formed foam, manufactured on site.

This is lightweight concrete that is produced by the addition of a synthetic or protein-based air entrainer which is added to the concrete with the use of a foam generator. The admixture entrains an inert bubble in the concrete thus reducing the density of the concrete. The foam can be added at the plant if traveling time is less than 30 minutes or on site – it is however, preferable to add the foam on site. If adding on site water and electricity must be available.

MANUFACTURE OF FOAM CONCRETE

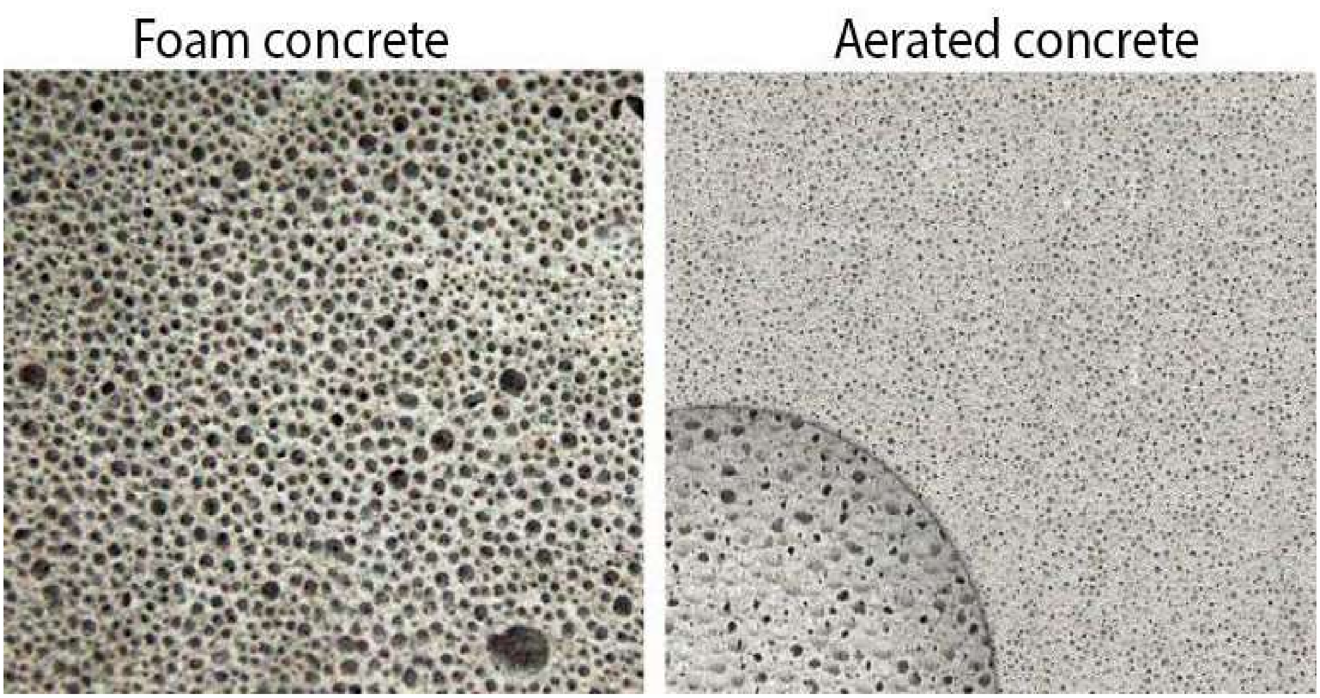
Foam concrete is produced either by: -

1) Pre-foaming method

Pre-foaming method comprises of producing base mix and stable preformed aqueous foam separately and then thoroughly blending foam into the base mix.

2) Mixed foaming method

In mixed foaming, the surface-active agent is mixed along with base mix ingredients and during the process of mixing, foam is produced resulting in cellular structure in concrete.



• The components of foam concrete mix should be set by their functional role in order as follows:

. Foaming agent

. Binding agent

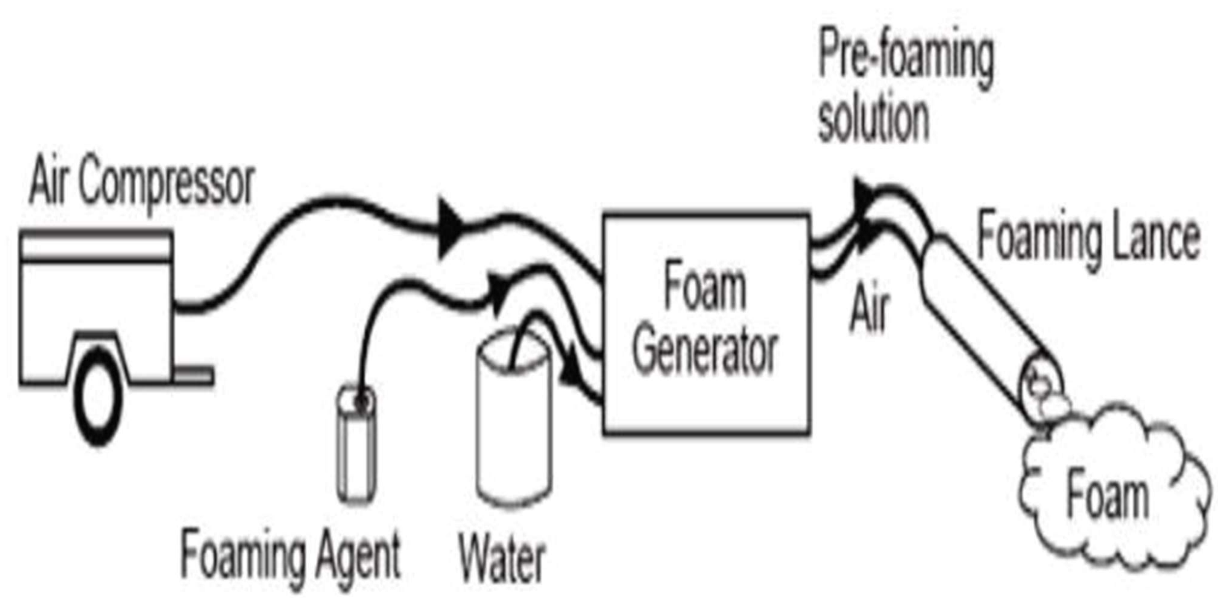
. Water

. Fine Aggregate

. Admixtures.

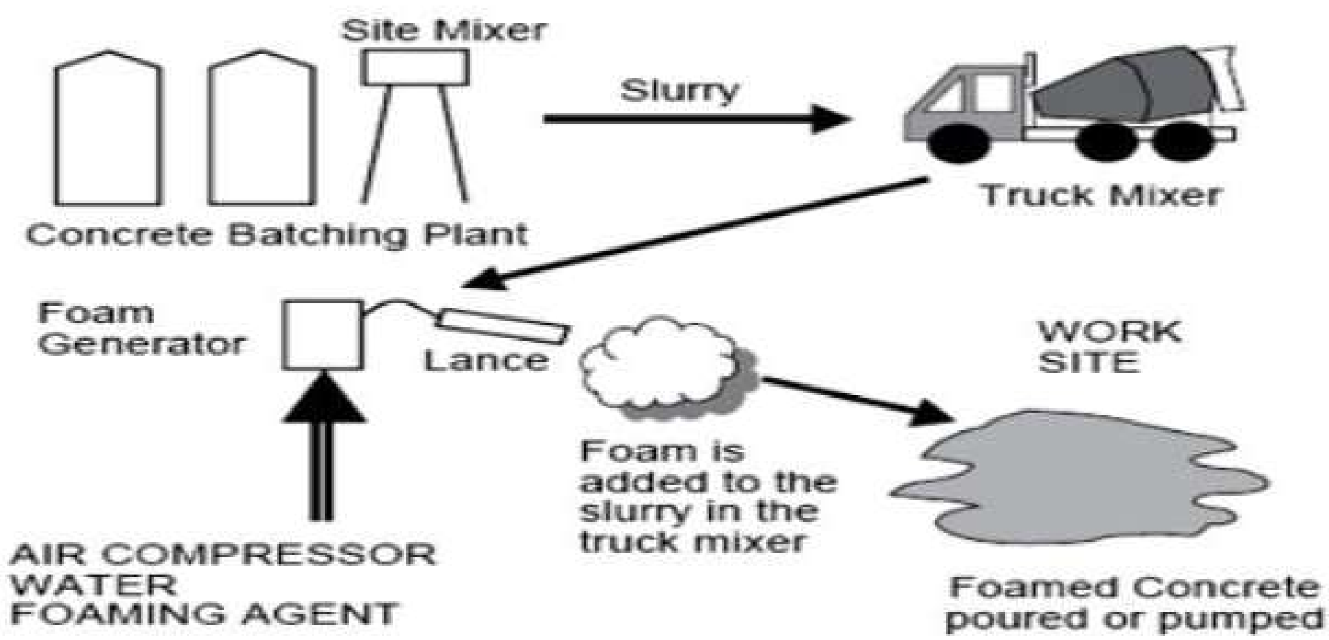
• Foamed concrete typically consists of a slurry of cement or fly ash and sand and water, although some suppliers recommend pure cement and water with the foaming agent for very lightweight mixes.

• The foaming agent used must be able to produce air bubbles with a high level of stability, resistant to the physical and chemical process es of mixing, placing and hardening.



Making foam from foaming agent, water and compressed air.

- Foamed concrete mixture may be poured or pumped into molds, or directly into structural elements.
- The foam enables the slurry to flow freely due to the thixotropic behavior of the foam bubbles, allowing it to be easily poured into the chosen form or mold.
- The viscous material requires up to 24 hours to solidify (or as little as two hours if steam cured with temperatures up to 70 °C to accelerate the process.), depending on variables including ambient temperature and humidity.
- Once solidified, the formed produce may be released from its mold.



A Schematic diagram showing the stages involved when making foamed concrete.

PROPERTIES OF FOAM CONCRETE.

• Foam concrete is a versatile building material with a simple production method that is relatively inexpensive compared to autoclave aerated concrete.

• Foam concrete compounds utilizing fly ash in the slurry mix is cheaper still, and has less environmental impact.

• Foam concrete is produced in a variety of densities from 200 kg/m^3 to 1,600 kg/m^3 depending on the application.

• Lighter density products may be cut into different sizes. While the product is considered a form of concrete (with air bubbles replacing aggregate), its high thermal and acoustical insulating qualities make it a very different application than conventional concrete.

• The workability of foamed concrete is very high and has a slump value of 150mm to collapse. These have a strong plasticizing effect. This property of foam concrete makes it highly demanded in most of the applications.

• Foam concrete in the fresh state is thixotropic in nature.

• The chances of bleeding in foamed concrete are reduced due to high air content. When the mix temperature increases, good filling, and contacts are carried out due to the expansion of air.

• Free fall of foam concrete at the end with turbulence, may result in the collapse of the bubble structure.

Flexural and tensile strengths

. Splitting tensile strengths of foam concrete are lower than those of equivalent normal weight and lightweight aggregate concrete with higher values observed for mixes with sand than those with fly ash.

. Use of Polypropylene fibers has been reported to enhance the performance with respect to tensile and flexural strength of foam concrete.

Durability of foam concrete

- Permeation characteristics
- Resistance to aggressive environment

- Permeation characteristics

- *Water absorption*: Water absorption of foam concrete decreases with a reduction in density, which is attributed to lower paste volume phase and thus to the lower capillary pore volume.

-The oxygen and water vapor permeability of foam concrete have been observed to increase with increasing porosity and fly ash content.

-Septicity: The moisture transport phenomenon in porous materials has been defined by an easily measurable property called septicity (absorbing and transmitting water by capillarity), which is based on unsaturated flow theory.

-Septicity of foam concrete is reported to be lower than the corresponding base mix and the values reduce with an increase in foam volume.

Resistance to aggressive environment

-Foam concrete mixture designed at low density taking into consideration of depth of initial penetration, absorption and absorption rate, provided good freeze-thaw resistance

-Sulphate resistance of foam concrete, reveals that foam concrete has good resistance to aggressive chemical attack.

Functional characteristics

Thermal insulation

-Foam concrete has excellent thermal insulating properties due to its cellular microstructure.

-The thermal conductivity of foam concrete of density 1000 kg/m^3 is reported to be one-sixth the value of typical cement–sand mortar.

Fire resistance

- Foam concrete is extremely fire resistant and well suited to applications where fire is a risk. Test have shown that in addition to prolonged fire protection, the application of intense heat, such as a high energy flame held close to the surface, does not cause the concrete to spall or explode as is the case with normal dense weight concrete.

FOAM CONCRETE APPLICATIONS

- Precast blocks
- Precast wall elements / panels
- Cast-in-situ / cast-in-place walls
- Insulating compensation laying
- insulation floor / roof screeds
- Filling of sunken portion.
- Trench reinstatement.
- Sub base for highways.
- Filling of hollow blocks.
- Prefabricated Insulation boards.
- Foam concrete is fire resistant.

-**Building Blocks** : Blocks and panels can be made for partition and load bearing walls. They can be made with almost any dimensions.

-**Floor Screed:** Foamed concrete can be used for floor screeds, creating a flat surface on uneven ground and raising floor levels.

-**Roof Insulation:** Foamed Concrete is used extensively for roof insulation and for making a slope on flat roofs. It has good thermal insulation properties and because it is lightweight foamed concrete does not impose a large loading on the building.

-**Road sub-base:** Foamed Concrete is being used road sub base on a bridge. Foamed concrete is lightweight so that the loading imposed on the bridge is minimized.

POURING

ADVANTAGES OF FOAM CONCRETE.

• The foam concrete mix does not settle so no compaction required.

• Reduction in dead weight as it is light weight concrete

• The foamed concrete under its fresh state has freely flowing consistency. This property helps in completely filling the voids.

• It has excellent load spreading and distributing capability.

• The Water absorption property.

• The foam concrete batches are easy to produce, so quality check and control are easily done.

• The foam concrete has higher resistance to freezing and thawing.

• Non-hazardous and faster work completion

• Cost effective, less maintenance

DISADVANTAGES OF FOAM CONCRETE.

• Presence of water in the mixed material make the foam concrete very sensitive

• Difficulty in finishing

• Time of mixing longer

• With the increase in density, the compressive strength and flexural strength decreases.

Foam Concrete Mix Design

Components for 1cub.m. of foam concrete:

(with foam agent Green Froth and foam generator foam-PGM)

Recommended weight of foam which is delivered to the mortar 5 g/l

Density of foam concrete	400	600	800	1000	1200	1400	1600
Sand	-	210	400	560	750	950	1100
Cement	300	310	320	350	360	380	400
Water for concrete mix	110	110	120	120	140	150	160
Water for foam	40	36	32	28	23	19	15
Amount of foam (liter)	800	715	630	560	460	370	290
Amount of foam agent Green Froth, kg	1	0.9	0.8	0.7	0.58	0,48	0,38
The weight of wet foam concrete	474	687	890	1075	1287	1510	1683
Cement/water ratio	0,58	0,54	0,53	0,47	0,49	0,47	0,46

1. Sand – clean washed dune sand of nominally 1.5mm grain size maximum
2. Cement – Portland cement DIN 1164 I 42,5

Recommended weight of foam which is delivered to the mortar 5 g/l

With the addition of *fly ash*

Density of foam concrete	400	600	800	1000	1200	1400	1600
Fly ash	90	275	450	520	730	900	990
Cement	300	270	290	310	320	320	340
Water for concrete mix	110	110	120	120	140	150	160
Water for foam	40	36	32	28	23	19	15
Amount of foam (liter)	800	715	630	560	460	370	290
Amount of foam agent Green Froth, kg	1	0.9	0.8	0.7	0.58	0,48	0,38
The weight of wet foam concrete	474	687	890	1075	1287	1510	1683
Cement/water ratio	0,58	0,54	0,53	0,47	0,49	0,47	0,46

Important! The overfired oxides of calcium and magnesium should not be in the mixture
The composition Sio2 not less than 45%, Cao not more than 10 %, R2O not more than 3 %,Mg not more than 4 %

References and Resources

1- Md Azree Othuman Mydin, Wang YC. Elevated-temperature thermal proper- ties of lightweight foamed concrete. J Constr Building Mater, in press, Doi: 10.1016/j.conbuildmat.2010.07.016.

2- Experimental Study of Foam Concrete by Using Different Mixes By
Aajma Kaushar1, Mr. Himanshu Shrivastav2

3-Some sources from the Internet