Review of Foamed Concrete

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Abstract- Foamed concrete as a new type of lightweight, high-strength and energy-saving building materials, it is widely used in the construction industry. This paper concludes that foam concrete can be an effective sustainable material for construction and also focuses on the cost effectiveness in using foam concrete as a building materialin replacement with clay bricks or other brick. As its high quality performance and broad space for development, Foamed concrete has been respected by the construction industry. There are two tests that have been done which are Mini Slump Cone Test and Compressive Strength test. The compressive strength test of the foamed concrete cubes was measured at the ages of 7, 14 and 28 days. This paper which based on the foam concrete properties and preparation process analyses the research progress of Blending material, admixtures and fibers’ effect on the performance of foamed concrete, puts forward the problem about development and application of the foam concrete in current research, and points out that the sustainable development is the basic idea of the foam concrete further research and application in future.

Index Terms- Foamed Concrete; Preparation Technology; Performance.

1. INTRODUCTION

This type of concrete lighter than normal concrete due to the foam that has been used. The main specialties of this concrete are its low density and thermal conductivity. Foamed concrete is manufactured by a kind of mechanical foaming method, which makes the vesicant foam in the foaming system of the foaming machine, then the foam can be fully and evenly mixed with the material such as cement paste. And then we construct or mold by the pumping system inside the foam machine. It is a new type of building materials which contains many closed bubbles and is formed in the natural conservation. Because of the foam concrete has light weight, good insulation properties, good fire-proof performance, good seismic performance, durability and other excellent construction performance, it has a very broad application prospect and significance of the research in the construction market in our country.

1. LITERATURE REVIEW

The term foam concrete is containing no aggregates only sand, cement, water and stable foam to perform the concrete. This action incorporates small enclosed air bubbles within the mortar there by making the concrete lighter. A foamed concrete is described as having an air content of more than 25% which distinguishes it from highly air entrained materials. Foamed concrete may have density from as low 500kg/m3 to 1600kg/m3 and strength from less than 1N/mm2 to 25N/mm2. The stable foam is the most important gradient in the production of foamed concrete. The foaming generator made foam, where is blend of sand, cement, and water (the base mix) and foaming agent either protein or synthetic are mixed and produced stable foam is foamed. According to a study by (Norizal, 2002) state that foams from protein foaming agent comes from natural sources and has a weight of around 80g/litre and expansion of about 12.5 x using port form foam generator. They generally are more stable then synthetic foams but have a shorter shelf life of about 12 month in open conditions. They also give a higher strength of concrete compared to synthetic foams. This is suitable for densities from 400kg/m3 to 1600kg/m3.

According to a study by (Norizal, 2002) state that synthetic foams have density of about 40g/litre with an expansion of about 25 x using portofoam. They are very stable at concrete densities above 1000kg/m3 and give good strength. Their shelf life is about 16month under sealed condition. This is suitable for densities of 1000kg/m3 and above.
3. CHARACTERISTICS OF FOAMED CONCRETE AND ITS PREPARATION PROCESS

Characteristics of foamed concrete

1. Light weight. The density of foamed concrete is lower than ordinary concrete about 50%-80%, and its apparent density is usually maintained at 300-1200kg/m³. Because of its low density and small load, the weight of today's construction can reduce weight about 25% whether its application on the inside(outside) wall or column structure, sometimes even reach 30%-40% of the overall quality of the structure.

2. Good heat-insulating property. Foamed concrete is a kind of heat preservation and insulation material which is mainly used in building wall and roof, and has high efficiency of energy saving. Its interior has many uniform pores which control the air in a large part and prevent from the cold and the heat exchanging. The thermal conductivity of the commonly used foam concrete is about 0.1W/(K/m), which is 7 times less than that of the clay brick and 14 times less than that of the ordinary cement concrete.

3. High fire resistance and sound insulation. Foamed concrete is mainly composed of cement paste, aggregate, other inorganic materials characteristics of spontaneous combustion) and dispersed pores, so it has the good fire resistance. At the same time, because of the existence of many closed pores, the foam concrete has a good sound insulation performance.

4. Good seismic performance. The foamed concrete is of light weight, small density and small elastic modulus. It is a kind of porous structure with many closed bubbles. The foam concrete is a kind of building material with excellent seismic performance when it is subjected to the action of earthquake wave, which can diffuse and absorb the impact load.

5. Other performance. Because of the porous structure, foamed concrete has good frost-resisting property and corrosion resistance. The foam comes from foaming machine in the stirring process can play a role in reducing the water and lubricating. The foam concrete can use large quantities of industrial waste and other materials, which is not only conducive to the environmental protection, but also reduce the production cost.

4. FOAMED CONCRETE MANUFACTURING

Foamed concrete is a lightweight, free flowing material which is manufactured by adding foam, prepared by aerating a foaming agent solution, to cement paste or 11 cement mortar. Figure shows the process of the manufacturing of the foamed concrete.

The 3 basic methods of producing foamed concrete are:
1. Pre-foamed method
2. Inline system wet method.
3. Incline system dry method.

1. Pre-foamed method

The pre-foamed method involves half a load (normally 3m³) or less, of base materials being delivered to site in a ready mix wagon, with the pre-foamed foam (either a wet or dry system) then injected directly into the back of ready mix wagon whilst it is on fast spin. The injection of the foam bulks the material up to a full load whilst lowering the density (Aldridge, 2005). The various foaming agents used are detergents, resin soap, glue resins, saponin, and hydrolysed proteins. Normally, the hydrolyzed protein based foaming agent been employed in the produces of the pre-foamed concrete. Inside the generator, the agent is diluted with water to make a pre-foaming solution which is then forced at high pressure through the foaming lance. This produces uniform and stable foam which has a volume of about 20 to 25 times that of the pre-foaming solution. Batchings of cement paste for adding the pre-foamed in to it to produced the foamed concrete. When batching of the cement paste a reaction of the cement paste will occur.

The three major disadvantages of this method are:

1. The manufactured volume is governed by the size of the truck.
2. The quality of foamed concrete is reliant on the mixing action of the truck to blend the foam.

3. If the material is out of specification then the whole is rejected. From experience it is known that some trucks mix better than others which can lead to large inconsistencies with both the density and consequently the yield of the foamed material. However if good reliable foam generators are used in conjunction with a modern fleet of truck mixers, and a correctly specified foamed concrete, then the results can be adequate (Aldridge, 2005). Using this method of foamed concrete production is it using a wet or dry foam generating system, although still practiced, is generally on the decrease due in the main to the material inconsistency and the associated problems.

2. Inline system wet method.

Inclined system (wet method) has been driven in the main part by the need for both higher product quality control and a commercial requirement for lower density material. These systems incorporate the same type of foam generator and foaming chemicals as used in the pre-foam method, but differs in that it excepts wet base materials into an onboard hopper and adds the foam through a completely separate process altogether. The base materials used in this method are generally wetter than the ones used in the pre-foam method but comprise of the same materials. These systems work by feeding the base material and the foam (dry type only) through a series of static inline mixers where the two components are mixed together. These mixers have the effect of blending the foam and the based materials together into a completely homogenized mix ensuring a completely repeatable mixing process along with a constant checking procedure via the continual onboard density monitor. Another advantages over the ore-foam method is that due to the method of production the output volume is not governed by the size of the ready-mix wagon, so one 8 cubic meter delivery of base materials from a ready-mix supplier will produce 35 cubic meters of a 500kg/m³ density foamed concrete. This is an extremely effective method of working, with truck movements reduced by 80% (Aldridge, 2005).

3. Incline system dry method

These inline systems in dry method are a relatively new development and are in the main operated in Europe although versions are gradually being accepted in the UK. They operate on a similar principal to the dry inline method but instead of accepting wet materials from ready-mix supplier they have dry materials loaded in on-board silo’s and aggregate bins. These materials can then be batched, weight and mixed on-site as required via on-board mixers. Once blended the base mix in then pumped to a mixing chamber where the foam is then added in a similar way to the dry method. A major disadvantage is that they require large amounts of water at site (to mix the cement and aggregate together) they are them unsuitable for congested city centre or projects where cannot be supplied at suitable rates.

![Figure 4.1 Manufacturing Process of Foam Concrete](image)

**5. MATERIAL OF FOAM CONCRETE**

6.1 Cement

Based on BS 12:1996, ordinary Portland cement is usually used as the main binder for foamed concrete. Portland cement is a hydraulic cement that when mixed in the proper proportions with water, will harden under water (as well as in air). The basic ingredient for Portland cement consists of:

1. Lime-rich materials, such as limestone, seashells, marl, and chalk that provided the calcareous components. 2. Clay, shale, fly ash, or sand to provided the silica and alumina. 3. Iron ore, iron containing shale, mill scale or similar material to provided.

6.2 Water
Water is one of the important material for the foamed concrete. The quality of the water must base on the BS3148. The criteria on of portability of water is not absolute. Water with Ph 6 to 8 is suitable for use. Natural water that is slightly acidic is harmless, but water containing humic or other organic acids may adversely affect the hardening of concrete.

6.3 Fine aggregate
Generally the fine aggregate shall consist of natural sand, manufactured sand or combination of them. For sand Sach & Seifert (1999) recommend that only fine sands suitable for concrete (to BS 882:1992) or mortar (to BS 1200: 1976) having particle sizes up to about 4 mm and with an even distribution of sizes should be used for foamed concrete.

6.4 Foaming Agent
KEMILITE-LW is a synthetic foaming agent used for producing controlled low density foam concrete. It can be added directly to the concrete or be added through foam generating equipment.

Product Specification
Physical Appearance – Light yellow translucent liquid
Specific Gravity – 1.0-1.05
pH - > 7.5
Chloride Content - < 0.10%

Dosage
Dosage may vary depending upon mix design, process, aggregate type and desired effect, however typically 200ml – 600 ml per 50 kg cement. In case of hard water, a higher dosage may be required.

6. CONCLUSION
Sustainable development is an eternal topic, we should make full use of all kinds of industrial waste slag or building materials to produce foamed concrete. At the same time, we should make comprehensive and meticulous research on the performance of foamed concrete, so that its excellent performance can be reasonable applied. The development direction of China's foamed concrete is clear, the policy environment is possessed, the application market is broad, we will make a breakthrough in the future and make it better serve the construction industries.

REFERENCES