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Experimental Research on Foam Concrete With Replacement of Sand by M-Sand

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ABSTRACT

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. The physical and mechanical properties of foamed concrete differ according to a different type of mixture and its composition.

1. INTRODUCTION

Foamed concrete is a material with a lot of practical aspects, a low weight and good thermal conductibility. Due to these good properties, the foamed concrete has been used so far mainly as a filling material. The applications in which the foamed concrete would be used as a load bearing material are until now scarce. The reason for that are the fairly low strength parameters. The parameters, which are possible to change during foam production, are air, pressure and water to concentrate ratio. The main aspect in foams is density and drainage, as it was used as a parameter of stability of foams. The air pressure influences both. With high air pressure the density and drainage are low. The second aspect to regulate the drainage is the water to concentrate value. With an increase of the water to concentrate ratio the stability goes up, without big changes in foam density. Foam is a dispersion of a gas in liquid or in solid. Foam is produced by distribution of gas in a liquid under the influence of a foaming medium, such as soap, oil, acid or a wetting agent. During the production small bubbles are formed and are separated from liquid by a membrane. Clearly, there are many different types of foams with various applications. Therefore, there are many different industries, which use foam-like products.

Samples are:

• Food industry
• Soap industry
• Industry of insulating materials
• Fire protection industry
• Industry for backfilling materials

FOAM GENERATOR:

There are three main parameters to control the foam generator:

• Water flow
• Water to concentrate ratio
• Air pressure

Water flow:

The water flow is difficult to influence, Herbst has added a valve between the water tube and the foam generator. From his work the average water flow inside of the HIF water supply system is known with an average flow.

Water to concentrate ratio:

The amount of concentrate, which goes into the generator by means of a special pump, can be continuously adjusted by a controller. One test series regarding this parameter, taken care of the range which is given by the producer, therefore new tests have been done to get the information about the water to concentrate ratio out with the recommended range.

Air pressure:

A manometer controls the air pressure at the generator. According to Herbst the air pressure is the best way to control density of the foam. It is relatively easy to vary the air pressure. To produce foams with different water to concentrate ratio and equal air pressure the manometer had to be readjusted.

2. FOAM CURING:

As for all materials, the performance of concrete is determined by its microstructure. Its microstructure is determined by its composition, its curing conditions, and also by the mixing method and mixer conditions used to process the concrete. Curing is used in the construction of structure such as bridges, retaining walls, pump house, large slabs and structured foundation. Curing is a process of preventing fleshly placed concrete from dying the first during the first day of its life to minimize any tendency to cracking and allow it to develop concrete strength. Curing begins after placement and finishing so that the concrete may develop the desired strength and hardness. To obtain good quality concrete, the process to preventing the loss of the moisture from the concrete whilst maintaining a satisfactory temperature regime is very important.

3. MATERIAL OF FOAMED CONCRETE:

Foaming Agent:

Foaming agents is also defined as air entraining agent. Air entraining agents are organic materials. When foaming agents added into the mix water it will produce discrete bubbles cavities which become incorporated in the cement paste. The properties of foamed concrete are critically dependent upon the quality of the foam.

There are two types of foaming agent:

i). Synthetic-suitable for densities of 1000 kg/m^3 and above.

ii).Protein-suitable for densities from 400 kg/m^3 to 1600 kg/m^3.

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.

Water:

Water is one of the important material for the foamed concrete. The criterion of portability of water is not absolute. Water with pH 6 to 8 which not tested saline or brackish 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. The present of algae in the mixing water will result in air entrainment with consequent loss of strength.

Fine aggregate:

Generally the fine aggregate shall consist of natural sand, manufactured sand or combination of them. the fine aggregate for concrete that subjected wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any material that deleteriously reactive in cement to cause excessive expansion of mortar concrete.

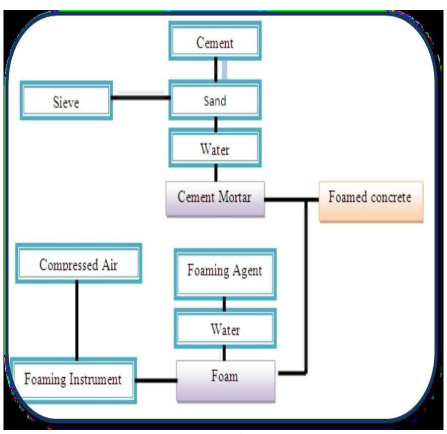

Figure 1. Flow chart for Foam Concrete preparation

4. EXPERIMENTAL TEST ON FOAM:

The concept for the experiments on the foam itself was to work with a constant water flow and run series of test on different values of water to concentrate ratio with a variation of the air pressure .Other tests about parameters like density or drainage were made to classify foams, but also to get some aspects about stability and indirect information about the bubble size distribution.

The tests are classified into two types:

- Compressive strength tests
- Tensile strength tests

4.1 Split Tensile Test On Concrete

The test consists of applying compressive loads along the opposite generators of a concrete cylinder placed with its axis horizontal between the platens of a compression testing machine. Due to the applied line loading a fairly uniform tensile stress is induced over nearly two-third of the loaded diameter. The magnitude of this splitting tensile stress (acting in a direction perpendicular to the line of action of applied compression) is given by

$$\sigma_{sp} = 2P/\pi dl$$

Where,

P = The applied compressive load at failure

d = Diameter of the cylinder

l = Length of the cylinder

Due to this tensile stress, the specimen fails finally, by splitting along the loaded diameter. Immediately under the load, a high compressive stress is induced. Therefore the load is applied through a packing of plywood strip, 25 x 4 mm in cross section. As the cylinder splits into two halves, the test is known as split test.

(i). Along a centre line parallel to the edges of a cube by applying two compressive forces through 15 cm square bars of sufficient length.

(ii). Along one of the diagonal planes by applying compressive force along two opposite edges.

In this investigation splitting tension test was performed on cylindrical specimens of size 150 mm diameter and 300 mm length. This test was conducted as per IS: 5816 – 1999.

The determination of flexural tensile strength is essential to estimate the load at which the concrete member may crack. The flexure tensile strength at failure is called modulus of rupture. This test is described in the next section.

4.2 Compression Test (Bs En 12390-3, 2002)

The compression test was conducted by using compressive strength machine. The test was performed in accordance with BS EN 12390-3 (2002). An axial compressive load with a specified rate of loading was applied to 100mm cube until failure The cubes were taken out from water tank and air-dried for two hours before the test was performed. Dimension of specimen was measured before the testing. This is to determine the cross-sectional area of specimen. Followed by that, the test specimen was placed at the center of the testing machine. Test specimen was loaded gradually with constant rate of loading of 0.02 mm/s until the specimen fails. The maximum load carried by the specimen was recorded and compressive strength was calculated based on Equation occurred. INSTRON 5582 Testing Machine was used to conduct the compressive strength test on the cubes. Mean value obtained from three cubes was then taken as cube compressive strength for each lightweight foamed concrete mix.

Figure 2. Casting of Cubes

Mix Proportions

The mix proportion of the lightweight foamed concrete incorporated with POFA was determined based on trial and error method. Trial mixes with various w/c ratio were carried out. The optimum mix proportion was determined based on density and strength of lightweight foamed concrete incorporated with POFA.

Trial Mix

During the trial mix stage, three types of mix proportion, namely LFC with 100 % sand as filler (LFC-CM), 10 % POFA replacement as part of filler (LFC-PF10) and 20 % POFA replacement as part of filler (LFC-PF20). The water to cement ratio for each type of mix proportion was tried from the range of 0.52 to 0.60 with the increment of 0.02 for each mix. Density for every mix was controlled to 1300 $kg/m^3 \pm 50 kg/m^3$.

Mixing Procedure

OPC, Sand and POFA were weighted and mixed in a concrete mixer until the dry mix was uniformly mixed. Next, water was weighted and added into the dry mix. The mix was mixed until the wet mix was uniformly mixed. Follow by that, an amount of foam was weighted and added into the wet mix repeatedly until the desired density, 1300 $kg/m^3 \pm 50 kg/m^3$ was achieved. Lastly, inverted slump test was carried out before fresh lightweight foamed concrete was poured into the mould.

Curing

Curing condition is very important in gaining the strength of lightweight foamed concrete. For this study, specimens were cure in water curing after demould for 7, 28, 56 and 90 days until testing age, respectively.

Splitting Tensile Test

The test was performed in accordance with ASTM C496 (2004). An axial load with a specified rate of loading was applied to cylinder with diameter of 100 mm and height of 200 mm until failure occurred. INSTRON 5582 Testing Machine was used to conduct the splitting tensile test on the cylinder. Mean value obtained from three cylinders was then taken as splitting tensile strength for each lightweight foamed concrete mix.

The cylinders were taken out from water tank and air-dried for two hours before the test was performed. Test specimen was placed in a steel mould and a thin plywood bearing strip was placed at the bottom and top of the cylinder. This thin plywood bearing strips are used to distribute the load applied along the length of the cylinder. Test specimen was loaded gradually with constant rate of loading of 1.2 mm/min until the specimen fails. The maximum load carried by the specimen was recorded and splitting tensile strength was calculated based on Equation.

5. RESULTS AND DISCUSSIONS

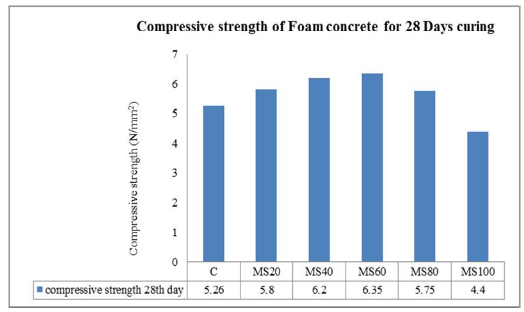

Figure 3. Bar Chart Compressive Strength of foam concrete

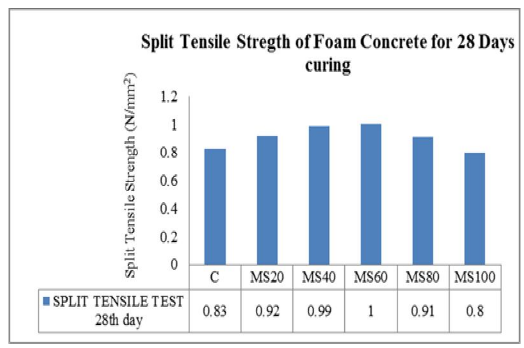

Figure 4. Bar Chart Split tensile Strength of foam concrete

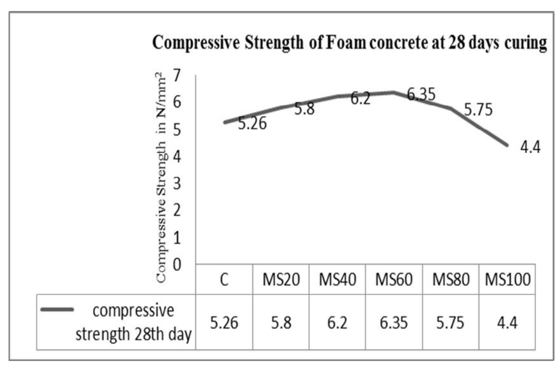

Figure 5. Compressive Strength of foam concrete

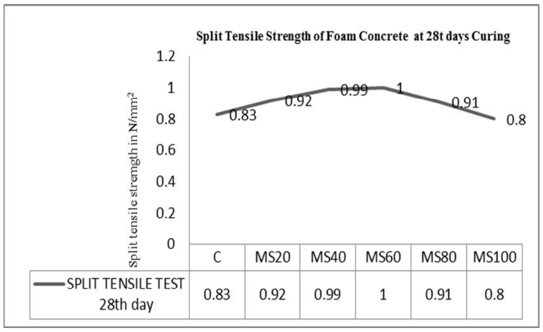

Figure 6. Graph Shows Split tensile Strength of foam concrete

For control specimen concrete using 0% M-sand compressive strength is 5.26 N/mm^2. For 20%, 40%, 60% and 80% of replacement of sand by M-sand the compressive strength is increased by 9.31%, 15.16%, 17.17% and 8.52% respectively.but for 100% replacement the compressive strength is reduced by 16.35%. The split tensile strength of controlled concrete using 0% M-sand is 0.83N/mm^2. For 20%,40%,60% and 80% of replacement of sand by M-sand the split tensile strength is increased by 9.78%, 16.16%, 17% and 8.79% respectively.But for 100% replacement the split tensile strength is reduced by 3.61%.

6. CONCLUSION

Foam concrete canbe made as low density high strength concrete.They can be employed as high thermal insulation and light weight concrete.This type ofconcrete is boon for remote areas where sand alone is available. It can be used in garden structures where water percolation is high.

When partial replacement of sand is done by M-sand due to this eco-friendly concrete can be achieved. The manufacturing and casting are fast and easy process.

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