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THE EFFECTS OF CARBOXY METHYL CELLULOSE AND POLYVINYL ALCOHOL ON FORM STABILIZATION FOR IMPROVING FOAM CONCRETE PERFORMANCE

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Abstract *In recent years, there has been a lot of buzz about foam concrete, a lightweight material that is known for its sustainability and adaptability in the building industry. There is a rising interest in understanding its scalability because to its widespread application in fields such as insulation, infrastructure, and building. When discussing foam concrete, the term "scalability" is used to describe its capacity to keep its mechanical characteristics and structural integrity constant regardless of the production size, whether it a small batch in a lab or a massive factory.*

Using a variety of surfactants (SLS and NPE) and additives (CMC), this study investigates the effects of scaling factors on beam and cube properties such as fresh density, spread, compressive behavior, and water absorption. Concerning foam concrete's qualities and functionality. The results of a thorough experimental study show that at a target density of 1800 kg/m3, NPE with CMC had the maximum compressive strength value of 19MPa and the lowest water absorption. In addition, the compressive strength of foam concrete specimens made with beams was 67% lower than that of foam concrete mixes using cubes, when compared with the scaling effect.

Keywords: *surfactant; foam concrete; scalability; compressive strength; water absorption*

1. INTRODUCTION

It is undeniable that reducing the structure's self-weight is a benefit, and in certain instances an absolute need, in concrete construction. Saving dead weight relative to a given live load capacity has several benefits, including decreased stresses throughout the structure's lifetime, easier handling and working, faster fabrication, and less energy consumption during construction. Lightweight concrete also provides superior fire protection, earthquake resilience, and thermal insulation compared to regular concrete.

One of the most promising and energy-efficient areas of growth in the construction materials business right now is the manufacture of foam concrete. Consequently, this study is necessary in order to overcome the existing challenges and build new strategies for the continuing growth of foam concrete manufacturing. In order to make foamed concrete more widely used in India, it is crucial to find an economical foaming agent and foam generator. Since the ultimate strength of foamed concrete is heavily dependent on the quality of the foam, optimizing the parameters for foam formation is vital for the identified foaming agents as well. Foamed concrete is "mortar with air bubbles in it," according to the most simplistic explanation. Two methods exist for adding air bubbles: pre-foaming and mix-foaming. While preformed foams are used with cement slurry to make pre-foamed concrete, surface active agents are added in during mixing to make mixed-foamed concrete.

Due to a lack of data, the industry is hesitant to employ foam concrete for structural applications; so, research into the qualities of foam concrete that may influence its structural behavior is necessary. There is a dearth of data on the physical, mechanical, and durability-related characteristics of foamed concrete, according to the literature review. This is why it's important to do thorough research on the effects of foaming agents on the characteristics of foamed concrete, as well as on the assessment of a few locally accessible materials that may constitute effective foaming agents.

1.1 Applications of foam concrete

Because of its advantageous qualities, such as being easy to place and make, and its comparatively low density, foamed concrete finds use in many different contexts. One clear benefit of using foam concrete in earthquake-proof buildings is that its low density allows for more efficient construction of supporting elements, such as foundations and lower-floor walls. Thanks to readily accessible portable foam generators, foam concrete may be made on-site during construction. Foamed concrete may be made in a variety of regulated densities, from 400 to 1800 kg/m3, thanks to precise foam dosage control. This allows for a broad range of products to be made for specialized uses, including structural, partition, insulation, and filler grades. Because of its porous structure, foam concrete is a great material for insulating roofs because of its great thermal insulation capabilities.

So, when strength and thermal insulation are both needed, foam concrete is a good option since it is an energy-efficient material. The capacity of foam concrete to absorb enormous amounts of industrial waste, such as fly ash, which is one of its component materials, is another major benefit of this material. As a result, it's a great way to put trash to good use. Plus, it's helping to prevent the loss of valuable topsoil by serving as a highly competitive alternative to clay bricks.

1.2 Surfactants

A class of compounds known as surfactants has both hydrophobic and hydrophilic functional groups. Surfactants' special properties allow them to either spontaneously self-assemble in solutions of different morphologies or to enrich at the interface, lowering interfacial tension. The wide range of businesses that make use of these surfactants—from washing autos to foaming in the chemical industry—is a testament to their adaptability. In addition, the foaming agent plays a crucial role in the reliable production of foam in the foam concrete industries, which is another significant application. The power to create foam in a liquid is conferred upon it by compounds known as foaming agents. A stable foam is necessary for the creation of high-quality foam concrete, and not all surfactants are effective foaming agents. Therefore, the qualities of foam, such as foam density, foam output rate, foam capacity, and foam stability, are significantly impacted by the surfactant choice, which in turn impacts the foam concrete's characteristics. In this context, we will provide a detailed description of surfactant qualities and categorize them according to numerous factors.

The surface tension and gas-liquid interfacial properties of foam are significantly influenced by the surfactant's features. Surfactant properties such as solubility, adsorption, critical micellar concentration, and adsorption are significant.

For the purpose of making foam concrete, blended surfactants are a mixture of two or more surfactants. Therefore, the qualities of foam, such as foam density, foam output rate, foam capacity, and foam stability, are significantly impacted by the surfactant choice, which in turn impacts the foam concrete's characteristics. Among the most important factors to think about are the following: water absorption, compressive strength, initial foam density, and foam stability.

2. LITERATURE STUDIES

Khawaja et al (2021) [1] "Eco-friendly incorporation of sugarcane bagasse ash as partial replacement of sand in foam concrete" In this study, sugarcane bagasse was used in place of sand in foam concrete. This research presents the microstructural, thermal, fresh, physicomechanical, and bagasse ash incorporation characteristics of foam concrete in contrast to control foam concrete. It seems that the foam concrete mix included 10% sugarcane bagasse ash. was the control mix's weakest link, with the least amount of thermal conductivity reduction and the greatest increase in compressive strength (14.50%). Foam concrete may have its sand replaced with sugarcane bagasse ash in an eco-friendly way without sacrificing its mechanical properties.

Namsonea et al (2017) [2] “Durability Properties of High Performance Foamed Concrete” In this study, the author spoke about how it has moderate strength, great thermal properties, and a low density. Formula Concrete is an additional kind of cellular concrete. Aerating cement mortar using foaming agents and adjusting the proportions of cement, sand, water, and agent may produce a range of densities, which can be tailored to specific uses. FC is made with a foaming agent, cement mortar, and no further heat processing. Particularly in cold and humid environments, FC durability must be considered.

Habsya et al (2018) [3] “Physical, mechanical and thermal properties of lightweight foamed concrete with fly ash” Lightweight foamed concrete's (LFC) density, thermal conductivity, compressive strength, and water absorption are variables that will be studied in this study. Fly ash (FA), foam, sand, water, and cement are the components of this LFC. To make LFC, you need a water-to-cement ratio of 1:1 and a cement-to-aggregate ratio of 1:4. The aggregates, which consisted of sand and FA, ranged in weight from 0% to 30%. The mortar had 30–40 percent foam by volume. The compressive strength, thermal conductivity, and density of LFC all decrease as the foam component increases. But that causes it to soak up more moisture. The FA concentration has an effect on density, thermal conductivity, compressive strength, and water absorption, among other properties.

3. MATERIALS SND MIX USED IN THE STUDY

3.1 Cement

The research in this study made use of ACC cement, which is an ordinary Portland cement of 53 grade.

OPC 53 Grade cement

3.2 Fine aggregates

Fine aggregate consists mostly of sands sourced from either land or sea. The majority of the particles in fine aggregates, which are typically made of crushed stone or natural sand, pass through a 4.75 mm screen. The study's fine aggregate, seen in the picture below, is river sand acquired from a local firm. We ran some preliminary testing on these materials, and the results are in their material characteristics.

Fine aggregates used

3.3 Sodium lauryl sulfate

Your shampoo bottle will include sodium lauryl sulfate (SLS) among its components. Unfortunately, you probably have no idea what it is unless you happen to be a scientist. Misunderstood chemical is included in several personal care and cleaning items. Various urban legends have connected it to diseases including cancer and skin discomfort. Research could provide contrasting findings. A "surfactant" is the technical term for SLS. Its utility as a foaming agent and cleanser stems from the fact that it reduces the surface tension between substances. Since SLS is included in many common home cleansers, toiletries, and cosmetics, it is understandable that many people are wary of using them. Another surfactant that has a similar chemical formula is sodium laureth sulfate, abbreviated as SLES. But compared to SLS, SLES is kinder and less irritating.

3.4 Polyvinyl alcohol (PVA)

PVA's low toxicity, biocompatibility, and low propensity for protein adhesion make it useful in many medicinal contexts. Cartilage substitutes, contact lenses, and eye drops are some of its specific applications. Suspension polymerizations make use of polyvinyl alcohol as an assist. As a protective colloid in PVAc dispersions is its most common usage in China. The manufacturing of Vinylon fiber is its primary use in Japan. Since no oil is needed to make this fiber, it is also produced in North Korea for self-sufficiency reasons. Photographic film is another use. In additive manufacturing, PVA-based polymers find extensive application. The pharmaceutical business, for instance, shows a lot of promise for 3D printed oral dose forms. By using PVA as a binder, it is feasible to manufacture drug-loaded tablets exhibiting altered drug-release properties.

3.5 Water

This experimental program has used locally accessible drinkable fresh water for mixing and curing, which is devoid of concentrations of chemical and organic contaminants.

3.6 Mix Trials used in the study

The following mix values are used for the preparation of the foam concrete to study the density, water absorption and compressive strength of concrete

1. Cement – 2.4kgs
2. Fine aggregates – 4.8kgs
3. Water – 1.734 liters
4. Foam is used as 6.5 grams

4. STUDIES ON FOAM CONCRETE

4.1 Studies on Foam

A mechanically-based foam generator was a laboratory-scale stirrer (Philips, model HR1459) with variable frequency capabilities. An essential factor influencing foam quality is the mixing speed of the stirrer. Moreover, several studies have shown that as the stirrer's rotating speed increases, the mean bubble size of the foam generated decreases (Gido et al.27; Hirt, Prud'homme, and Rebenfeld28). Therefore, in order to understand how the stirrer speed affects IFD, several early experimental investigations were carried out. Research using the stirrer approach revealed that the resulting foam had a significant percentage of liquid. If you want to make foam with a lower liquid percentage using a stirrer, the trick is to crank up the speed.

Foam used in this study

4.2 Studies on Fresh State Characteristics of Foam Concrete Mixes

Foam concrete mix's water-solid ratio was determined to be within 50 kg/m3 of the target design density. In addition, at the optimal w/s, the mixes' workability was assessed by measuring (i) spread in a flow table (ASTM C230/C230M14, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement [Superseded]31) and (ii) flow in a modified Marsh cone (Jones, McCarthy, and McCarthy32).

4.3 Studies on Compressive Strength of Foam Concrete

For each design density, 700 x 100 x 75 mm beams and 70.6 x 70.6 x 70.6 mm cubes were cast to examine the compressive strength. Demolded specimens were subjected to wet curing for a duration of 28 days after casting. The compressive strength of the foam concrete was measured using the procedures outlined in the Standard Test Method for Compressive Strength (ASTM C495/C495M-12).

Compressive strength of concrete

4.4 Studies on Dry Density of Foam Concrete

When describing the physical characteristics of foam concrete, dry density is a frequent metric to utilize. After 28 days of moist-curing, the cubes were baked at 100°C until they and the beams had a consistent mass, as per ASTM C495/C495M-12 standards, and then the dry density was measured.

Concrete specimens after curing

4.5 Studies on Water Absorption of Foam Concrete

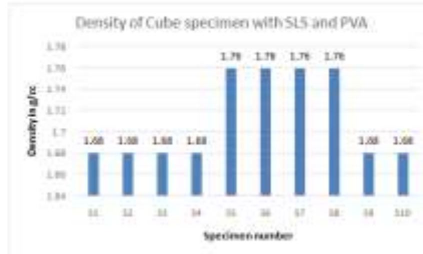
For each combination, we cast and moist-cured 70.6 x 70.6 x 70.6 mm cubes and 300 x 100 x 75 mm beam specimens, and then we examined them to see how much water they absorbed. To find the average amount of water that the specimens absorbed, we subtracted their average dry mass from their average wet mass, using the guidelines laid forth by ASTM C495: 2012. Soaking the specimens in water until they attained a consistent weight allowed us to measure their wet mass. Once the specimens were placed in an oven set at 100°C, their weight was recorded every 24 hours until it stabilized. This allowed us to determine their dry mass. Foam concrete's density varies widely, thus scientists measure its water absorption as a proportion of its volume (Nambiar and Ramamurthy). By dividing the average mass of water absorbed by the density of water in kg/m3, we were able to determine the average volume of water absorbed (Vw). With these equations, we can determine the water absorption.

5. RESULTS AND ANALYSIS

Density of concrete

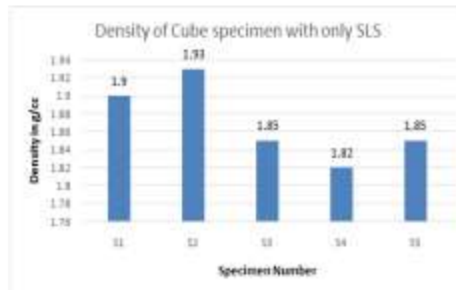
50mmX50mmX50mm size specimens

Density of 50mmX50mmX50mm cube only with SLS

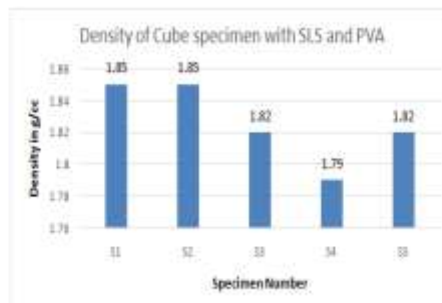


Density of 5mmX50mmX50mm cube only with SLS and PVA

70.6mmX70.6mmX70.6mm size specimens



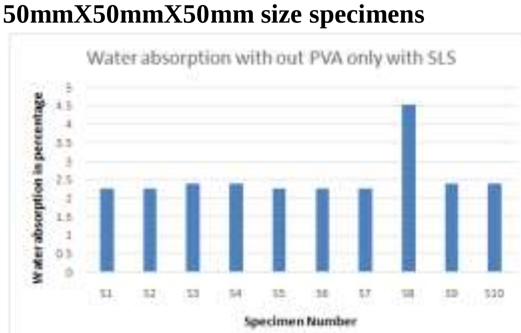
Density of 70.6mmX70.6mmX706mm cube only with SLS



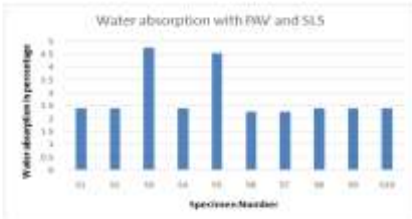
Density of 70.6mmX70.6mmX706mm cube only with SLS and PVA

Water absorption test

50mmX50mmX50mm size specimens

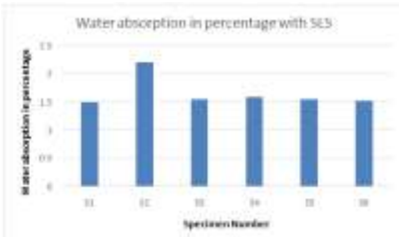


Water absorption of 50mmX50mmX50mm cube only with SLS

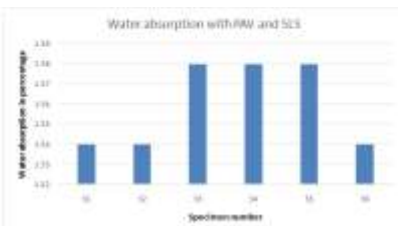


Water absorption of 5mmX50mmX50mm cube only with SLS and PVA

70.6mmX70.6mmX70.6mm size specimens

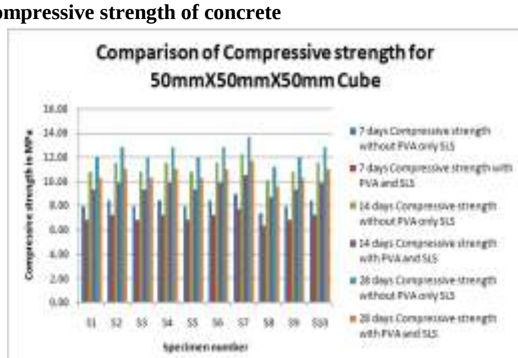


Water absorption of 70.6mmX70.6mmX706mm cube only with SLS

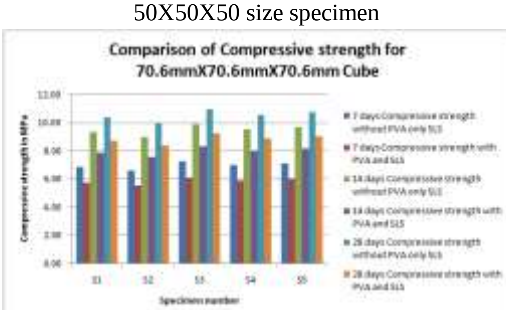


Water absorption of 70.6mmX70.6mmX706mm cube only with SLS and PVA

Compressive strength of concrete



Comparison of compressive strength of concrete for 50X50X50 size specimen



Comparison of compressive strength of concrete for 70.6X70.6X70.6 size specimen

6. CONCLUSIONS

The study's results suggest that:

1. The building sector may make good use of foam concrete because of its attractive qualities. There is a lot of room for innovation in the field of high performance aerated concrete.
2. The compressive strength of foamed concrete is affected by factors such as the shape, size, and manner of pore creation, as well as by the age of the sample, the direction of loading, the components' characteristics, and the process of curing.
3. The mechanical properties of the material are determined by the volume, type, and volume of fibers employed in its production.
4. Materials, foaming agents, foam preparation processes, air-void distribution, mixture design strategies, and manufacturing methods all play a role in creating a stable foam concrete mix.
5. The quantity of air in the concrete, the kinds of fibers, and their volume percent are the main factors.
6. Concrete may have its weight reduced and transportation costs lowered by using foaming agents instead of fine aggregate.
7. With our exceptional property and little self-weight, we may get additional advantages such as economy, user-friendliness, and give superior expose characteristics.
8. Both the density and compressive strength of foam concrete grow with time, and the former also grows with an increase in foamed concrete's density.
9. The compressive strengths of foaming agents based on protein are higher than those of foaming agents based on synthetic materials.

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