EFFECT OF TEMPERATURE VARIATION ON AUTOCLAVE AERATED CONCRETE BEAM USING CERAMIC WASTE AS COARSE AGGREGATE

Muthu Krishnan.A[1], Muthu Kumar.K[2] , Sibi Rajan.R[3]
[1, 2] Assistant Professor, [3]PG Student
[1,2,3]Civil Engineering Department
[1]Assistant Professor Sree Sastha Institute of Engineering and Technology, Chennai
[2]Assistant Professor Prathyusha Engineering College, Chennai, TamilNadu,

ABSTRACT:
This project involves an experimental study to investigate the effect of temperature variation on an autoclave aerated concrete beam. The mix design is based on IS2185 (iii)-1984 the mixing ratio is confirmed with basis of trial and error method. Cement, gypsum, fly ash, ceramic waste, silica fume, lime and aluminium powder were used to make aerated concrete. In this work the ceramic aggregate replace the coarse aggregate in various proportion. The aluminium powder (0.04% & 0.08%) is reacted as a foaming agent. Steam curing is done to cure the beams with different temperatures. The specimens are tested under compressive loading. And also the specimens are subjected to two-point loading to check its flexural properties. The tests are conducted on nine beams of size (1.2x0.15x0.1m). AAC is cured in an autoclave at high temperature and saturated steam pressure for a period of 8h. AAC is unique among construction materials incoming excellent thermal resistance and sound insulation. This work also focuses the ecofriendly AAC for effective utilization of ceramic waste.
Keywords: Autoclave Aerated Concrete (AAC), Ceramic waste, Aluminium powder, Light weight, Temperature, Steam curing.

1. INTRODUCTION

Aerated concrete refers to concrete having an excessive amounts of air voids. These air bubbles are created to reduce the density of the concrete and provide good thermal insulation. Aerated concrete was first produced in Sweden in the 1930s and can also be referred to as cellular, foamed or gas concrete. It was originally designed for use as building blocks, but today, the applications have been expanded to larger units, such as floors and walls that have a low weight.

Autoclaved aerated concrete (AAC) usually is made from quartz-rich sand, lime, cement, and calcium sulfate with traces of aluminium powder as pore-forming agent. These components are mixed with high amounts of water and molded to produce a cellular green body by H_2gas generation at atmospheric pressure, and then autoclaved at 180°C under saturated steam pressure for several hours. Calcium silicate hydrate (CSH) phases are formed from reactions between silicates and CaO of the bonding agent.

Generally, the physical properties of autoclaved aerated concrete are determined by its structure, mineralogical composition, and texture. Although the structure can be controlled up to a certain extent by addition of pore-forming agents such as Al powder and water, mineralogical composition and texture depend strongly on composition and reactivity of the raw materials.

For these reasons the influence of new raw materials on phase formation must be studied carefully. The influence of alternative SiO_2 sources, as well as various Al compounds, on phase formation under hydrothermal conditions was studied by many authors. Pure substances and different commercial products including waste materials such as fly ash and slag from power plants, bricks, and ceramic tiles were considered as sources for SiO_2 and Al_2O_3. In contrast, different types and sources of CaO and $CaSO_4$ and their behaviour in the hydrothermal process were rarely investigated.

The air pores in aerated concrete are usually 0.1 to 1 mm in diameter. They can be formed by a few different methods but the most common is by the addition of aluminium powder which is added to the mixing ingredients at about 0.04% to 0.08% by dry weight of cement. The aluminium reacts with hydroxide of calcium or alkali which liberates hydrogen gas and forms bubbles. The speed at which the air bubbles form is critical to the success of the final aerated concrete product. Other methods of inducing air pores include using a foaming agent, hydrogen peroxide (to release oxygen), powdered zinc oran aluminium alloy.

1.1 NEED FOR AAC

Very low density in the range of 450 to 1600 kg/m^3 compared with normal concrete at 2500 kg/m^3, provides ease of handling. Increase in air content of 3% to over 50% compared with normal concrete gives the low density. Ease of working, such as the ability to cut with a hand saw,chisel, hold nails and screws, or enable utilities to be placed through channels routed directly into the AAC blocks. Ease of creating simple structures, especially for small buildings. Environmentally friendly, such as having less construction site waste and using 1/5 the amount of resources as compared to conventional concrete.

1.2 ADVANTAGE OF AUTOCLAVE CURING

Some of the drawbacks of aerated concrete are that it has a lower strength, a higher moisture content and higher shrinkage compared with standard concrete. But these properties and others can be drastically improved if the aerated concrete is high pressure steam-cured in an autoclave. The autoclave procedure includes curing 4–8h at 180–200°C. Autoclave curing the aerated concrete further enhances its properties, such as At least doubling the compressive strength. Improving long-term drying shrinkage to well under 0.1% . Providing low thermal conductivity of about 0.1 J/m^{2}s °C/m which is about 10 times lower than normal concrete. Having insulation property similar to timber but much greater fire resistance. Providing delayed heat transfer which benefits climate control in areas with large outdoor temperature fluctuations. Providing sound insulation 7 dB greater than other solid building materials at the same weight per surface area. Giving an attractive light gray or near white colour, although it may be surface covered in buildings or structures.

2. AIM AND SCOPE OF THE WORK

This project is intended to study the flexural strength of aerated concrete beam at different temperature in the autoclave curing. And to study the influence of ceramic waste as a coarse aggregate. AAC is unique among construction materials incoming excellent thermal resistance and sound insulation. This work focuses on the usage of Autoclave aerated concrete as a structural member by adding light weight coarse aggregate such as ceramic waste. The usage of aluminium powder in the AAC highly reduces the dead weight of the concrete thereby increases the compressive strength.

3. PROPERTIES OF MATERIALS

3.1 GENERAL

The basic raw materials used in the manufacture of Aerated concrete beams are Portland cement, lime, gypsum, water, sand or fly ash, and aluminum. The sand is ground to a powder-like consistency and mixed with the remaining materials to form slurry. The slurry is then poured into molds. Entrained air bubbles are created by a chemical reaction between the hydration products and the aluminum powder, which causes the material to rise in the mold. The units then are steam cured under stream pressure in stream curing for 3 days; High transforms the material into a hard calcium silicate. Aerated Concrete manufacturing produces a naturally occurring mineral found in limestone, heated lime called as Quick Lime.

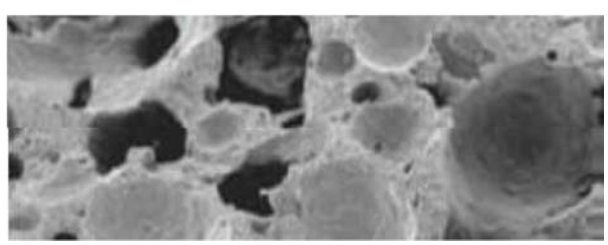

FIG1:- Air bubbles are created by a chemical reaction between the hydration products and the aluminum.

3.2 *MATERIALS USED*

Cement : The cement used in all mixture was commercially available Ordinary Portland Cement (OPC) of 43 grade confirmed to IS: 8112-1989. The initial and final setting times were found as 80 minutes and 453 minutes respectively.

Coarse Aggregate : Coarse aggregate used in this study consist of crushed stone of size 12mm and below. Laboratory tests were conducted on coarse aggregate to determine the different physical properties as per IS: 3831970.

Ceramic Waste Aggregate : The ceramic waste, such as flowerpot, tiles and sanitary ware were broken into small pieces about 5mm – 12mm sizes by a hammer. 20mm size.

Silica Fume: Silica Fume is a by-product of electric arc furnace used for the production of silicon metal or alloy, having specific gravity of 2.2 and bulk density of 720kg/m^3.

Fly ash: Fly ash is finely divided residue resulting from the combustion of powedered coal and transported by the flue gases and collected by electrostatic precipitator. AAC can be manufactured by using the low calcium (class-F) fly ash obtained from Tuticorin Thermal Power Plant.

Aluminium powder: Aluminium powder acts a foaming agent that helps in the entrainment of air inside the concrete. It highly reduces the density of the concrete. Aluminium powder is obtained as a waste material from metal powder industry.

4. *EXPERIMENTAL PROGRAMME*

4.1 *GENERAL*

The experimental program consisted of casting, curing and testing the cube of size 150x150x150 mm.

4.2 *CONDUCTING TEST TRAILS*

The Mix design was done by trial and error method (Collected from various AAC journals and manufacturers) and the further mixes were improved proportionally. For the same mixes, the additive material used is replaced with other materials. The mixes used for the test trails are given below. From the trail mixes, the best mix is deduced.

Cement	Fly ash	Coarse aggregate	Water
1	1.136	1.90	0.5

Table 1 Mix ratio

Trail mix 1 for one cube:

MATERIAL	RATIO	WEIGHT (Kg)
Cement	0.682	1.198
Lime	0.158	0.279
Silica fume	0.09	0.159
Gypsum	0.067	0.119
Fly ash	1.136	1.998
Coarse Aggregate	1.425	2.520
Ceramic waste Agg	0.475	0.840
Water	0.5	0.880
Aluminium powder	0.08%	$3.2x10^{-3}$

Table 2 **Trial Mix 1**

Trail mix 2 for one cube:

MATERIAL	RATIO	WEIGHT (Kg)
Cement	0.682	1.198
Lime	0.158	0.279
Silica fume	0.09	0.159
Gypsum	0.067	0.119
Fly ash	1.136	1.998
Coarse Aggregate	0.95	1.680
Ceramic waste Agg	0.95	1.680
Water	0.5	0.880
Aluminium powder	0.08%	$3.2x10^{-3}$

Table 3 **Trial Mix 2**

Trail mix 3 for one cube:

MATERIAL	RATIO	WEIGHT (Kg)
Cement	0.682	1.198
Lime	0.158	0.279
Silica fume	0.09	0.159
Gypsum	0.067	0.119
Fly ash	1.136	1.998

Coarse Aggregate	0.475	0.840
Ceramic waste Agg	1.425	2.520
Water	0.5	0.880
Aluminium powder	0.08%	$3.2x10^{-3}$

Table 4 **Trial Mix 3**

4.3 *CASTING AND CURING*

Steel mould was used for casting the cubes. Before casting, machine oil was applied on the inner surface of the mould. Concrete was mixed using a tilting type laboratory mixer and was poured into the moulds in layers. Compaction of concrete was done using a needle vibrator. After 24 hours from casting, all the cubes were cured under autoclave steam curing 4–8 hours at 60°C – 200°C.

Fig 2 Autoclave curing

4.4 *TESTING*

The specimens shall be tested in accordance with IS: 516-1959.All the cubes were tested under Compression Testing Machine (CTM).For loading the Cubes 2000 KN capacity hydraulic compression testing machine was used.

Fig 3 Specimen placed in CTM

4.5 *BEAM DETAILS*

From the optimum mix obtained, the beam specimen are to be cast and cure under autoclave steam curing about 4 –8 hours at 60°C –200°C. This study is restricted to rectangular AAC beams of size 1.2x0.15x0.1m only. The Autoclave aerated concrete beams can fail in several ways when loading in bending. The collapse mechanism is to be identified and analyzed in this study. The type of loading to be applied is two point loading to determine the structural properties as shown in fig 3.

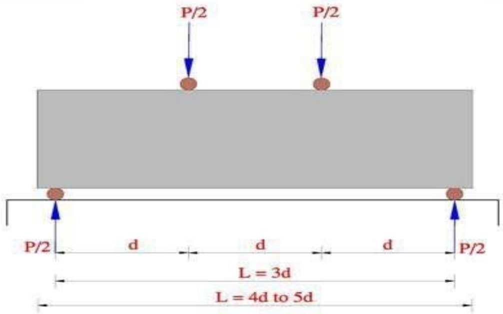

Fig 4 Two point loading in beam

5. *POSSIBLE CONCLUSION*

Based on the experimental observation the mix proportion for Autoclave aerated concrete was achieved and the fresh properties had been studied. The Coarse aggregate replacement by ceramic waste gives good results in light weight but the expected compressive strength can't be achieved.

The specimens cured in autoclave at elevated temperature shows an increase in the compressive strength and water absorption capacity by 10%. Good results are expected to attain optimum temperature for autoclave curing. The results are to be compared both experimentally and analytically.

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