e-ISSN: 2455-5703

Comparison on Auto Aerated Concrete to Normal Concrete

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Abstract

Aerated concrete is relatively homogeneous and compared to normal concrete, as it does not contain coarse aggregate phase that shows vast variation in its properties. The properties of aerated concrete depend on its microstructure and composition, methods of pore-formation and curing. AAC is a relatively new concrete masonry material that is lightweight, easy to construct, and economical to transport. However, in other parts of the world it use has been used successfully as a building material for over fifty years. It was observed that fly ash responds poorly to autoclaving. This paper details the history, physical properties, manufacturing process, and structural design of AAC and concludes that it has important advantages as a structural building material comparing with the Normal Concrete that deserves further consideration for use in the United States.
Keyword- AAC, Aerated concrete

I. INTRODUCTION

Aerated concrete is a cement or lime mortar, classified as lightweight concrete, in which air-voids are entrapped in the mortar matrix by suitable aerating agent, comparing the Concrete is a multiphasic material with the densities of the numerous components entering traditional concrete mix vary between 1000 kg/m^3 (water) and 3200 kg/m^3 (cement). Aerated concrete falls into the group of cellular concrete. The projecting advantage of aerated concrete is its lightweight, which economizes the structural design including the foundation and walls. It provides a high degree of thermal insulation and considerable savings in material due to the porous structure which is less than Normal Concrete. By appropriate method of production, aerated concrete with a wide range of densities (300± 1800 kg/m^3), which is good compare to the Normal Concrete. There have been several investigations on the properties of aerated concrete in the past. This review aims to compare the studies on aerated concrete related to its structure and properties and Density to the Normal Concrete Properties.

II. COMPARATIVE CLASSIFICATION OF AUTO AERATED CONCRETE & NORMAL CONCRETE

A. Base Raw Materials

Suitable Raw material for autoclaved aerated concrete are fine grades which are Silica or quartz sand, lime, cement and aluminum powder are the main raw materials for assembling AAC. Lime is one of the principal mix components and requires less energy to produce than Portland cement, which is fired at higher temperatures. Sand requires only milling before use, not heating. Lime may require less energy to manufacture compared with Portland cement but more CO_2 is produced per ton. Silica sand's percentage is higher than the other aggregates in aerated concrete mix. Both silica and quartz sand are mineral based aggregates which can be accomplished from broken rocks or sandstones. At the same time fly ash, slag, or mine tailings can be used as aggregates in mix with silica. All fine aggregates as silica sand or quartz sand and lime are mixed with cement. The water additional to this mix and hydration starts with cement forming bond between fine aggregates and cement paste. Expansion agent for this process is aluminium powder; this material reacts with calcium hydroxide which is the product of reaction between cement and water. Aluminium powder and calcium hydroxide ancestries forming of microscopic air bubbles which results in increasing of pastes volume. The hydrogen that is formed in this process bubbles up out of the mixture and is replaced by air.

B. Based On Mix Proportion and Production

Foamed concrete is produced either by pre-foaming method or mixed foaming method. Pre-foaming method involves the separate production of base mix cement slurry and a firmly preformed aqueous and then the thorough blending of this foam into a base mix. In mixed foaming, the surface active agent is mixed with the base mixture ingredients and during the process of mixing; foam is produced resulting in cellular structure in concrete as shown in Fig.

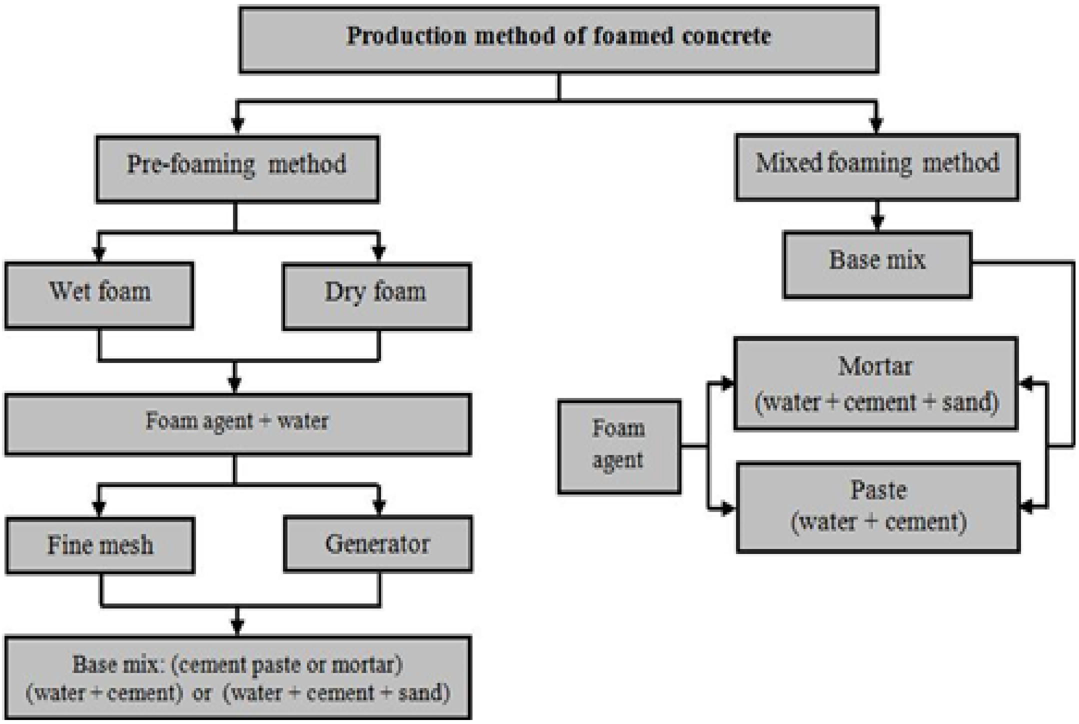

Fig. 1: Based On Mix Proportion and Production

Considerably higher crystallinity of hardened binding material, and that the plate like shape of crystals generated in this case is typical to hydro silicates with lower ratio C/S. The formation of such AAC structure increase in compressive strength by 20.0%, bending strength by 31.0% and decrease in shrinkage at temperature of 700 °C by 0.1% versus AAC. It is concluded that ANS added to AAC forming mass serve as nucleates during the hardening of concrete, stimulating higher crystallinity in the hardened structure than that without these additives and improving AAC mechanical properties. The volume increase is dependent upon the amount of aluminium powder/paste that is introduced to react with the calcium hydroxide in the mixture. This reaction is shown in following equations

$$2Al+3Ca(OH)_2+6H_2O \Rightarrow 3CaO.Al_2O_3.6H_2O+3H_2$$

Aluminium powder + Hydrated Lime ⟹ Tricalcium Hydrate + Hydrogen

C. Compressive Strength

Compressive strength of foamed concrete influenced by many factor such as density, age, curing method, component and mix proportion. Cement paste characteristics are dependent on the w/c ratio, admixture and mixing time. Cement paste with high viscosity and high flow suitable for making porous concrete is obtained with the use of low w/c of 0.20–0.25, an incorporation of 1% super plasticizer, and sufficient mixing. Porous concretes having suitable void ratios are produced with appropriate paste content and flow, and sufficient compaction. For low void ratio, high strength porous concrete of 39 MPa is obtained using paste with low flow. For high void ratio, porous concrete of 22 MPa is obtained using paste with high flow. Furthermore, the results indicate that the strength of porous concrete could be estimated from strength equation of porous brittle material. The gel pores do not influence the strength of concrete through its porosity, although these pores are directly related to creep and shrinkage. Compressive strengths and drying shrinkage of moistures and AAC with sand or fly ash for different curing conditions are presented in Table.

Compressive strengths of moist-cured and AAC					
	Compressive strength (MPa)				
	Moist-cured			*Autoclaved*	
Mix details	*28 days*	*90 days*	*150 days*	*8 h*	*12 h*
Cement-sand	*7.4*	*7.8*	*7.9*	*12.1*	*14.5*
Cement- fly ash	*5.5*	*6.8*	*7.5*	*7.9*	*9.3*

Table 1: Compressive strengths of moist-cured and AAC

Just and Middendorf, 2009 founded that the increase in the compressive strength depends on the mass density. The compressive and splitting tensile strengths of all the concrete mixtures were determined at the same test ages using the BS EN 12390: Part 3: 200920 and ASTM C 29321 guidelines. For each mixture, nine 150 mm cubes were used for the compressive strength tests at 7 days, 28 days and 90 days. Similarly, six 100 mm × 100 mm × 500 mm prisms were also used for flexural strength tests at 28 days and 90 days. For the compressive strength test, samples were placed in a compression test machine and loaded at a constant rate of 0.7 MPa/s until failure occurred. Similarly, prisms for the flexural strength (center-point loading) tests were subjected to a constant loading rate of 3.0 MPa/min until failure occurred. The strength also increases with rising mass density. For a mass density of 700kg/m^3 the compressive strength increase amounts to a calculated 17% and when the mass density raises to 1100kg/m^3 the compressive strength increases to 20%. The smaller the diameter of the pores, the more regularly they are formed. Regularly formed air voids increase the compressive strength with comparable densities. Capillary pores and other large pores are responsible for reduction in strength and elasticity etc. Strength and porosity relation in terms of w/c ratio and density for a particular type of cement, n=1-[dc (1+0.2ϙc)/ (1+k)ϙc*¥w]^b

Where, ϙc is specific gravity of cement, ¥w is the unit weight of water, dc is the concrete density, n is the porosity, k is the water-cement ratio and b is an empirical constant. While establishing the strength porosity relationship for AAC with slate waste, a factor called reciprocal porosity (Vs/Vp ± solid to pore volume ratio) has been coined, the relation of which with compressive strength is linear compared to normal concrete.

D. Density

The water-cement materials ratio is related to the amount of aeration obtained and the density. The ratio increases with proportion of sand. For AAC with pozzolans, water-solids ratio appears to be more important than the water-cementations ratio, irrespective of the method of pore-formation. For gas concrete, lesser water-solids ratio leads aeration while a higher one results in rupture of the voids, increase in density being the consequence in both the cases. Thus the water requirement is to be determined by consistency of the fresh mix rather than by a pre-determined water-cement or water-solids ratio. Regularly formed air voids increase the compressive strength with comparable densities. Two densities of foamed concrete were tested, 650 and 1000kg/m3. The results consistently demonstrated that the loss in stiffness for the foamed concrete at elevated temperatures occurs predominantly after about 90°C, regardless of density. This directs the primary mechanism causing stiffness degradation is micro-cracking, which occurs as water expands and evaporates from the porous body. Reducing the density of foamed concrete reduces its strength and stiffness. A higher density of the AAC has a good influence on the condition of the wall structure.

Type	*AAC Blocks*	*Solid Clay Blocks*	*Hollow Blocks*	*Ceramisite Conc. Blocks*	*Normal Conc. Blocks*
Density(kg/m³)	*400-700*	*1600-1800*	*900-1700*	*1400-1800*	*2000-2400*

Table 2:

E. Drying Shrinkage

Drying shrinkage occurs due to the loss of adsorbed water from the material and is significant in aerated concrete because of its high total porosity (40 to 80%) and specific surface of pores (around 30 m/g). Calcium Silicate shrinks on drying out to the same manner as the concrete products, although the drying shrinkage, 0.01% to 0.04% is half with the associate with the latter. Decrease in pore sizes, along with a higher percentage of pores of smaller size is reported to increase shrinkage. The capillary tension theory of drying shrinkage of porous building materials states that the water in the pore exists in tension and this creates an attractive force between the pore walls. Drying shrinkage of aerated concrete with only cement as the binder is expressively higher than that produced with lime or lime and cement. The shrinkage of lime and cement products is the least. The increased amount of irritable silica in the paste, shrinkage increases and attains a maximum value at 30 to 60% silica replacement and then decreases the duration and method of curing, pressure of autoclaving, and chemical composition of silica, additives like fly ash, the size and shape of the specimen and the time and climate of the drying shrinkage. Air-cured specimen has very high drying shrinkage. Moist-cured cement and sand mixes show drying shrinkage values ranging from 0.06 to over 3% when dried at ordinary temperatures, the lower values being associated with higher densities and higher percentages of sand. The time dependence of shrinkage is inclined by the properties of material, size of specimen and shrinkage climate. This apart, the value of shrinkage depends on the initial moisture content. In the range of higher moisture content (>20% by volume), a relatively small shrinkage occurs with loss of moisture, which can be attributed to the presence of more number of large pores which do not contribute to shrinkage.

F. Durability

Autoclaved Aerated Concrete contains of tobermorite, which is more stable when compared to the other products formed in normally cured aerated concrete. Freeze-thaw reactions are reported to be significant as far as AAC is concerned at saturation degrees of 20-40%. Though it has high porosity allowing penetration for liquids and gases which may lead to damage of the matrix (RILEM, 1993; Narayanan et.al, 2000a). At higher degrees of saturation, the sample becomes brittle and cracks completely, (Roulet, 1983; Narayanan et.al, 2000a). Senbu and Kamada analyzed the deteriorations of AAC by various test methods such as freezing thawing test, critical degree of saturation method and top surface freezing test. Depending on the capillary theory they concluded that ice forms in air voids while capillary water is kept unfrozen when deterioration occurs. The deterioration mechanism of AAC develops as the capillary pressure differential between ice in air voids and water in capillaries. For more of saturation, the sample becomes brittle and cracks completely. Carbonation can lead to increase in density but it is not very serious unless the exposure to CO_2 is too severe.

Curing	LWC35		LWC50		NWC50	
regime (1)	28 day (2)	270 day (3)	28 day (4)	270 day (5)	28 day (6)	270 day (7)
Full	4.7	6.0	2.8	3.5	0.9	1.6
1SS	2.8	3.8	1.7	2.4	0.6	1.2
7SS	2.2	3.80	1.0	1.7	0.6	1.5

Table 3:

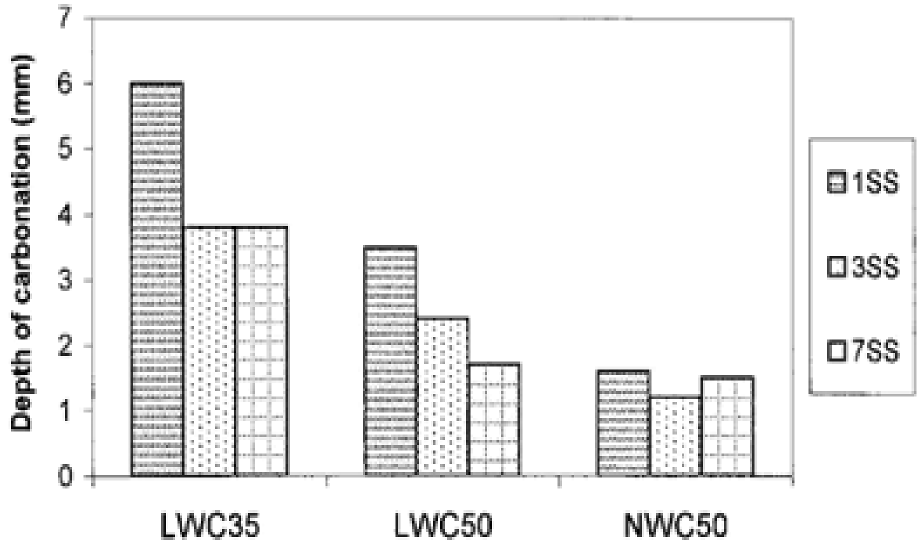

Fig. 2:

By the water penetration, the carbonation depth for LWC35 is higher than that of LWC50. On the whole, the depth of carbonation of NWC50 is less than the LWC50, on the other hand, after 7 days of water curing and on subsequent exposure to the seaside; the carbonation depth of the two concretes is very similar. The results suggest that curing of LWAC is more critical with regard to carbonation depth than the curing of corresponding NWC. However, durability refers to the ability of concrete to resist corrosion from the environment or service in which it is placed. Properly proportioned concrete that is properly placed, finished, and cured should endure without significant distress throughout its service life.

G. Thermal Conductivity

Thermal conductivity depends on density, moisture content and ingredients of the material. It is largely a function of density, it does not really matter whether the product is moist cured or autoclaved as far as thermal conductivity is concerned. The amount of pores and their distribution are also critical for thermal insulation. As mentioned above finer the pores better the insulation. As the thermal conductivity is influenced by the moisture content it increase in moisture by mass increases 42%, it should not be reported in oven dry condition. Based on the thermal performance requirements for buildings, an optimum material design has been proposed by Tada.

Dry density (kg/m^3)	Compressive strength (MPa)	Modulus of elasticity (E- value) (GPa)	Thermal conductivity (3% moisture) (W/mK)	Drying shrinkage (%)
400	0.5-1.0	0.8-1.0	0.10	0.30-0.35
600	1.0-1.5	1.0-1.5	0.11	0.22-0.25
800	1.5-2.0	2.0-2.5	0.17-0.23	0.20-0.22
1000	2.5-3.0	2.5-3.0	0.23-0.30	0.15-0.18
1200	4.5-5.5	3.5-4.0	0.38-0.42	0.09-0.11
1400	6.0-8.0	5.0-6.0	0.50-0.55	0.07-0.09
1600	7.5-10	10.0-12.0	0.62-0.66	0.06-0.07

Table 4:

III. CONCLUSION

The relevant conclusions as observed from the investigations with reference to the composition and treatment of the samples are studied in this paper. Aerated lightweight concrete is unlike conventional concrete in some mix materials and properties. The air-voids in concrete formed by foam agent, this action is physical handling. Aerated lightweight concrete does not contain coarse aggregate, and it possess constructive such as low density with higher strength compared with natural concrete, enhanced in thermal conductivity, reduced dead load and that could result several advantages in decrease structural elements and reduce the transferred load to the foundations and bearing capacity. The air-voids is homogenously distributed within aerated lightweight concrete. Aerated is consider economy in materials and consumption of by product and wastes materials such as fly ash. Strength and porosity relationships have been developed for aerated concrete based on concept of gel-space ratio. The drying shrinkage of AAC is lower; the range from one-fourth to one-fifth of that of material. The material properties and shrinkage climate also influences drying shrinkage. Hence, it is concluded that it is very useful and good in every kind of proposed characteristics.

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