STUDY ON LIGHT WEIGHT MASONRY BLOCKS- A Review

Aiswarya T J[1], Indu Susan Raj[2], Dr. Elson John[3]

[1]PG student, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam, Ernakulam,
[2]Woman Scientist, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam, Ernakulam
[3]Associate Professor, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam, Ernakulam

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Abstract - *Lightweight concrete is low density concrete and its density varies from 900-1900 kg/m³. It has good properties such as easy handling, preparing and cheaper excellent acoustic and thermal isolation; high resistance to fire; lower costs in raw materials, easier pumping and application; and finally, it does not need compacting, vibration or leveling. Aerated concrete is a type of light weight concrete which consists of cement, sand and suitable air entraining agent. The aluminium powder reacts chemically with the concrete to release hydrogen gas, acetylene gas etc. and creates air voids. Foamed concrete is another type of light weight concrete which consists of cement, sand and preformed foam. The purpose of the foam is to supply a production mechanism of a high ratio of air cells that when they are mixed with cement produce a porous solid. In order to reduce the density of the concrete cement is partially replaced by GGBFS or Fly ash and fine aggregate is partially or completely replaced with quarry dust or rubber powder or plastic powder in various percentages. Using the optimized results Aerated and Foam concrete blocks of dimension 300 x 200 x 150 mm are casted. Compressive strength, water absorption, density of blocks & durability of specimens were tested.*

Key Words: Light weight concrete, Aerated concrete, Foam concrete, Aluminium powder, Foaming agent

1.INTRODUCTION

Depending on the method of production light weight concrete can be divided into:

- Light weight aggregate concrete, which can be produced by using porous light weight aggregate of low specific gravity instead of normal aggregates.
- Aerated, cellular, foamed or gas concrete, which can be produced by introducing voids within the concrete or mortar by means of using suitable air entraining agents
- No fine concrete is a type of concrete produced by omitting fine aggregate

Light weight concrete can also be classified on the basis of its use as (a) structural light weight concrete-28day cylinder compressive strength should not be less than 17 MPa and density within the range 1400-1800 kg/m³ (b) masonry concrete- 28 day cylinder compressive strength should be in between 7 to 14 MPa and density within the range 500 to 800 kg/m³ (c)insulating concrete- compressive strength in between 0.7 to 7 MPa and density generally lower than 800 kg/m³.

Aerated concrete mixture is a homogenous structure that contains small air bubbles of diameter between 0.1 and 1.0 mm being their form nearly spherical. The enhanced properties in these concretes are due to its distribution of pores and size of pores. The porosity in light weight concretes can be obtained by means of chemical action or mechanical action.

The introduction of different types of foaming agents like synthetic foaming agent and protein foaming agents made the production of foam concrete more popular and big efforts had been made to study the characteristics and mechanical behavior with the idea of using cellular concrete main construction applications[2]. These light weight concretes can reduce the dead load; improve thermal and acoustic properties etc. Light weight concrete blocks are usually produced from Portland cement, water, and sand or any lightweight aggregates[3]. The prime consideration of using the aerated concrete masonry blocks is to reduce the density of masonry units. Light weight concrete masonry blocks can be made by adding light weight aggregates or constructing the blocks as hollow. Light weight aggregates can be prepared by the processes such as expanding, palletizing, or sintering processes[4][5]. The self-weight of Light weight block is much lesser than the normal concrete masonry blocks. As block weight is reduced, installed cost is also gets reduced.

In light weight concrete, the mixture is a homogenous structure that contains small spherical air bubbles of diameter 0.1 to 1.0 mm. There are several methods to accomplish the porosity in concretes: chemical agents that include the air in the mortar, foaming agents that are added to the mixture that manages to create pores due to the internal strains generated in the paste[1]. Aerated concrete is produced by mixing binder, fine aggregate and an aerating agent. Aerating agents used are aluminium, hydrogen peroxide, bleaching powder or calcium carbide. Aluminium is commonly used due to its purity, fineness and it prevents the escape of gas before hardening of mortar [6]. The chemical response of aluminium paste results in a mass of increased volume and leaves a porous structure when gas escapes [6]. Foam concrete is produced by mixing binder, fine aggregate and synthetic/protein-based foaming agent with compressed air/high-speed mixing. Foam concrete needs low or no compaction as it is flowable, pores are introduced through chemical action and also the foam must be very stable so that it does not dissolve. The physical properties of the material, the light weight, low thermal conductivity, high resistance to fire, low compressive strength and low resistance to freezing is due to the size and distribution of pores [1].

The aluminium powder consists of minimum of 90% of metallic aluminium content and it is 100% miscible in water. Aluminium dosage is varied from 0.25% to 0.5% of the weight of cement. In the case of aerated cement mortar preparation, cement, sand, aluminium powder was dry mixed and then water is added and mixed well. Workability is determined using marsh cone and flow cone tests. Flow table determines the variation in initial workability with variation in w/c ratios. Marsh cone test determines the reduction in workability with time caused by aeration. It is concluded that with constant dosage, an increase in the fineness of aluminium powder results in a decrease of density. Appropriate dosage of aluminium powder and w/c ratio is fixed based on the desired density and strength [7]. Aluminium dross, a by-product of the aluminium smelting process is mechanically crushed and sieved to form aluminium dust and aluminium metal-rich particles. In this study, aluminium dust is used as a foaming agent instead of aluminium powder. It is concluded that an amount of 15.6 g of aluminium dust is equivalent to aluminium powder to generate the same amount of gas. Al dust-AACs possess high compressive strength compared to AACs due to its higher density. Volume expansion and density remain unchanged with increases in dosage of aluminium dust. Hence, it does not achieve a low-density concrete but does not compromise on mechanical properties [8]. Foaming agents are responsible for controlling the density and porosity of light weight concrete through the inclusion of air bubbles. The foam agents are commonly synthetic, protein-based, detergents, glue resins, hydrolyzed protein, resin soap, and saponin [9]. The most common foam agents are synthetic and protein-based. Both foaming agents reduce surface tension and facilitate formation of air bubbles. Synthetic foaming agents are hydrophilic in nature and easily dissolved in water yielding air bubbles. It produces larder bubbles and less isolated cells and created a complex chemical environment. In the case protein-based foaming agent, it creates bubbles by means of degradation of the protein. Stronger and closed smaller size bubble structure will be formed [1][10]. Thermal conductivity decreases with an increase in density. Conductivity associated with cellular concrete produced by a synthetic foaming agent was less sensitive to change in air content than concrete produced using a protein-based foaming agent [10]. Stable foamed concrete production depends on many factors such as type of foam agent, method of preparation of foam etc. To produce foamed concrete with high consistency and stability, it is recommended to reduce the volume of foam agent, by partial replacement of cement by either fly ash or silica fume, and lightweight aggregates, which reduces the process of heat of hydration [9].

Light weight concrete requires the same materials as of normal concrete for its production like cement, sand etc. The most important binders in light weight concrete manufacturing are Portland cement, calcium and sulphoaluminate cement, high alumina cement (within the range of 25-100 %). Light weight aggregates can be prepared by the processes such as expanding, palletizing, or sintering processes. Ingredients are collected and palletizing is done i.e. agglomeration of finer particles using a binding agent. The hardening of the fresh pellet is done by sintering, autoclaving or cold bonding processes. Sintering is an energy consumption process than a cold-bonding process. But cold bonding process takes 28 days to attain desired strength for aggregate, whereas physical and mechanical properties of sintered aggregates, are better [11]. Coarse aggregate is not used for the production of light weight concrete[2]. It is reported that there is a significant rise in the emission of carbon dioxide from the cement production industry and also depletion of natural resources due to the extraction of materials like sand. In order to solve the problems of depletion of natural resources, accumulation of construction wastes and also to transform the construction sector towards a more sustainable one, a potential replacement for cement and sand can be taken into practice. [12]. Various by-products from the agricultural, industrial, quarry and construction industry can be used. Each product has its properties, some might improve consistency, long term resistance or simply lower production costs and generally, it can result in a low density, low cost and adequate compressive strength concrete [1]. Power plant wastes like fly ash and bottom ash are used as a partial replacement for cement, as they have a certain degree of pozzolanic reactivity and adequate fineness for cement replacement. Rice husk ash, waste glass, silica fume has high amorphous silica content, hence it is suitable for replacement. Larger size materials, which do not exhibit pozzolanic reactivity like rubber crumbs, C&D wastes are used as a replacement for fine aggregate [12]. Considerable partial replacement of the cement with fly ash can enhance the properties because they are known for their pozzolanic activity and they help in the hydration process. The use of fly ash allowed a reduction in 50% of the amount of cement needed per cubic meter and 40% of the hydration temperature, increase in compressive strength at early ages due to the reduction of bubble size and reduces densities within a range of 1100 and 1500 kg/m^3. Fly ashes have been used as an alternative to sulphoaluminate and other quick-setting cementitious materials, accompanied by hydrogen peroxide, cellulose and dispersants, accomplishing a concrete of ultra-low densities between 100 and 300 kg/m^3, with a pore size between 2 and

4 mm, of low thermal conductivity and higher durability compared to sulphoaluminate mixtures [1]. The addition of coal bottom ash and silica fume increases the density and decreases the volume of permeable voids due to the reduction in hydrogen gas, while excessive addition of coal bottom ash (more than 30%) can weaken the strength[13]. The study on partial replacement of cement with a combination of fly ash and silica fume results in an increase in compressive strength. The various mortar mixes considered are silica fume with 0, 5 and 10% with fly ash of 15%. Enhancement in compressive strength is due to the finer particle size of silica fume, hence good adherence with the aggregate and cement matrix and by replacing cement with fly ash, results in conversion of calcium hydroxide to calcium silicate hydrate gel. Silica fume replacement of more than 10% results in decreases in compressive strength and water absorption. Hence it is concluded that the optimum replacement percentage of silica fume is 5% because this amount is enough to create a densified ITZ & reduction in thickness of zone and thereby enhancing the properties of the mix considered [14]. Pozzolanic materials such as zeolite, silica fume and granulated blast-furnace slag are used as a partial replacement for cement. These are added at various amounts like 7, 14, 21 % of cement weight [15][13]. The compressive strength is enhanced as the pozzolans are added, the more the pozzolanic materials are utilized, and more is the strength. Zeolite was found to be the most effective material, because the compressive strength was improved about two times compared to the control specimen, whereas in silica fume and granulated blast-furnace slag it is equal to 83% and 72%, respectively. It is also concluded that replacement above 21% results in decreases in compressive strength. The use of silica fume is more practical compared to the other pozzolanic materials to reduce water absorption [16]. The iron-making industry generates waste like blast furnace slag. Ground granulated blast furnace slag (GGBFS), when used at 50% replacement of cement, decreased the slump flow due to its higher fineness while the compressive strength of foamed concrete could be improved when GGBFS was used at 30–70% replacement levels. At the cement replacement level of 30%, there is an increase in strength of about 25%. Compressive strength reduces when the replacement level is more than 30%. When un-ground GGBFS is used relatively lower strength is obtained due to its lower reactivity[12]. Rubber crumbs are produced from scrap tire by shredding process followed by granulation, grinding and separation. It is observed that when the replacement of rubber increases the compressive strength of concrete decreases. Crumb rubber repels water from its surface and entraps air, such that it increases the air content in the mix and reduces strength. Crumb rubber is less bonded to the cement matrix, cracks are formed at a weak interface between cement and crumb rubber. At the same time when the replacement of CR increases, water absorption also increases [14]. Synthetic waste materials like PP, polyvinyl have been used in foamed concrete. These can be used as a partial or complete replacement of fine aggregate. Compressive strength of 1–16 MPa can be obtained for these concretes with densities ranging from 600 to 2000 kg/m^3. Foamed concrete with ground polyvinyl waste as 30% fine aggregate replacement have more compressive strength than the control concrete [12]. Rocks from the quarry are crushed and washed, results in the accumulation of a large amount of waste sludge. It results in a decrease in soil permeability and reduces the percolation of air and water. This waste sludge upon air-drying results in the formation of powder[6]. This reports the suitability of using quarry dust in developing the concrete blocks by evaluating the strength, durability, acoustic and thermal properties of concrete. 60% replacement of fine aggregate with quarry dust results in an increase in compressive strength of about 108%. The presence of finer particles results in a denser mix. These finer particles cam maintain stability of foam in a better way. High silica content in quarry dust results in formation of calcium silicate which results in a stronger concrete. The experimental test result of 30% of fly ash with 30% of quarry dust shows that the higher split tensile strength is 1.75 MPa at 28 days with a w/b ratio of 0.4. 30% of replacement is the optimum level of replacement, beyond that limit results in negative impact. The filling effect is prominent in 30 % replacement. The optimum content of fly ash for foamed concrete to increase the higher short-term compressive strength is achieved as 20% - 25%. Higher water absorption is found in mixes with replacement greater than 30% due to an increased mean surface area [17]. Various proportions ranging from 10% to 20% of cement replacement by POFA (palm oil fuel ash) is reported to be optimum for the compressive strength of concrete. The use of ultrafine POFA has been reported to produce concrete strength up to 90 MPa at 28 days. The use of Nano-POFA has also been reported to produce strengths more than normal concrete. Incorporation of 10–20% of POFA as filler in lightweight foamed concrete improves the compressive, flexural, and tensile strength compared with lightweight foamed concrete containing sand only. The use of POFA as a secondary cementitious material can help reduce the drying shrinkage in concrete. POFA can also be used as partial cement replacement to produce self-compacting concrete. The finer the particle size of POFA, the higher is the compressive strength of the resulting concrete[12] [18]. The water cement ratio should be in between a range of 0.4 to 1.25 or 6.5-14% of target density. Lower water content results in a stiff mix, increased density and results in breaking of bubbles. High water content makes the slurry too thin to hold bubbles which cause segregation of foam from mix and increased density. Amount of water added should be appropriate or else it absorbs water from foam and cause rapid degeneration of foam [9].

Replacement using wastes is more seen in fine aggregate than cement because cement replacement is associated with optimum cement replacement level for an effective pozzolanic reaction while excessive replacement results in a decrease in compressive strength. Whereas the fine aggregate can be replaced fully as it can reduce density without compromising its strength. In general, the maximum percentage of replacement for cement should be 75 whereas fine aggregate can be replaced completely. The replacement for cement is limited because it can hinder the hydration process when a high percentage of cement is replaced.

2. CONCLUSIONS

Light weight concrete reduces density of concrete on the introduction of stable voids within the hardened concrete. Voids can be produced by means of addition of any aerating agent or foaming agent. Strength of concrete is governed by total volume of voids in concrete and w/c ration of mix. A review of the literature on the use of different waste materials as a substitute for cement or aggregate highlights the importance towards environment sustainability. Thereby reducing the problems facing due to the depletion of natural resources, waste disposal problems and forms an eco-friendly environment.

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