EFFECT OF FILLER MATERIALS IN AERATED CONCRETE: A REVIEW

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Abstract - *As of late, the lightweight concrete are broadly applied in construction projects. Cement can be replaced by different pozzolanic materials to improve the various properties of concrete and reduce harmful environmental impact. This paper sums up the impact of various pozzolanic materials on the characteristics of aerated concrete. Aerated concrete was made by using aluminium powder. Reusing of waste material should be possible by utilizing as a fractional substitution of fine aggregate in concrete. This paper discusses the change in property of concrete due to the effect of different material. Optimum percentage of each filler materials can be obtained from different studies*

***Key Words*: Aluminium powder, pozzolanic materials, filler materials, compressive strength**

1. INTRODUCTION

Light weight concrete is a developing pattern in the construction industry. It reduces the dead weight of the structure. In addition to that, it gives good sound and thermal insulation for the structure. Lightweight materials can enhance the seiemic capability of a building. According to production methods, the types of light weight concrete are (a) Light weight aggregate concrete, (b) Aerated, cellular, foamed or gas concrete which can be manufactured by creating bubble voids within the concrete or mortar mass by suitable air entraining agents, and gives more homogeneity and distribution of the voids within the concrete, (c) No fines concrete, which can be produced by removing the fine aggregates from the mix and this gives no segregation between the ingredients.

According to utilization purposes it can divided as (a) Structural lightweight concrete (b) Masonry concrete (c) Insulating concrete has thermal coefficient should be below about 0.3 J/m2 sec °C/m.

Different type of pozzolanic materials can be incorporated in the concrete as a replacement of binder [1]. The OPC production was reported to be responsible 5-7% global CO_2 emissions[2] . So as to decrease the CO2 outflow brought about by OPC, GGBS, fly ash and Silica have been utilized in place of OPC and were accounted for to accomplish better physical properties [3]. In the presence of moisture, pozzolanic material form calcium silicate hydrates after the chemical reaction with calcium hydroxide [4].

Diverse waste materials can be utilized as a fractional replacement of aggregates in the concrete [5]. The accumulation of waste materials can cause a negative environmental impact. It can also be considered as an effective method for recycling of waste materials. Strength of the concrete decreases with the increasing percentage of filler materials [6]. Concrete waste after the demolition can also be crushed and reused as the coarse aggregates. Reusing or recuperating waste materials has two fundamental favorable circumstances that it moderates the utilization of regular total and it protects the utilization of landfill for materials which can't be reused [7]. A certain pretreatment method can be applied to improve the bond between the concrete matrix and waste materials. Thus an improvement in the strength was observed with the addition of surface modified waste materials [8]. Concrete with cement and pozzolanic material have higher strength than concrete with cement only. Studies have been conducted on the concrete containing silica fume for different percentage of crumb rubber. Strength increases in crumb rubber silica fume combination rather than the crumb rubber cement combination [9].

1.1 Light Weight Concrete

Light weight concrete has density in ranges from 320 to 1920 kg/m^3. It could be in multistory buildings, long span bridges, offshore platforms and large structures [10]. It was made by using light weight aggregates or by adding aerating agents. The light weight aggregates that can be utilized, changes from natural pumice aggregate to man-made sintered aggregate. Aerated concrete and foam concrete are two major classification of light weight concrete [11]. Foam concrete is made by a foaming agent and aerated concrete is made by first made air bubbles in the concrete. Aerated concrete sometimes called cellular concrete.

Aerated concrete is generated by making calcareous materials (lime and cement), silicon materials (quartz sand ad fly ash) and blowing agent(Aluminium) through several process, like grinding, proportioning, mixing, casting, foaming, standing, cutting and curing. The apparent density of aerated concrete is about 300-1200 kg/m^3 and its strength is about 0.5-7.5 MPa, and thermal conductivity coefficient is about 0.081-0.29 W/m K[12]. The aerated concrete has large porosity, small water absorption, low strength, good insulation, and bad frost resistance, often used for roof boards and walls [13].

Foam concrete is a kind of porous concrete made by blending cement paste with foam agent hardening [14]. Its apparent density and compressive strength are 300-500 kg/m^3 and 0.5-0.7 MPa respectively. It can be cast on the site directly, mainly used for the insulating layers of roof boards. When produced, foam concrete is usually conserved by steam or autoclave. The optimum foam volume was found out to be 5-7.5 % [15]. The use of different cementious material which is freely and readily available can make foamed concrete cost effective [16].

Awham Mohammed Hameed et al studied the effect of plastic waste in concrete. Their studies show that, the addition of plastic waste result in the lowering of densities of the concrete. So it tends to be utilized as a reasonable addition in light weight concrete.

Due to the poor adhesive properties baetween cement paste and plastic , strength will decreases. The presence of PET aggregate in the concrete prompts to stop the crack propagation because it acts as barriers to crack growth. Hence, the values of flexural strength increase with addition of aggregate but it sometime create defects (some voids) inside the concrete and then decline its strength [17].

The plastic waste can also made as light weight aggregate by compression moulding technique. This technique was developed by overcoming the disadvatages of heat mixer and extrusion technique. The density of concrete contains lightweight aggregates decreases and compressive strength decreases with the increase in replacement of light weight aggregates. They were observed that thermal conductivity reduces in that type of concrete and then produce good insulation. Poisson's ratio of the concrete was reduced as 9–41% when the replacement level was increased from 25 to 50%, as compared to the natural light weight aggregate concrete [18].

Durga Chaitanya Kumar Jagarapu et.al conducted a study on the light weight concrete by using palm oil sheels. They were replacing cement by granulated blast furnace slag and aggregtaes by palm oil sheels. The concrete containing palm oil fuel ash gives 30 MPa with 30 percent replacement of GGBFS. Concrete containing 20 % POS give higher strength. Emre Sancak et. al discussed the effect of light weight concrete at elevated temperature. They pointed out the effect of superplasticizer as concrete shows higher weight when it contain superplasticizer when compared to concrete without superplasticizer[20]. The rate of strength loss is lower in the case of light weight concrete when compared to conventional concrete.

Light weight concrete blocks have variety of application. It has a great application in construction industry because the weight of whole structure is very low [21]. The light weight block produce using vermiculate have minimum density is 1800 kg/m^3 and 5 N/mm^2 is minimum average compressive strength and minimum compressive strength of individual units not less than 4 N/mm^2. It can meet the Indian standards in light weight masonry structure. Light weight blocks are produced by using foam concrete containing 10 % volume of foam [22]. Specimens of size 100*100*100 mm are used for the tests. Along with this foam cement can be replaced with fly ash and sand can be replaced by quarry dust. Then we can eliminate one of the disadvantages of foam concrete as higher usage of sand. Concrete masonry of foam concrete seeks more application in the recent days because of its less density, less thermal conductivity and reduced mortar joints [23]. Fibers can also added in this mix, then surface of block made to a rough surface and it help to establish a proper bond between block and mortar. But durability of this light weight blocks is an important parameter to study [24].

2. AERATED CONCRETE

Aerated concrete consist of cementitous material, sand and water. Sometimes cement can be replaced by fly ash, ggbfs and other type of pozzolanic materials. The addition of pozzolanic materials will improve the strength properties and reduces the moisture ingress of concrete [25]. Aerated concrete increases its strength double times when zeolite is in the mixture. There is no increase in strength when replacement percent exceeds 21%.

Some studies was conducted to found out the effect of mix proportion, amount of foaming agent, water-solids proportion, steam pressure, and time for curing on the attributes of autoclaved aerated concrete[26]. The amount of Aluminium powder added will influence the density of the aerated concrete. Porosity of aerated concrete should be found out in order to obtain the exact physical properties of concrete. The hydration reaction can be enhanced by the high pressure steam condition. Properties of concrete also increase due to the high pressure steam. Microstructure study of aerated concrete shows that the pores in the concrete were filled with the hydration products [27].

Certain replacement can be done in the aerated concrete. Cement can be replaced by suitable pozzolanic material to improve the properties and there is a fiber reinforced aerated concrete can be develop to improve the tensile strength of concrete [28].Aerated concrete can be made upto 25 Mpa strength by replacing cement with fly ash. The density of aerated concrete decreases due to flyash and GGBFS [29]. Studies were done on the aerated concrete containing different filler materials. There is a proper bond establish between wood fiber and matrix. Mechanical strength of WFAC specimens obviously increased when an appropriate fiber content was used, especially 0.4% fiber content [30].PVC granules can incorporate into the aerated concrete. The optimum content of aluminium powder was obtained as 0.5 %when it contains fly ash and PVC granules [31]. Rubber powder can also use as filler material in aerated concrete. The replacement leads to a less density of mix. The optimum dosage of rubber powder was obtained as 5% [32]. Addition of filler materials also affects the workability of the concrete. Induction furnace slag can be utilized as a halfway substitution of fine totals. But workability shows a decrease in the concrete beyond 40 % substitution of fine aggregates due its angular nature [33]. Workability also depends upon the addition of various mineral admixtures. Initially workability increases with the addition of mineral admixtures, but then it decreases with higher percentage replacement of cement [34]. Dosage of superplasticizer should optimized based on Admixture-cement compatibility and admixture- admixture compatibility. The workability of the concrete reduces with increasing the dosage of super plasticizer [35].

Air entrained concrete used in manufacturing of lightweight masonry blocks. Studies have been conducted for the varying percentage of aluminium powder. The density of aerated concrete decreases when the percentage of aluminium powder increaes. The level of decrease in density is between 5.45 – 20 % when the level of aluminum powder is changed between 0.1-5% by weight. According to this study, optimum percentage of aluminum powder for masonry blocks was found out to be less than two percent by weight of cement [36]. Aerated concrete are porous in nature and have comparatively higher water ingestion, so it ought to be put or beautiful exteriors [37]. The aerated concrete with 0.5% of Aluminum powder and partial replacement of 20% of cement with Fly Ash is suitable for masonry purposes [38]. Quarry dust can replace fine aggregate along with these pozzolanic materials. Strength of concrete increases initially and decreases due to the fineness of quarry dust[39].

Hamdy El-Didamonya et.al. studied the application of industrial waste and agricultural waste. Initially temperature was high in the concrete contain slag or metakaolin, later temperature decreses at a faster rate [40]. Waste glass also can be incorporate into the aerated concrete. This study discusses use of waste glass having particle as >90 μm and 45-75 μm. By using this, we can reduce the density of the concrete and 10% value if found out as the optimum replacement of waste glass [41]. Thermal conductivity is the ability to conduct heat. Aerated concrete have less thermal conductivity and have great insulation, so it could be used in different type of application. Fiber commitments made into the base material directly influenced the thermal conductivity of doped material as per expansion sums by volume/mass [42].

The removal of waste of aerated concrete is majorly discussed areas. AAC waste are used as concrete aggregate, prefabricated concrete tiles, concrete blocks, shuttering blocks and cement supplementary material. Physical characterization of aerated concrete waste should be studied to identify the proper use of waste. Crystal phase composition of AACW mainly includes quartz, calcite and tobermorite. Physical texture of AAC waste can absorb water and have internal curing potential due to its porosity. The pore size of aerated concrete varies from dozens of microns to a few millimeters. The disposal and utilization of AACW in building materials brought environmental and economic benefits [43].Crushed AAC waste used as light weight aggregates. Then fabrication cost and energy was less compared to the normal concrete construction. Aerated concrete powder can be added in the concrete and compressive strength increases by 37%. Aerated concrete powder also shows an improved character of freeze and thaw resistance [44].

Recycled AAC waste after accelerated carbonation can be added as a replacement in concrete. The improvement in the strength is an important advantage of accelerated carbonation method. This study was also conducted on the chloride ion permeability also and shows a decrease in the value after accelerated carbonation curing method. More crystalline rather than amorphous $CaCO_3$ is generated for refining pore structure after accelerated carbonation curing method [45].

3 PROPERTIES OF AERATED CONCRETE

Addition of Aluminium affects the density of the light weight concrete. The bulk density decreases up to 23.47 % due to the addition of Aluminium powder. When Portland cement replaces with the bottom ash at 10% and 30%, its bulk density shows an increase of 2% to 7% respectively. The increase in density of bottom as AAC was due to development of the tobermorite phase. Volume of porous voids of bottom ash AAC decreased with increasing percentage of bottom ash and silica fume. It will directly affect the weight of concrete also [46].

Compressive strength depends on both intrinsic and extrinsic factors. Intrinsic factors include water content, type of cement and aggregates, content of cement and aggregates while extrinsic factors include curing and testing conditions [47]. Porosity of the concrete affects the compressive strength. There by its density is related to compressive strength. Reduction in the strength was observed due to the development of large micropores. So compressive strength value is between 1.91-5.10 MPa at a density of 590-780 kg/m^3, but compressive strength was reduced to 1.3-2.8 MPa if the density is 400 kg/m^3. The dosage of superplasticizer in concrete varies with the temperature. Optimum amount of superplaticizer should be found out to get the required strength and workability [48].

Thermal conductivity depends upon pore structure of the light weight aggregates, density of concrete and the cement matrix. Thermal conductivity reduces with the decreases in bulk density and it also depends upon the moisture content of the concrete. Thermal conductivity of AAC is 1.1-5.0 W/m K. [49].

Aerated concrete have large voids due to the aeration, so it is expected to have high freeze resistant. But aerated concrete tend to liquid and gas penetration due to the high lead to damage to the concrete [50]. Concrete became more brittle with a high degree of saturation. Freeze thaw resistance of the concrete can be measured by using the scaling method, where the samples undergo 25 and 50 cycles of freezing of 8h freezing at 15^{0}C and thawing of 8h at 20^{0}C. These samples were also tested at different moisture condition like dry, 10% saturated and completely saturated. According to the test, the dry samples show no sign of mass loss or compressive strength loss after 25 cycles. Samples with 10% moisture shows high percentage of mass loss say 1.3-1.5 %. For capillary saturated samples, the loss of compressive strength was more severe after 50 cycles. The freeze-thaw is tolerated in strength range of 1.8-4.0 MPa for dry and 10% samples. Low density and high open porosity of material accelerates carbonation processes. Possible shrinkage, caused by carbonation, also lead tocrack and loss of durability [51]. The durability of the foam concrete contains fly ash and quarry dust was studied. Concrete contain 30 % fly ash have less water absorption rate. The utilization of pozzolanic admixtures and turbulence mixing technology (with effect of cavitation) makes possible to conceivable to create more water safe [52].. The study was conducted by adding polypropylene fiber, carbon, basalt and glass fiber. According to this study higher thermal conductivity was obtained for the concrete containing carbon fiber. Thermal conductivity of the fiber reinforced aerated concrete vary linearly with the volume of doped material [53]. Fiber improves not only the strength characteristics but also the ductility of the concrete [54].

Yingying Wang et.al conducted the study on thermal conductivity of aerated concrete with the variation of humidity. The strength of aerated concrete was increased by 89.73 % when humidity changes from 0 to 100 %. CSC shows 0.5 % increase in conductivity of heat, while in case of AC was 4.6% when temperature vary from 20^{0}C to 50°C[55]

Tkach Evgeniya et.al proposes an efficient method to change the hydrophysical properties of aerated concrete using industrial waste. Aerated concrete have some disadvantages like high moisture ingression, high vulnerable to frost. These disadvtanges can be minimized by the joint application of waterproofing additives and hydrophobic traeger in the form of pellets made from bitumen and fly ash. Modified concrete has reduced by 30% of the value of the residual moisture, water absorption on 38-39% and capillary suction on the 30-32% [56].

Agnieszka Rózycka et.al studied the effect of addition of perlite in aerated concrete. Sand undergoes a partial substitution by using perlite. The use of this expanded perlite result in the deduction of unit weight of the concrete. Due to the replacemant of perlite waste up to 10% by weight decreased, the thermal conductivity about 15% without huge loss of compressive strength. The use of expanded perlite wastes to replace quartz sand consumes less natural minerals and reduces the amount of waste stored in the landfill [57].

Zdzisława Owsiak et.al discuss the effect of halloysite powders on the performance of the slow-setting silicate based autoclaved aerated concrete (SW production technology).Strength of concrete increases by 5.8 % due to the application of halloysite as a substitution of cement with the same bulk density of autoclaved aerated concrete. Heat conduction of the concrete is not affected due to halloysite [58].

4. CONCLUSION

Light weight concretes have a wide range of applications in the construction industry. It have application in multi storey buildings, long span bridges, offshore platforms and large structures. Its good thermal and sound insulation properties also come into play in different applications. Along with this, the replacement of binder with different pozzolanic materials shows improvement in the properties of concrete. We can produce an ecofriendly concrete by replacing the binder with various cementitious materials. The basic slag substitution in commercial production is 20-50% of the cementitious materials. Light weight concretes are the emerging trend in construction industry. It reduces the dead weight of the building and it induces seismic capability to the building.

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