STUDY OF PROPERTY CHANGES IN AERATED LIGHTWEIGHT CONCRETE

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Abstract : Aerated Lightweight Concrete (ALWC) is an ultra-light weight concrete masonry product. It's weight is 1/5 times less than ordinary concrete due to distinct cellular structure having millions of air voids trapped in concrete.. This cellular structure in concrete gives LWC a large variation in physical characteristics exceptionally. LWC contains sand, cement, lime, fly ash, gypsum, aluminium powder paste(AAC), water and an expansion agent(Foaming agent). Silica sand which is main the raw material used in the maximum volume in LWC, is one raw material in world's most abundant natural resources list. The final concrete is approximately up to five times of the volume compared to the raw materials volume used, it depends on the requirement of strength and density. Due to this large increase in volume, ALWC is very resource efficient for construction. In construction sector concrete is highly consumed and the raw materials for the concrete used in building construction are in chronic shortage and the responsible for associated environmental damage. From the last decade, construction industry has started conducting various researches all over the world on the utilization of easily available raw materials in building construction. This work is done to investigate the property changes in lightweight concrete against the ratio of the air entrapped in concrete. There are two main objectives of the project are to produce aerated lightweight concrete in laboratory and to determine the effectiveness of voids using foam in mortar. To determine and compare strength of aerated lightweight concrete, at different ratio of the air entrainment in the concrete.

***Index Terms* - Aerated Lightweight Concrete.**

I. INTRODUCTION

Concrete which has entrained voids in the intentionally in hardened cement paste or mortar to produce a cellular structure with low density is known as aerated, gas, foamed or foam concrete, cellular concrete. Lightweight concretes is produced for an over-dry density(low density) range of approximately 300kg/m3 to a maximum of 2000kg/m3, with a targeted cube strength from approximately 1MPa to over 60 MPa having thermal conductivities of 0.2W/mK to 1.0 W/mK. While these values are compared with the values for normal weight concrete of approximately 2100–2500kg/m^3, which is greater than 100 MPa and 1.6–1.9 W/mK. Mainly, Lightweight concrete is prepared by two methods, either by omitting the finer sizes of the aggregate or even replacing them by air voids, cellular or porous aggregate or it can be achieved by injecting air in its composition. Particularly, the lightweight concrete is categorized into three groups:

1. No-fines concrete
2. Lightweight aggregate concrete
3. Aerated/Foamed concrete

Aerated/Foamed concrete can be divided into two main types on the basis of the method of production. One is foamed concrete (non-autoclaved aerated concrete (NAAC)) and second is autoclaved aerated concrete (AAC). Foamed concrete can be achieved by injecting preformed stable foam which is produced by chemicals or by adding a specific air-entraining admixture known as a foaming agent directly into the base mix of cement paste or mortar matrix(cement, water or cement, sand & water). The AAC is produced by adding a predetermined required amount of aluminum powder and other additives into slurry of ground high silica sand, cement or lime and water. Aluminium powder is usually added to produce autoclaved aerated concrete by a chemical reaction in mortar and aluminium powder generating a gas in fresh mortar, so that when the concrete sets it has a large number of voids formed by gas bubbles.

II. LITERATURE REVIEW

Lightweight Foam Concrete is introduced in 90th century as construction material in the construction industry. It was first patented in year 1923 and a very limited scale of construction was aware of LFC in 1923. And use of Lightweight Foam Concrete was very limited for a long time, until the late 1970s, then it was started to be utilized in Netherlands for two purposes ground engineering applications and voids filling works. In 1987, a full scale assessment on the utilization of Lightweight Foam Concrete as a trench reinstatement was started in the United Kingdom and the achievement for this trial led to the extensive utilization of Lightweight Foam Concrete for trench reinstatement and some other applications also introduced in 2001. Since then, Lightweight Foam

Concrete is well known for building material and it has become more utilized with expanding construction production and wide range of applications. From the past 20 years, Lightweight Foam Concrete has been preferably used all around the world for filling bulk areas, trench reinstatements, back-filing of retaining walls and abutments of bridges, insulation for footings and roof tiles, acoustic insulation, soil stabilization (especially for the construction of slopes in embankment), grouting in tunnel works, sandwich filling for precast units and pipeline infill. However, in the last few years, there is wide growth in using Lightweight Foam Concrete for a purpose of lightweight non-structural or semi-structural material in construction industry to take advantage of its lightweight and a very good insulation properties. Lightweight Foam Concrete can be prepared in a wide range of densities and each density produced has a different type of application. The AAC was first introduced by Mr E. Hoffman, in year 1889. The aeration in mortar was produced by carbon dioxide which was produced in the reaction between the Hydrochloric Acid and limestone used. Powdered Aluminium and Calcium Hydroxide were introduced as aeration agents in mortar mixtures by Aylsworth & Dyer while working in USA in 1914. In 1917, a Dutch patent registered for using yeast in mortar as an aerating agent. The use of powders taken out from metals for producing Hydrogen gas as forming agent was developed by Grosahe in Berlin in 1919. The first attempt for achieving autoclave aerated concrete was done in 1923 in Sweden. Autoclaved aerated concrete is a highly lightweight material for construction and it is mainly used as blocks. AAC consists of basic constructio materials which are easily and widely available. These contains sand, cement, lime, gypsum, water and an expansion agent. Silica sand as a raw material has the greatest volume in AAC. Silica sand is one of the world's most easily available natural resources. At present there are 31 manufacturing plants for AAC blocks in India and they are working with heavy concentration.

Abbreviations and Acronyms

Lightweight Concrete - LWC
Aerated Lightweight Concrete - ALWC
Autoclave Aerated Concrete - AAC
Lightweight Foam Concrete - LWFC

III. RESEARCH METHODOLOGY

Foamed concrete production is done by two methods pre-foaming method and mixed foaming method. Pre-foaming method has the separate preparation of base mix cement slurry(cement paste or mortar) and a stable preformed aqueous (foam agent with water) and then the thorough mixing of this foam into the base mix. In mixed foaming, the surface active agent is used and it is mixed with the base mixture of mortar and while the process of mixing is going on, foam is produced which results in cellular structure in concrete. The preformed foam can be in the form of wet or dry foam. The wet foam is achieved by spraying a chemical solution of foaming agent on a fine mesh, it has 2-5mm bubble size and relatively it is less stable. Dry foam is produced by mixing the foaming agent solution with some pressure through a continuous high density series restrictions and keeping a forcing compressed air into the mixing chamber simultaneously. Dry foam is highly stable and it has voids size smaller than 1mm.

3.1. Foam Agent

The foam agent which is used for obtaining foamed concrete is defined as an air entraining agent. The foam agent is the responsible material for the influence in the foamed concrete. The foam agents are added into the water then it will produce millions of discrete bubbles cavities which are later incorporated in cement paste after mixing. The properties of foamed concrete are totally dependent on the quality of the foam.

Foam agent are classified according to types of foaming agent:

1. Synthetic - They are suitable for densities of 1000kg/m3 and above.

2.Protein - They are suitable for densities from 400kg/m3 to 1600 kg/m3.

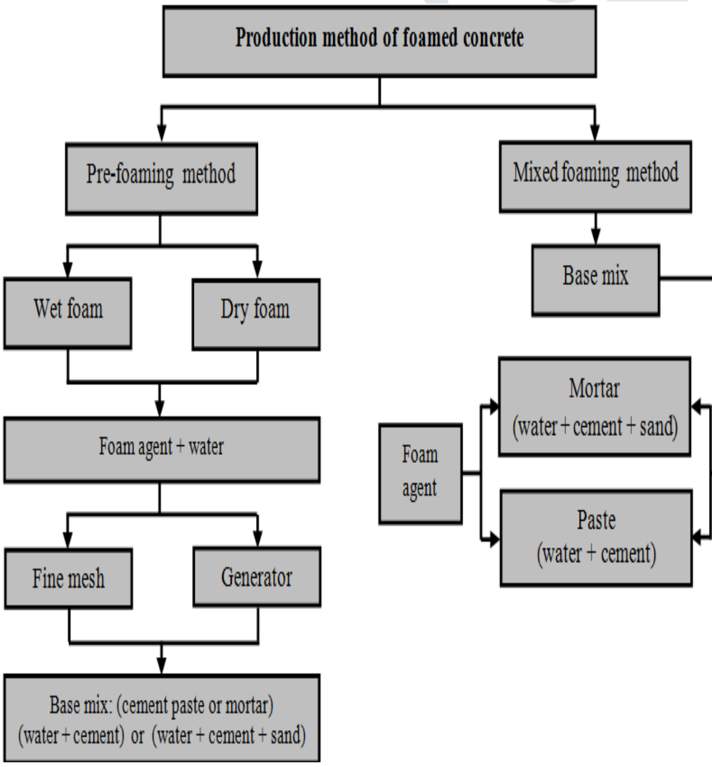
Raw materials which are more suitable for autoclaved aerated concrete are fine grading materials. Silica or quartz sand, lime, cement and aluminum powder are main raw materials for producing AAC. The percentage of Silica sand is highest in the raw materials of aerated concrete mix. Mineral based aggregated are both silica and quartz sand which can be taken out from broken rocks or granites. As well as fly ash, slag, or mine tailings can also be used for aggregates in addition with silica. All fine aggregates like silica sand or quartz sand and lime are added with cement. Then water will be introduced to this mix and hydration will starts while cement forms the bond between different fine aggregates and cement paste. After the mixing process, expansion agent is mixed with the mix to increase its volume and this increase can be controlled between 2 to 5 times more than the original volume of the cement paste. Finally, the expansion agent which is used to obtain AAC is aluminum powder; this material start reactions with calcium hydroxide which is obtained by the product of reaction between cement and water. This reaction between aluminum powder and calcium hydroxide is the reason for forming of microscopic air bubbles or voids which in result increase the volume of paste volume. The hydrogen gas bubbles up out of the mixture in this process and is replaced by air.

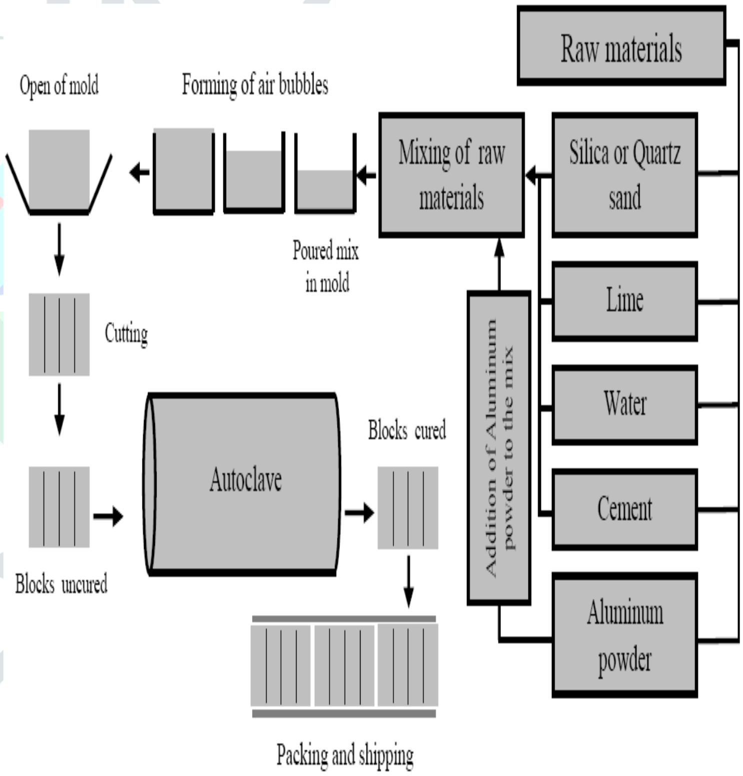
3.2 Aluminum Powder

Aluminum powder is usually used to produce autoclaved aerated concrete by a chemical reaction with cementious paste generating void bubbles in fresh mortar, so that when it hardens it contains a huge number of gas bubbles. Aluminum is foaming agent in AAC production worldwide and it is strongly proven as the best admixture for its purpose. When aluminum is added (approx. between 0.2% to 0.5% by dry weight of cement) to the paste. The Aluminum powder is classified into three types: Atomized, Flake and Granules. In case of an atomized particle, its length, width and thickness are all equal in size, where the length or width of a flake particle can have hundred times to its thickness. The requirement for AAC requires aluminum powders that contain particles finer than 100 or 50µm. This is important to obtain required and designed mechanical properties of the aerated concrete.

The concrete mix ratio used is 1:2:2 and 1:2.5:2. As well as it is conducted with and without reinforcement. Nominal reinforcement is added at different ratio 0.25%, 0.50%, 0.75%, 1.0%. The experiments are done on the specimens to check the following properties.

1. Compressive Strength
2. Flexural Strength
3. Splitting Tensile Strengrh





A. Production process of Foamed Concrete *B. Production process of AAC Blocks*

IV. RESULTS AND DISCUSSION

By this study it has been observed that on 7-days curing age, the compressive strength of the unheated aerated concrete samples with 1:2:2 mix ratio and w/c ratios of 0.60 and 0.80 are 2.85 N/mm^2 and 2.60 N/mm^2 respectively. After 21-days curing, the average compressive strength of the samples with w/c ratio of 0.60 and 0.80 are 4.46 N/mm^2 and 3.65 N/mm^2 respectively. After 90-days curing, aerated concrete with 1:2:2 mix and w/c ratio of 0.60 shows compressive strength value of 4.69 N/mm^2 while for 1:2:2 mix and at 0.80 w/c ratio, the compressive strength is 4.56 N/mm^2.

In all the test cases, the mean compressive strengths of test samples with w/c of 0.60 are higher than the respective values for test samples with 0.80 w/c ratio. There is depression in strength of test samples with w/c of 0.80 with respect to test samples prepared with w/c of 0.60, it could be understood as presence of excessive moisture in w/c of 0.80 sample for hydration process in the aerated concrete.

All aerated concrete specimens shows escalation in compressive strength while addition and raising the percent of steel fibers. There is boost in compressive strength after 7 days sample about (27.15%, 42.95%, 30.33%, and 17.49%) for (1.0%, 0.75%, 0.50%, and 0.25%) steel fibers respectively. While after 28 days samples, adding (1.0%, 0.75%, 0.50%, and 0.25%) steel fibers shows increase in compressive strength nearly(30.34%, 51.74%, 33.78%, and 21.27%) respectively. It can be observed that the increase in compressive strength of light weight steel fiber concrete after 28 days is higher than their respective compressive strength after 7 days. Such change in compressive strength is observed due to the heat of hydration process around steel fibers and near to all the voids of aerated concrete.

All aerated concrete specimens shows continued escalation of flexural strength with raising the steel fibers quantity. This rise in flexural strength for lightweight aerated concrete with steel fibers with reference to plain aerated concrete mix are 20.90%, 29.26%, 41.68% and 54.25% for lightweight aerated concrete while adding 0.25%, 0.50%, 0.75% and 1.0% steel fiber by volume of total concrete respectively. This type of behavior is mainly exhibited to the role of the steel fiber in minimizing fracture energy near crack tips which is basic need to stop crack growth by transferring all stress from a side to other side. As well as this nature is due to the increase in the resistance to cracking of the composite and the property of fibers to increase repelling forces after the aerated concrete matrix has been cracked.

For splitting strength also the addition of steel fibers in aerated concrete mix has shown a considerable raise in splitting tensile strength with reference to normal mix (without fibers). Splitting tensile strength has been increasing as the steel fiber quantity increases. However, the change in splitting tensile strength of lightweight aerated steel fiber concrete (LWSFC) with respect to reference plain aerated concrete at 28 days are 62.63%, 33.75% , 17.28% and 5.94% for LWSFC when steel fibre is 1.0%, 0.75%, 0.50% and 0.25% by volume of aerated concrete respectively. This increase is may be due to the good mechanical bond of steel fibers at their surface which took it to high strength in the fibers and the aerated concrete matrix.

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