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Autoclaved Aerated Concrete: Versatile building material

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ABSTRACT

The lightest masonry material available in today's market is AAC blocks (Autoclaved Aerated Concrete Blocks) whose density is about 1/3rd times of the clay bricks and fly ash bricks and about 1/5th times of the Concrete because of its foam-like structure made up of 80% of air voids while they are being used since the 1920s in most of the part in Europe still many are not accepting them in countries like India and America. Due to its lightweight and great thermal resistance, it is gaining popularity all across the world but not only it is gaining popularity because of its engineering properties but also because it is an eco-friendly product which is why even government and other organizations are promoting its usage. But this lightweight eco-friendly product is also economic as even after the initial costing is higher than clay bricks but its light weight causes the reduction in dead weight around 1/3rd times hence the total project cost decreases by 15-30%.

Keywords*— Autoclaved Aerated Concrete (AAC), Blocks, Eco-friendly, Lightweight, Engineering properties*

1. INTRODUCTION

The history of the AAC blocks start from Europe in the 19th century, when a German researcher Michaelis got his patent on the steam curing process in 1880 and not too late in 1889 Czech Hoffman made another patent on AERATING the concrete from Carbon Dioxide (CO_2).

Then at the start of the 20th century that is in 1914, two Americans place their support in the development, they were Dr. Aylsworth and Dyer who were able to attend the porous cementitious mix using calcium hydroxide and aluminum powder for which they received patent too. But it was firstly perfected in Sweden in around mid-1920 where it was designed and perfected at RIT (Royal Institute of Technology) by the Swedish inventor and architect Dr. Johan Axel Eriksson along with Professor Henrik Kreüger. In 1920 he got the method of making the aerated mix of limestone and ground slate patented. And by 1923 he came to a conclusion that the moist foamed mass can easily handle the pressurized steam curing (AUTOCLAVING) which was a breakthrough in the development of AAC blocks from here He concluded that when it is steam cured the material hardens quicker and not only this but also there was comparatively negligible shrinkage then the air cured ones. This finally completes the process and hence the Autoclaved (by Axel Eriksson started by Michaelis) Aerated (by Czech Hoffman and perfected by Axel Eriksson) Concrete that is AAC was made. In much less time Axel Eriksson drops this in the commercial market in Swedish city Hällabrottet in 1929 as AAC Blocks in a factory named "Yxhults Stenhuggeri Aktibolag "under the name Yxhult whose name was changed to Ytong in 1940. But this was not a small thing soon in 1932 that is in 3 years another factory Carlsro Kalkbruk Skovde was set up with the product brand name as Durox. But soon in 1934, the biggest competitor arrived in the market with the brand name Siporit (renamed to Siporex in 1937). Siporex not only produced the simple blocks but was also the first one to make reinforced elements in 1935 which were initially the roof/floor panels and lintels. The good engineering properties of the AAC block soon caught the eye of many engineers and lock builders which soon results in starting 6 plants alone in Sweden. Slowly the news spread all over Europe and countries like Germany and England accepted it with open hands.

Since the beginning of construction, the walls were the basic elements of any structure as time progressed technology gets better and better so we have walls made up different materials like the historical mud bricks and stones were replaced by clay bricks nowadays we hardly see the walls built with stone masonry. But as we progress with clay bricks we start to feel the demerits of its usage like the release of CO_2 While the manufacturing as well as the raw material for clay bricks is Clay. Once the clay is taken out of ground its fertility decreases and the place where the kilns are set up also destroys the nearby land fertility and adversely affect the environment. So the first counter was thought to be Fly ash bricks. As there was a time when the fly ash was becoming a big problem as they were not decomposable waste and was being produced in a large amount every day but it was soon found that the fly ash has engineering properties and hence they were soon be used as puzlona material in cement and in fly ash bricks. Fly ash bricks not only use the waste non-decomposable material but also helps the environment by reducing the use of clay bricks which prevent the fertile soil and clay. Fly ash is made up of 60% of fly ash along with 30% sand and the remaining 10% is of cement or any other cementic material. When the fly ash was in usage several merits and demerits were found like they are having better compressive strength then clay bricks, the compressive strength of bricks is 3.5MPa(common bricks while first class even have 10MPa+) whereas compressive strength of Fly ash bricks are 7.5MPa. Other advantages are that the surface of Fly ash bricks are smooth so less mortar is required but it was soon seen that there are several disadvantages like The thermal conductivity of fly ash bricks are way high than those of clay bricks along with the density of fly ash bricks are slightly higher than those of clay bricks so total dead load increases plus due to the smooth surface the plaster does not stick on the surface nicely. So the thought was given how to counter all these problems and the answer was the usage of AAC blocks. AAC blocks are a cellular structure made with 70-80% of air voids by using the foaming agent and creating air voids (by the formation of hydrogen bubbles). They are more eco-friendly than both of the above-discussed bricks. As in the production of both clay and fly ash bricks lot of CO_2 is released, and being a greenhouse gas CO_2 is one of the prime reasons for the global warming hence we can say that the production of AAC blocks with a minimum amount of CO_2 makes it the most economical eco-friendly building blocks available in the market. Other than these we have many other advantages includes great thermal resistant, sound resistant, pest resistant, lighter, appreciable strength and workable. AAC blocks are made of 80% of air voids hence the blocks are great at thermal resistant as well as they are soundproof. Using them will result in a decrease of temperature change by 30%. Not only this, because of its porous structure they are fireproof. Alongside they are super workable as well as they are having a compressive strength 4MPa+ (4.62MPa in a test conducted). But yet they are not much popular in India and the USA while in European countries like the UK about 40% and in Germany, about 60% of total construction is being done using these blocks.

AAC in India: Right now there are more than 31 plants with heavy working concentration are present near Surat due to cheap fly ash available due to the power plant. And in Rajasthan, there are three major plants with two plants in Jaipur and one plant in Kota due to the available fly ash from KTP. The normal cost of AAC blocks varies from about Rs 2,300 to 3,500 per cubic meter. In other regions of India it is also getting popular like in Chandigarh and Mumbai, where even Government Of India is supporting the usage of AAC blocks as it is an ecofriendly material being consuming fly ash and not using much of earthen material and even the production is much less polluting than the normal clay bricks and fly ash bricks.

2. LITERATURE REVIEW

Anurag Wahane [1] Studied the formation of Autoclaved Aerated concrete and its manufacturing process in which he stated the various materials used in the process. According to the study he stated that cement, fly ash, sand, limestone, aluminium powder and gypsum is used where the aluminium acts as the expansion agent due to the reaction between calcium hydroxide, aluminium, and water which cause the release of hydrogen gas. In the process he discussed each individual step listing: 1) raw material preparation 2) Dosing and mixing 3) Casting, rising and curing 4) Demoulding and cutting. From his study, Anurag concluded that the weight of structure reduces which causes a reduction in the impact of earthquakes and the weight of AAC blocks is about 80% less than that of conventional bricks.

Farhana et.al [2] The paper reveals the history of the novel building material, Autoclaved Aerated concrete and how the product was finally achieved its final form. There are 31 manufacturing plants in India near Surat, and its production is highest in the state of Gujrat. The various advantages and disadvantages are discussed in details which reveals a discussion and comparison between the conventional concrete and AAC. The manufacturing process is briefly explained along with sub-processes and raw materials and it can be concluded that AAC blocks provide a good opportunity to entrepreneurs special in the state of Gujrat.

Robert et.al [3] The review report deals with the general intro about the AAC and its manufacturing process but the main emphasis of the report is given to the uses and engineering properties of Autoclaved Aerated concrete. The product is a lightweight porous concrete made up of cellular structure where autoclaving provides the product with its strength and dimensional stability along with a low thermal conductivity but still retains the bearing capacity suitable for structural use. The AAC is a versatile product where different forms of blocks and panels are used for the construction of both load-bearing and non-load-bearing components in a structure. The study of energy efficiency embarks on the various positive aspects of AAC on countering the climatic effects though, under severe climatic conditions, autoclaved aerated concrete may be insufficient if used alone for thermal resistance. Hence in such a situation, AAC should be used along with additional thermal insulation.

3. MANUFACTURING OF AAC

3.1 Raw Materials

3.1.1 Cement: Cement act as the binder material in AAC block, Top quality 53-Grade OPC cement is recommended to use for the production of AAC block. Cement manufactured from big firms and plants is recommended as small size plants don't guarantee the quality of cement. Alongside this, the cement whose age is less than 3month is used as if the age of cement is more than 3 months its strength decreases by 20%. Some big plants even have their own clinker and cement manufacturing plant which process lime to obtain the optimum quality of cement and quick use, the cement is stored in silos.

3.1.2 Fly ash: It is an industrial waste product that was initially thought to be a useless and indecomposable waste hence it was soon introduced to construction materials to reduce the cost of construction. Its density is about 400-1800 kg/m3. It provides thermal insulation, fire resistance, and sound absorption. It's generally easily found in regions with thermal power plant like in Kota we have Kota Thermal Power Plant (KTP). For AAC blocks class C fly ash is used which contains about 20%lime (CaO).

3.1.3 Sand: Fine aggregate smaller than 4.75 mm and larger than 75 microns is coined as sand. In general, the minimum amount of silica content shall be at least 80%. It is generally used in sites or places where fly ash is not available as in the case of fly ash available it is more costly, especially in the current situation in India where the sand is not easily available.

3.1.4 Lime powder: It is simply obtained by crushing limestone and for the manufacturing of AAC blocks lime in crushed powder form is required. As some time lime powder is costly in those cases big factories also contain crusher machine which crushes the limestone on the factory site itself with the help of ball mill, jaw crusher, etc.

3.1.5 Aluminum powder: This part of raw material is very important and must be added with correct precision in a very limited quantity, which is roughly 0.5%. Finely powdered aluminum powdered is required which reacts with active lime and silica to make aeration due to the sudden release of hydrogen gas making the product swell and light.

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

3.1.6 Gypsum: It is a readily available industrial product. Normally it is produced as the by-product in fertilizer plant. Its work is to provide long term strength to the blocks.

3.2 Manufacturing process

3.2.1 Preparation of raw material and storage: In the first process sand and (or) fly ash is ground in the ball mill and the materials are prepared with the various process like dry grinding (powder), wet grinding (slurry) or mixed grinding with quicklime (CaO). Mixed milling is done by two methods, the first is dry mixing which produces binding material and the second one is wet mixing. Quicklime is crushed and then ground as most of its materials are agglomerate. Generally, gypsum is ground with quicklime or fly ash instead of using any separate milling. The preparation of other supplementary and chemicals is also done. Storage maintains the continuation of the process with proper material stability which guarantees the nonstop on-time supply. After this, the raw materials are batched in proper proportioning. The pre-step provides a homogeneity in materials that ensure the proper standard for AAC production.

3.2.2 Dosing and mixing: Once the preparation of raw materials is completed the next step is of dosing and mixing where the ratio of ingredients of the AAC is maintained in a proper proportion so the desired optimum quality of AAC and AAC blocks are obtained. The general ratio of: Fly ash/sand: Lime: Cement: Gypsum = 69:20:8:3. One cycle of mixing is about 5 minutes and 30 sec long. To produce a correct mix a dosing and mixing unit is used, and fly ash is being pumped into the container pumping is done until the desired weight is poured in. Using conveyors in the same fashion the lime powder, cement and gypsum are poured into an individual container. Control system release all the ingredients in the mixing drum. A small amount of aluminum is feed in about 0.5% using a small bowl type structure attached to the mixing unit. As the mixture is churned for a set of time it is being poured into the molds by the dosing units, where dosing unit fill only the amount of preset quantities into the mold. The process of dosing and mixing is done simultaneously as if there is any gap or stoppage in the process the mixing and dosing then it results in hardening and choking of the plant by residual matter. Normally in AAC plant all such process is automated and done with negligible human help.

3.2.3 Casting, foaming, and pre-curing: Since the mixture is prepared in the above discussed two processes, the mix is poured in the mold. The size of the mold varies from site to site and depends on the installed capacity. Before pouring in the mix, the inner surface of the mold is greased or oiled so the uncooked mixture (green cake) does not stick on it. Once the mixture is poured along with the small amount of aluminum the reaction between aluminum, calcium hydroxide and water takes place which causes the release of hydrogen gas at a rapid rate. This high-speed reaction causes the green cake to expand and make it light and porous because of the release of hydrogen gas. The expansion generally increases the volume of cake about 2 to 3 times the original volume. The size of voids formed due to air release is 2-5mm (macropores) which provides it with the insulating properties. Once the process is over the cake is allowed to settle down and is pre-cured. In general, the process of pre-curing and rising takes about 1 to 4 hours. In the pre-curing chamber, the process of foaming and hardening takes place under the set temperature. Since the pre-curing is done under set temperature hence it is also known as heating-room-pre-curing. In general it is not a complex process but still, any kind of vibration must be avoided in the whole process.

3.2.4 Demoulding and cutting: In this process, the pre-cured block is cut into a smaller size of the desired blocks. Once the block has sufficient strength it is lifted and mold is simply unhooked or open (varies from place to place) the workability and high size of blocks make the concentration easy and quick. Cutting in initial stages were done manually with thin wires of GI, but as time progresses the manual cutting is hardly seen as nowadays mostly cutting is done by mechanical means that is by the cutting machine which simply consists of big wire mesh and is allowed to pass through the cake cutting it.

3.2.5 Autoclave curing: This is the last major step of AAC block manufacturing in which the pre-sized blocks are fed in the autoclave where the blocks are cured under high pressure of 12 bar and the high temperature of about 190 degrees C. The blocks are being cured in the autoclave for about 10-12 hrs. and then it is pulled out of the autoclave and next batch is fed in the autoclave. Under this hot and humid condition, the AAC blocks went from the final stages of hydrothermal synthesis reaction to transform the green cake into the final solid AAC block which contains the desired properties with the required strength. The overall process of autoclaved curing significantly improves the strength and quality of the AAC block.

3.2.6 Grouping: The last and final step in the manufacturing process of AAC is grouping (though in some cases a process of converting the AAC block into the panel is followed). After the inspection of the manufactured block, the packaging is done.

4. APPLICATIONS

There are various applications of Autoclaved Aerated concrete as it can substitute not only building blocks but even the nominal concrete.

4.1 AAC Blocks
The first and foremost thing for which AAC is used is building blocks. Being lightweight and having resistance to fire thermal and acoustic attacks it acts as an ideal building material to be used for making non-structural walls. The building of the outer wall, as well as partition wall from AAC, blocks not only provide a faster and better wall but even its finishing is much better than ordinary clay and flies ash bricks. Being size of 8 times of a clay brick speed of construction increases rapidly as well as being lightweight it reduces a dead load of walls by 67%.

4.2 AAC Panels for roof and floor
When the AAC blocks were flourishing with every leap and bound all around Europe people tried to make more usage of them and AAC panels were developed. Generally, the density of the AAC panel is more than that of the block, about 800 kg/m^3. The density is increased to obtain the desired strength. Floor and roof panels are based on the Strength Class and the ones supplied are AC4 and AC6. The maximum length is 20'0" and the standard width is 2'0" though the thickness of panels varies according to loading and span.

4.3 Void filling
AAC is a foam concrete and in the stage before curing it is in the free-flowing state hence it can be used to fill in every gap which occurs while construction and still keeping the void light due to its lightweight property. It can quickly fill up the narrow openings in a handsome quantity. AAC is used not only in emergency void filling but also in the regular ones. In the case study at Lublin, Portland AAC was used in an emergency situation to stabilize the ground. And in many more situations, it had been used for void filling as it is lightweight and fluid in initial stages.

4.4 Pavement over soft ground
In the case of the soft ground, the surface below pavement begins to sink in a non-uniform manner which results in a broken and uneven surface over the pavement. To solve this problem the top soft soil is excavated and is replaced with a less dense material like autoclaved aerated concrete which creates a floating road sub-base. This construction helps in stopping the sink and is already been used in road construction at Holland. This type of construction is also cost effective as it reduces the cost of the foundation.

4.5 Reinforced AAC
Being lightweight and insulation materials AAC still has some drawbacks like low strength and cracking in walls being very brittle in nature hence it was found necessary that the Autoclaved aerated concrete must be reinforced just like the OPC. Reinforced AAC floor slabs and blocks with bonded screed and inner skins of cavity walls made with AAC blocks have performed satisfactorily as building components with good thermal insulation properties. But still in the study of pre-1980 installation has given rise to the serviceability problems like for example large deflections and cracking, presumably attributable to inadequate workmanship and insufficient attention to various properties of the material.

5. ENGINEERING PROPERTIES
5.1 Physical properties
5.1.1 Shape and size: AAC can be shaped into any mold easily as per the purpose though in general, the mold used is rectangular due to the brittle nature after casting. The size of AAC block depends on the purpose through the size is 625 mm long, 240 mm wide and thickness may vary as 100mm, 150mm or 250mm generally. The maximum size of the AAC panel as discussed before is 20'0" and its standard with is 2'0" whereas the thickness varies as per the loading and span requirements.

5.1.2 Color: The ingredients used in the process of manufacturing of AAC is responsible for the resulting coloring of the AAC. The white color is achieved if the major constituent is sand while if it's fly ash the color achieved is grey. On the other hand, external coloring agents are also added to AAC to impart new color (eg. red) to AAC though it increases the total cost of AAC.

5.1.3 Density: As the AAC is one of the lightest material which is even lighter than water and paints, the resulting density is quite less. It varies from 550 to 850 kg/m^3, which depends on the purpose of usage. In general, the masonry block varies from 550-650 kg/m^3, and the most commonly used is of density 600 kg/m^3. Similarly, the density of the AAC panel varies from 750-850 kg/m^3 with 800 kg/m^3 being the most common one.

5.1.4 Capillarity: Capillarity is the property of any building material which is responsible for its wetting and drying. Though the AAC has a structure with 80% air voids still the capillarity is very low because of the size of pores. The pores of AAC are macropores hence the capillary suction is low because the size of the void is large in contradiction the size of voids is quite small in the case of conventional red bricks hence its capillary suction is quite high though being less porous.

5.1.5 Coefficient of thermal expansion: The coefficient of thermal expansion of steel and concrete is almost equal which is about 12 x 10^{-6} per °C (specifically of mild steel) whereas the coefficient of thermal expansion is about 8×10^{-6} per °C in case of AAC which is lesser in comparison.

5.1.6 Creep: Not only just AAC even all the other autoclaved materials the creep is low in relation to elastic deformation. Generally, the creep is affected by factors like relative humidity, ambient temperature, stress level, and moisture content. The ratio of creep strain and elastic strain is known as the creep coefficient, and its value is 0.8 to 1.2 for AAC having a density of about 500kg/m^3.

5.1.7 Fire resistance: AAC is a non-combustible material and along with this, the thermal conductivity is quite low which causes the rate of heat migration being quite lower than in comparison to dense concrete. According to the fire rating for the AAC units issued in some of the European countries, in comparison to the other building materials, the AAC is quite good at fire resistance.

From one study it was seen that for the same thickness the fire resistance offered by AAC is 30 to 40% more than that of concrete. In conclusion, it can be said that AAC is quite a good fire resistant material up to 1200°C.
5.1.8 Expansion and shrinkage due to moisture: AAC behaves quite similar to the conventional dense concrete when it comes to change in volume due to moisture content. Similar to concrete the AAC shows shrinkage on drying and expansion on wetting. When the drying shrinkage measured from saturated condition to a condition of equilibrium (45% Relative humidity) varies between the ranges of 0.1 to 0.5%.

5.1.9 Moisture migration: The AAC has quite a high moisture absorption as compared to the dense concrete or conventional brick due to the high porosity. The moisture migration may take place through diffusion, through capillarity or via both of them. In the case of high moisture content, the migration is mainly due to capillarity though in normal conditions diffusion is more dominant. In the case of moisture content above 40-50% (by mass), migration is almost due to capillarity alone.

5.1.10 Permeability: The permeability of the AAC depends mainly on the moisture content, it shows an inverse relation with moisture content as it increases with the decrease of the moisture content and vice versa. Though in general even in dry conditions and normal pressure differences the permeability is quite low and can almost be taken as negligible. But in the case of improper joint and connection, there can be seen a significant amount of penetration.

5.1.11 Working: AAC is highly workable as it can be easily drilled, milled, nailed, cut, and shaped to the size desired to accommodate buildings. To cut and size the ordinary woodworking tools can be easily used. Though it is suggested not to cut or shape reinforced flexural member without the manufacturer's authorization as encourage of reinforcement might be affected by it.

5.1.12 Specific heat: From the definition, the heat required by material to raise the one-degree temperature of a unit mass is known as specific heat. In simple terms, we can say it is the measure of capacity to store heat by the material. The value of specific heat for the AAC is approximately 1.0-1.1 kJ/ kg°C at a normal moisture content (4-6% by weight).

5.1.13 Efflorescence: The solubility of the strength-related components of AAC is very low in the water. Though, some quantity of the soluble salts may be present in the raw materials and mix proportions which in some climatic conditions like slow evaporation may form efflorescence by crystallizing on the surface.

5.1.14 Sound absorption: It is considered that the AAC provides quite a good sound insulation whose sound absorption is even better than dense concrete. But this property decreases when the AAC is painted or coated as in general the sound transmission for solid construction depends on the mass and density of the material and the density of AAC is less than that of paint hence on painting the mass of structure increases.

5.1.15 Strength: In the general scenario, the strength is considered to be directly proportional (straight line) to the density of AAC though thermal resistance shows an opposite inverse relation. Grimer and Brewer tested four AAC of varying density (530 - 690 kg/m^3). This reveals that with an increase in depth strength shows a slight systematic increase, strength increases with an increase in specific gravity, and strength is also influenced by the moisture content.
- **Compressive strength:** As discussed compressive strength of AAC increase when the density of AAC is increased. In the testing done by Grimer and Brewer, it was observed that for a dry density of 400 kg/m^3 the compressive strength was reported about 2 MPa (unacceptable according to Indian Standards), and when the dry density was 700 kg/m^3, the compressive strength observed was 6 MPa (acceptable according to Indian Standards). Hence in general, the adopted density of AAC blocks shall be 600 kg/m^3 as we obtain 4 MPa strength at it respectively which is greater than the minimum value that is 3.5 MPa by Indian Standards.
- **Tensile strength:** In general, it is considered that the tensile strength of AAC is about ¼ to ⅙ times the observed compressive strength but from the study conducted by Mr Edlind it's stated that the amount of tensile strength should be considered about 20% of compressive strength. Though it was also observed that even slight moisture also affects the property at a visible amount hence the property is sensitive to test conditions which can be supported by the findings in the experiment conducted by Grimer and Brewer.
- **Shear strength:** On the basis of pure punching shear, the shear rupture strength can be assumed about 20-30% of the observed compressive strength. If the info regarding the shear strength is not available then the value of pure shear can be directly taken for tension.

5.1.16 Temperature resistance
When the AAC is exposed to dry air in the presence of high temperature for a long time the shrinkage cracks appear as the result as the excessive drying takes place. This is the reason why the structural AAC must not be allowed in the place which is exposed to high temperature (50°C-70°C) and dry air without taking any kind of extra protection and precaution against excessive drying though in case of non-structural one, AAC can be exposed up to a temperature of 700°C only if correct precautions are taken.

6. ADVANTAGES AND LIMITATIONS
6.1 Advantages
6.1.1 Lightweight: The density of the AAC block is about 600 kg/m3 which means its weight is about 1/3rd of general clay brick and concrete/fly ash bricks. When it is cast in floors and walls panel its density is still 750-800 kg/m3 which is way less than that of concrete this results in decreasing the overall dead load of the structure to a great extent.

6.1.2 Fire resistance: It has high fire resistance as its general fire resistance in hours varies from 2-6 which depends on the thickness and whereas in the same case the fire resistance is as low as 2 hours of normal conventional clay brick. This makes it an ideal choice for fire protection around steel columns and steel beams and in the construction of shaft walls, stairwells, corridors, and firewalls.

6.1.3 Speed of construction: As the size of one AAC block is generally 8 times the size of clay brick and being lightweight it is easy to handle this results in the rapid increase in the construction speed where AAC blocks are being used.

6.1.4 Eco-friendly: Only the natural materials are used as the raw materials and there are no pollutants or by-products obtained from the complete manufacturing process and along with this, AAC is completely free from any kind of toxic and harmful substance. The energy consumed while the production is quite minimal, the wastage of material is also quite low, and the high energy efficiency is some of the factors making AAC a very eco-friendly product.

6.1.5 High workability: AAC block is much more workable than any of the other building block including stone, brick, fly ash brick, CLC Blocks, Timber, etc. AAC block can be easily cut with a hacksaw into any desired size and shape at the site.

6.1.6 Thermal resistant: As the AAC block is a porous block and contains air voids hence it has a very low thermal conductivity as compared to the other building blocks. Its conductivity is even less than those of the hollow blocks. Its thermal conductivity is 0.24 while of clay brick is 0.81 and of fly, ash brick is even more.

6.1.7 Good compressive strength: Normal compressive strength is about 4N/mm2 which is more than the minimum required the strength of clay brick that is 3.5N/mm2. Hence even after being 1/3rd of the weight of clay brick yet, it is suitable to be used as a building block.

6.1.8 Economical: Even though initially, it seems that the cost of AAC block is more as 1cumec of AAC block is higher than 1 cumec of clay brick but the overall cost of a building made from AAC block is lesser than that of clay brick. As the wall dead load decreases by 2/3rd hence it results in a decrease in the use of concrete and reinforcement. Along with this the amount of mortar used with the clay brick is much higher as one brick is much smaller and uneven surfaced than an AAC block.

6.2 Limitations

As truly said no roses without thrones so is true for AAC Even after so many merits there are some reasons because of which they are still not in a fashion in some countries like India.

6.2.1 High water absorption: Where the water absorption of clay brick is about 25% of its weight whereas in the case of AAC block the water absorption is about 50%.

6.2.2 Cracking: Even after taking many measures including the strength of mortar shall be less, block shall be cured before using, and following criteria of the thickness of mortar crack still appears on the surface of wall which decreases the aesthetic look of the building, it occurs in the first 6 months of construction. To avoid this there are some preventive measures like using reinforced AAC block but it still is a demerit as it increases the cost of construction.

6.2.3 Plastering: Even though the surface finish is clean and aesthetic but still when we try to apply plaster on AAC blocks it is comparatively way harder than the case of clay bricks as the plaster do not stick well to the smooth surfaces even after forming artificial ridges at wall surface because of absorption of water by the AAC block surface.

6.2.4 Some Other Disadvantages: Other than the discussed disadvantages of AAC some remaining are discussed in the following section. One of them is the presence of Portland cement. Generally, there are not a large number of manufacturing plants which causes a rise in transportation cost along with this, installation needs skilled labor which also adds extra in the labor cost. As the AAC is highly porous hence stucco or cladding is must on the exterior to avoid water. Re-baring may be needed in case of load-bearing units. Due to the lack of test results of AAC, it is yet to be accepted in building codes in many states and countries. Due to the high percentage of limestone in Portland cement, it is still nor 100% environment-friendly as in the preparation of cement calcination takes place at high temperature in kilns which causes a release of big amount of carbon dioxide (CO_2), an infamous greenhouse gas.

7. CONCLUSION

- AAC blocks can be used in place of conventional building blocks like bricks and stones being lightweight and eco-friendly.
- The raw materials used in the construction of AAC are generally eco-friendly, and the increase of usage of fly ash as a major constituent is making it greener.
- The manufacturing process of AAC is not a complex one and the degree of automation has a wide range of adjustment.
- AAC is not simply a Block but instead a versatile product like concrete having several applications like the void filling, block and panel construction in both load bearing and non-load bearing applications for walls, floors, and roofs, etc.
- Engineering properties shows that the AAC has several benefits over the conventional building materials like the low density, high thermal resistance, high sound insulation, etc.
- Being currently a new product in Indian product it’s not that much popular as it is in European countries, where its usage was started in 1929.
- In the current scenario, the use of Autoclaved Aerated Concrete is increasing day by day in high rise buildings as well as in road construction, tunnels, etc.

- There is still a lot of development required as there are still some major flaws left in the building material so more scope of research and development is present.

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