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An Introduction to Autoclaved Aerated Concrete (AAC)

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I. Overview:

AAC was developed in mid 1923 in Sweden. It is also known as Autoclaved Cellular Concrete (ACC) or Autoclaved Lightweight Concrete (ALC). Production process of AAC is fairly simple. It has become one of the most used building materials in Europe and is rapidly growing in many other countries around the world. It is made with made with a mixture of flyash, lime, cement, gypsum, an aeration agent and water. Aeration process, imparts it a cellular light weight structure. AAC products are precast in various sizes and provide structure, insulation, and fire and moldresistance.

Fig: figure of AAC blocks.

Use of Autoclaved Aerated Concrete (AAC) blocks in construction industry in India offers interesting proposition for various segments in the society. At the point when AAC is blended and cast in structures, a few compound responses occur that give AAC its light weight and warm properties. The hydrogen gas froths and copies the volume of the crude blend making gas rises to 3mm (⅛ inch) in distance across. Toward the end of the frothing procedure, the hydrogen escapes into the air and is supplanted via air. For a project developer it means faster and lower cost construction. For environmentally conscious it means eco-friendly products and for those who occupy buildings built with AAC blocks it means better safety and lower energy costs for cooling or heating.

Primary raw material for AAC is fly ash. Thousands of tonnes of fly ash is generated by thermal power plants everyday and its disposal is a cause of concern. Moreover, using fly ash does not harm the environment at all. Infact using fly ash takes care of issues related to disposal of fly ash. Therefore by using fly ash to produce AAC products provides a sustainable, economic and environment friendly option. At the end it all translates to a better world for future generations.

It is then cut into either blocks or panels, and placed in autoclave chamber for 12 hours. During this steam pressure hardening process, when the temperature reaches 190° Celsius and the pressure reaches 8 to 12 bars, quartz sand reacts with calcium hydroxide to form calcium silicate hydrate, which gives AAC its high strength and other unique properties of the relatively low temperature used AAC blocks are not considered fired brick but a lightweight concrete masonry unit.

II. Features of AAC products:

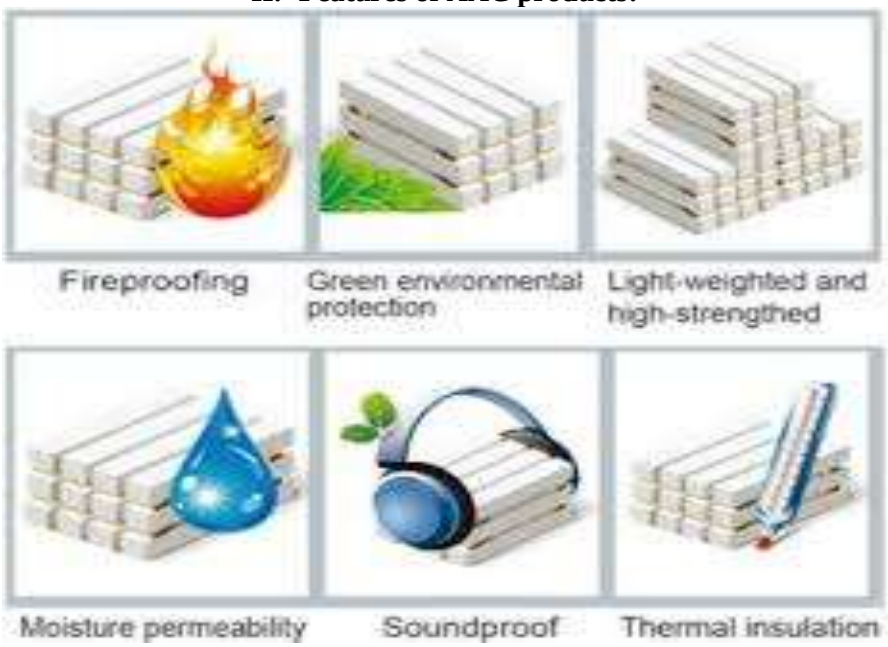

Fig 2.0. Features of AAC Blocks.

1.1. High Compressive Strength

The block has an average compressive strength of (3-4.5) N/mm³ which is superior to most types of light weight blocks, 25% stronger than other products of the same density.

1.2. Lightweight

These blocks possess a cellular structure created during manufacturing process. Millions of tiny air cellsimpart AAC blocks very light weight structure. Density of these lightweight blocks usually ranges between 550 –650 kg/m3. AAC blocks are lighter than water and literally float on water**.**

1.3. Easy to Use

AAC blocks are very easy to work and handle. These blocks can be cut or drilled using normal tools used with wood.Since AAC is steam-curried, it is ready to be used as soon as it comes out of autoclave. It does not shrink it is removed from autoclave.

1.4. **Versatility**

AAC can be used to make any design, be it carving or irregular shapes. Moreover it can be manufactured invarious shapes and sizes to suit intended purpose. These blocks have an attractive appearance.

1.5. Long Lasting

AAC does not rot or deteriorate over time. Structures built with AAC have a long life and retain good finish evenafter decades. AAC is manufactured from non-biodegradable materials, which neither rot nor attract mould, keeping interiors clean and durable.

1.6. Environment friendly

AAC has excellent thermal insulation property leading to lower energy requirements for heating and cooling. AACserves as one stop solution for structure, insulation, and fire protection. Use of AAC eliminates use of differentmaterials for structure, insulation, and fire protection as these requirements are met by only using AAC. By using AAC, separate materials are not required to meet these requirements leaving to lower energy footprint of abuilding. Using AAC is a must for any green building project.

AAC is a non-toxic product which does not pollute the air, land or water. During the manufacturing process, waste from the cutting process is recycled back with raw materials and used again. During construction, there is virtually no waste generated. The energy consumed in the production process is only a fraction compared to the production of other materials. The manufacturing process emits no pollutants and creates no by-products or toxic waste products .AAC is manufactured with industrial waste like fly ash and pond ash. AAC manufacturing process requires lessenergy is non-polluting and does not produce any waste products.

1.7. Thermal Insulation

Cellular structure of AAC creates millions of tiny air pockets. These air pockets give AAC very good insulatingproperties. Better insulation translates to lower cost for heating and cooling. AAC block has exceptional thermal insulating qualities. The thermal conductivity of the AAC blocks helps maintaining the

inner temperature to be warm during the winters and cool during the summers which ultimately leads to savings in air conditioning load and consequently enhanced energy efficiency.

1.8. Fire Resistance

AAC offers amazing fire resistance. They offer fire resistance from 2 hours up to 6 hours.

1.9. Sound Insulation

Tiny air pockets created during production of AAC stop sound from travelling one end of the wall to another. Soundinsulation of a wall built using AAC is much higher than a wall of similar thickness built using other materials. Some AAC companies even offer special AAC products produced specifically for sound insulation.

1.10. Weather Resistance

AAC does not decay, rust, deteriorate or burn. AAC has been found to be earthquake resistant. AAC structures areknown to maintain structural integrity in heavy rains, extremely low temperature and salty air.

1.11. Pest Resistance

Primary raw material used to manufacture AAC is fly ash. Fly ash (or pond ash) is an inert material and does notallow termites or other pests to survive.

III. Advantages of using Autoclaved Aerated Concrete

1.12. Lightweight

AAC blocks are about 50% lighter than clay bricks of equivalent size. This translates into less dead weight of buildings and allows entire structure to be lighter therefore reducing amount of steel and concrete used instructural components like beams, columns and roof/floor slabs.

1.13. Easy workability

AAC is very easy to work with and can be cut accurately reducing the amount of waste generated.

1.14. Environmental impact

Manufacturing of AAC does not have high energy requirements. Moreover since AAC is light weight, it also savesenergy required for transportation and leads to reduced CO_2 emissions by transport vehicles. Since AAC is madefrom fly ash – an industrial waste product – generated by thermal power plants, it offers a low cost and sustainablesolution for today and tomorrow. AAC is a requisite for green buildings.

1.15. Easy transportation

It is easy to transport AAC as it does not suffer from high transit breakage usually associated with clay bricks.

1.16. Longevity

AAC does not lose strength or deteriorate over time. Buildings constructed with AAC do not require routine repairsthat are required for buildings using clay bricks.

1.17. Thermal Insulation

AAC block has exceptional thermal insulating qualities. The thermal conductivity of the AAC blocks helps maintaining the inner temperature to be warm during the winters and cool during the summers which ultimately leads to savings in air conditioning load and consequently enhanced energy efficiency.

1.18. Shorter Project Duration

Buildings can be built with AAC 50% faster compared to clay bricks. This translates to lower project completiontimes benefiting project developers.

1.19. Fire Resistance

Due to high fire resistance offered by AAC, structures made from AAC have higher rate of survivability in case of fire.

1.20. Sound Insulation

Sound absorption properties of AAC make it ideal material for reducing ambient noise. AAC is well-suited for establishments like hospitals and offices situated in noisy areas.

2.0. Raw Material

Fig 4.1. various ingredients for preparation of AAC.

Fly Ash or Sand

Key ingredient for manufacturing AAC blocks is silica rich material like fly ash or sand. Most of the AAC companiesin India use fly ash to manufacture AAC blocks. Fly ash is mixed with water to form fly ash slurry. Slurry thusformed is mixed with other ingredients like lime powder, cement, gypsum and Aluminium powder in quantitiesconsistent with the recipe. Alternately sand can also be used to manufacture AAC blocks. A 'wet' ball mill finelygrinds sand with water converting it into sand slurry. Sand slurry is mixed with other ingredients just like fly ashslurry.

Lime Powder

Lime powder required for AAC production is obtained either by crushing limestone to fine powder at AAC factory or by directly purchasing it in powder form. Although purchasing lime powder might be little costly, manymanufacturers opt for it rather than investing in lime crushing equipment like ball mill, jaw crusher, bucketelevators, etc. Lime powder is stored in silos fabricated from mild steel (MS) or built using brick and mortar depending of individual preferences.

Cement

53-grade Ordinary Portland Cement (OPC) from reputed manufacturer is required for manufacturing AAC blocks.Cement supplied by 'mini plants' is not recommended due to drastic variations in quality over different batches.Some AAC factories might plan their captive cement processing units as such an unit can produce cement as wellas process lime. Such factories can opt for 'major plant' clinker and manufacture their own cement for AACproduction. Cement is usually stored in silos.

Gypsum

Gypsum is easily available in the market and is used in powder form. It is stored in silos.

Aluminium Powder/Paste

Aluminium powder/paste is easily available from various manufacturers. As very small quantity of Aluminiumpowder/paste is required to be added to the mixture, it is usually weighed manually and added to the mixing unit.

Raw Material Preparation and Storage

Fig: raw material mixing process and stage.

The first step of AAC production is grinding of silica rich material (sand, fly ash, etc) in ball mills. For different materials, different processing is adopted, such as dry grinding (into powder), wet grinding (into slurry) or mixed grinding with quick lime (CaO). There are two methods for mixed milling. One is dry mixing to produce binding material, and the other method is wet mixing. Since most quicklime is agglomerate, it should be crushed and then grinded. Gypsum is normally not ball milled separately. It is grinded with fly ash or with quicklime, or it could begrinded with the same miller for quicklime in turn. Other supplementary and chemicals are also have to be prepared .

Raw material storage assures the continuous production and material stability. The continuous production guarantees the non-stop & on-time supply, and the material stability guarantees the quality of products, since theraw material might come from different sources, with different qualities. Raw material preparation & storage is thepre-step for proportioning batching. This pre-step guarantees the raw material meet the standard for AAC production, and it is also finishes the storage, homogenization and aging process. It is the basic process that assures the smooth production and production quality.

Dosing and mixing

Maintaining ratio of all ingredients as per the selected recipe is critical to ensure consistent quality of production.This is accomplished by using various control systems to measure and release the required quantity of various raw materials.

A dosing and mixing unit is used to form the correct mix to produce Autoclaved Aerated Concrete (AAC) blocks. Fly ash/sand slurry is pumped into a separate container. Once the desired weight is poured in, pumping isstopped. Similarly lime powder, cement and gypsum are poured into individual containers using screw conveyers.Once required amount of each ingredient is filled into their individual containers control system releases allingredients into mixing drum. Mixing drum is like a giant bowl with a stirrer rotating inside to ensure proper mixing of ingredients. Steam might also be fed to the unit to maintain temperature in range of 40-42^{o}C. A smaller bowltype structure used for feeding Aluminium powder is also attached as a part of mixing unit. Once the mixture hasbeen churned for set time, it is ready to be poured into molds using dosing unit. Dosing unit releases this mixtureas per set quantities into molds for foaming. Dosing and mixing process is carried out continuously because if there is a long gap between charging and discharging of ingredients, residual mixture might start hardening andchoke up the entire unit.

In modern plants, entire dosing and mixing operation is completely automated and requires minimum humanintervention. This entire operation is monitored using control systems integrated with computer and CCTVcameras. As with any industrial operation, there is provision for human intervention and emergency actionsintegrated inside the control system.

Casting, Foaming and Pre-curing

AAC BLOCK PRODUCTION LINE

Once the desired mix is ready, it is poured into moulds. These moulds can be of various sizes depending on theproduction capacity of a manufacturing unit. Once mix is poured into moulds, it is ready for pre-curing.

After casting, the slurry in molds will be in the pre-curing chamber to finish foaming and hardening. Foaming andhardening actually starts when the slurry is fed into molds, which includes gas-forming expansion and perform curing to achieve certain strength, which is enough for cutting. Pre-curing is always done under set temperature;hence it is also called as heating-room-pre-curing. Pre-curing is not a complicated process, but should avoidvibration. Operators must keep eyes to monitor the slurry change during foaming and provide feedback to dosing,mixing and casting operators. Pre-form defects (cracking, sinking, etc) mainly occur during the process.

Cutting

Fig: Cutting of AAC block

During this process, the pre-cured block goes through cutting and shaping, into different size & shapes as per requirements. The high workability and large variety of sizes make AAC production more suitable for massiveproduction with higher mechanization. Cutting can be done mechanically or manually. With a cutting machine, theproduction efficiency and dimensional accuracy is easily achieved.

Autoclaved Curing

Fig: AAC Blocklines :

After cutting into the desired sizes & shapes, 'green' AAC blocks are transferred into autoclaves. Autoclaves areused for steam curing under pressure. AAC must be pre-cured and steam cured to finish the physical and chemical changes, and then to achieve enough strength for desired usage. A batch of AAC blocks is steam cured for 10-12hours at a pressure of 12 bar and temperature of 190°C. In hot and humid conditions, AAC blocks undergo laststages of hydro-thermal synthesis reaction to transform into a new product with required strength and various physical performances. Autoclaved curing imparts inherent properties and performance of AAC.

Comparison between AAC Block and Clay Brick

Parameter	AAC Block	Clay Brick
Structural Cost	Steel saving upto 15%	No saving
Cement Mortar for Plaster & Masonry	Required Less due to flat,evensurface and less number of joints	Requires more due to lrregular surface and more number of joints.
Breakage	Less than 2%	Average 10 to 12%
Construction Speed	Speedy construction due to its big size, light weight and easy to cut in any size or shape.	Comparatively slow
Quality	Uniform & Consistent	Normally varies
Fitting & Chasing	All kind of fitting and chasing possible	All kind of fitting and chasing possible
CarpetArea	More due to less thickness of walling material	Comparatively Less
Energy Saving	Approx. 30% reduction in air-conditioned Load	No such saving
Chemical Composition	Flyash used around: 65 to 68% which reacts with lime and cement to form AAC	Soil used contains many inorganic impurities like sulphateetc.resulting in efflorescence

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