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Concrete masonry units: the future building blocks of the construction industry

KEYWORDS
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ABSTRACT In order to tend to the ever growing world population, it is imperative to devise methods that act as guidelines for effective and efficient resource utilisation. Shelter comprises of one of the most fundamental and basic necessities of every human being, tending to which will only become a mammoth task in the coming years, considering the exponential increase in the population every year. It is therefore imperative that sustainable methods of construction are developed and used extensively. Concrete masonry units, an extremely viable alternative to the traditional clay bricks is one such step towards sustainable world development.

Introduction

A concrete masonry unit (CMU) is a large rectangular block used in building construction.

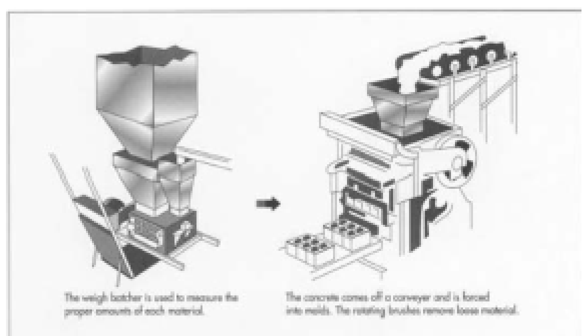
These blocks use cinders (fly ash) are called cinder blocks in Canada, the United States, and New Zealand, breeze blocks in the United Kingdom and New Zealand, and hollow blocks in the Philippines. In non-technical usage, the terms cinder block and breeze block are often generalised to cover all of these varieties.

Concrete blocks may be produced with hollow centres(cores) to reduce weight or improve insulation. The use of block work allows structures to be built in the traditional masonry style with layers (or courses) of staggered blocks. Blocks come in many sizes. In the US, the most common nominal size is 16 in × 8 in × 8 in (410 mm × 200 mm × 200 mm); the block measures a 3/8 in shorter, allowing for mortar joints. In Ireland and the UK, blocks are usually 440 mm × 215 mm × 100 mm (17.3 in × 8.5 in × 3.9 in) excluding mortar joints. In New Zealand and Canada, blocks are usually 390 mm × 190 mm × 190 mm (15.4 in × 7.5 in × 7.5 in) excluding mortar joints.

Block cores are typically tapered so that the top surface of the block has a greater surface on which to spread a mortar bed and for easier handling. Most CMU's have two cores, but three- and four-core units are also produced. A core also allows for the insertion of steel reinforcement, tying individual blocks together in the assembly, with the goal of greatly increased strength. To hold the reinforcement in proper position and to bond the block to the reinforcement, the cores must be filled with grout (concrete). Reinforcement is primarily used to impart greater tensile strength to the assembly, improving its ability to resist lateral forces such as wind load and seismic forces.

A variety of specialised shapes exist to allow special construction features. U-shaped blocks or knockout blocks with notches to allow the construction of bond beams or lintel assemblies, using horizontal reinforcing grouted into place in the cavity. Blocks with a channel on the end, known as jamb blocks, allow doors to be secured to wall assemblies. Blocks with grooved ends permit the construction of control joints, allowing a filler material to be anchored between the unmortared block ends. Other features, such as radioed corners known as bullnoses may be incorporated. A wide variety of decorative profiles also exist.

Concrete masonry units may be formulated with special aggregates to produce specific colours or textures for finish use. Special textures may be produced by splitting a ribbed or solid two-block unit; such factory-produced units are called split-rib or split-face blocks. Blocks may be scored by grooves the width of a mortar joint to simulate different block modules with the grooves filled with mortar and struck to match the true joints.



Manufacturing

The production of concrete blocks consists of four basic processes: mixing, molding, curing, and cubing. Some manufacturing plants produce only concrete blocks, while others may produce a wide variety of precast concrete products including blocks, flat paver stones, and decorative landscaping pieces such as lawn edging. Some plants are capable of producing 2,000 or more blocks per hour.

The following steps are commonly used to manufacture concrete blocks.

Mixing

1) The sand and gravel are stored outside in piles and are transferred into storage bins in the plant by a conveyor belt as they are needed. The portland cement is stored outside in large vertical silos to protect it from moisture.

2) As a production run starts, the required amounts of sand, gravel, and cement are transferred by gravity or by mechanical means to a weigh batcher which measures the proper amounts of each material.

3) The dry materials then flow into a stationary mixer where they

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are blended together for several minutes. There are two types of mixers commonly used. One type, called a planetary or pan mixer, resembles a shallow pan with a lid. Mixing blades are attached to a vertical rotating shaft inside the mixer. The other type is called a horizontal drum mixer. It resembles a coffee can turned on its side and has mixing blades attached to a horizontal rotating shaft inside the mixer.

4) After the dry materials are blended, a small amount of water is added to the mixer. If the plant is located in a climate subject to temperature extremes, the water may first pass through a heater or chiller to regulate its temperature. Admixture chemicals and colouring pigments may also be added at this time. The concrete is then mixed for six to eight minutes.

Moulding

5) Once the load of concrete is thoroughly mixed, it is dumped into an inclined Concrete Block bucket conveyor and transported to an elevated hopper. The mixing cycle begins again for the next load.

6) From the hopper the concrete is conveyed to another hopper on top of the block machine at a measured flow rate. In the block machine, the concrete is forced downward into moulds. The moulds consist of an outer mold box containing several mold liners. The liners determine the outer shape of the block and the inner shape of the block cavities. As many as 15 blocks may be moulded at one time.

7) When the moulds are full, the concrete is compacted by the weight of the upper mold head coming down on the mold cavities. This compaction may be supplemented by air or hydraulic pressure cylinders acting on the mold head. Most block machines also use a short burst of mechanical vibration to further aid compaction.

8) The compacted blocks are pushed down and out of the moulds onto a flat steel pallet. The pallet and blocks are pushed out of the machine and onto a chain conveyor. In some operations the blocks then pass under a rotating brush which removes loose material from the top of the blocks.

Curing

9)The pallets of blocks are conveyed to an automated stacker or loader which places them in a curing rack. Each rack holds several hundred blocks. When a rack is full, it is rolled onto a set of rails and moved into a curing kiln. several hundred blocks. When a rack is full, it is rolled onto a set of rails and moved into a curing kiln.

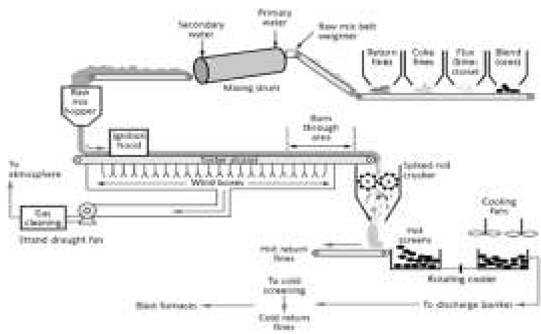
10) The kiln is an enclosed room with the capacity to hold several racks of blocks at a time. There are two basic types of curing kilns. The most common type is a low-pressure steam kiln. In this type, the blocks are held in the kiln for one to three hours at room temperature to allow them to harden slightly. Steam is then gradually introduced to raise the temperature at a controlled rate of not more than 60°F per hour (16°C per hour). Standard weight blocks are usually cured at a temperature of 150-165°F (66-74°C), while lightweight blocks are cured at 170-185°F (77-85°C). When the curing temperature has been reached, the steam is shut off, and the blocks are allowed to soak in the hot, moist air for 12-18 hours. After soaking, the blocks are dried by exhausting the moist air and further raising the temperature in the kiln. The whole curing cycle takes about 24 hours.

Another type of kiln is the high-pressure steam kiln, sometimes called an autoclave. In this type, the temperature is raised to 300-375°F (149-191°C), and the pressure is raised to 80-185 psi (5.5-12.8 bar). The blocks are allowed to soak for five to 10 hours. The pressure is then rapidly vented, which causes the blocks to quickly release their trapped moisture. The autoclave curing process requires more energy and a more expensive kiln, but it can produce blocks in less time.

Cubing

11) The racks of cured blocks are rolled out of the kiln, and the pallets of blocks are unstacked and placed on a chain conveyor. The blocks are pushed off the steel pallets, and the empty pallets are fed back into the block machine to receive a new set of moulded blocks.

12) If the blocks are to be made into split-face blocks, they are first moulded as two blocks joined together. Once these double blocks are cured, they pass through a splitter, which strikes them with a heavy blade along the section between the two halves. This causes the double block to fracture and form a rough, stone-like texture on one face of each piece.



13) The blocks pass through a cuber which aligns each block and then stacks them into a cube three blocks across by six blocks deep by three or four blocks high. These cubes are carried outside with a forklift and placed in storage.

Fly Ash

Fly ash brick (FAB) is a building material, specifically masonry units, containing class C fly ash and water. Compressed at 272 atm and cured for 24 hours in a 66 °C steam bath, then toughened with an air entrainment agent, the bricks last for more than 100 freeze-thaw cycles. Owing to the high concentration of calcium oxide in class C fly ash, the brick is described as "self-cementing". The manufacturing method saves energy, reduces mercury pollution, and costs 20% less than traditional clay brick manufacturing.

A typical concrete masonry brick had the following composition – fly ash(40%), sand(40%), sludge(10%), pop(5%).

Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material, when used in conjunction with portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both.

Fly ash is a pozzolanic material. It is a finely-divided amorphous alumina-silicate with varying amounts of calcium, which when mixed with portland cement and water, will react with the calcium hydroxide released by the hydration of portland cement to produce various calcium-silicate hydrates (C-S-H) and calcium-aluminate hydrates. Some fly ashes with higher amounts of calcium will also display cementitious behaviour by reacting with water to produce hydrates in the absence of a

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source of calcium hydroxide. These pozzolanic reactions are beneficial to the concrete in that they increase the quantity of the cementitious binder phase (C-S-H) and, to a lesser extent, calcium-aluminate hydrates, improving the longterm strength and reducing the permeability of the system. Both of these mechanisms enhance the durability of the concrete.

The performance of fly ash in concrete is strongly influenced by its physical, mineralogical and chemical properties. The mineralogical and chemical composition are dependent to a large extent on the composition of the coal and since a wide range of domestic and imported coals (anthracite, bituminous, sub-bituminous and lignite)

Advantages

1.Dimensional Accuracy & Symmetry - concrete masonry is batch produced moulds and therefore the size can vary in only one plane, usually the height, as opposed to other products on the market that can vary in length, width and height. The SABS 1215 allows for a variation of +/- 3mm on the specified height. Concrete Masonry is also symmetrical, so the units are rectangular and not wedge-shaped or bent. No more "banana" bricks…

2.Consistency - because concrete masonry is batch produced, the quality of the units is consistent within a particular batch. There are no issues with some bricks being hard and brittle, others being soft and crumbly. All units are manufactured to the same high standard. It is also smooth and lends itself to fair face and bagged applications.

3.Versatility - concrete masonry is probably the most versatile masonry product available. It offers the designer a rich variety of dimensions, aspect ratios, textures, colours and profiles as the basis of wall design. There is an almost limitless palette of possible colours. It can be made almost totally waterproof. The size and shape of units available is only limited by having the correct mould. It can be made to have special textures. The units can be fluted or plain. The list of possibilities is almost endless.

4.Energy efficiency - concrete masonry is also naturally energy efficient, the secret being in its mass. The thermal mass of concrete slows down the passage of heat moving through a wall and allows the masonry structure to absorb heat instead of passing it through to the inside of the building, keeping the inside cool. As the wall is cooled by nightfall, the absorbed heat is released, gradually warming the inside. Likewise, this thermal barrier helps to keep a concrete masonry structure warmer in the winter months. This effect of ensuring that buildings stay warm in winter and cool in summer lessens the need for artificial climate control and therefore wasted energy. From manufacture to transport to construction, concrete masonry is modest in its energy needs and generous in its payback.

5.Modular system - another major architectural benefit of concrete masonry is the modular masonry design concept. The modular system of concrete masonry allows for efficient design co-ordination of sizes of building components, such as door and window frames. Units such as bricks and blocks are the dimensions which permit other components to fit into the space provided in a controlling reference system in a particular direction. Modular co-ordination enables components to be built on site without modification, as well as reducing the range of sizes required. Large savings arise from the ease of building in units which fit into the space provided without having to be cut or modified.

6.Thermal & Acoustic insulation - the thermal insulation properties are covered above under the heading Energy Efficiency. Concrete masonry is a highly suitable material for attenuating noise as it is an extremely dense material which reduces the transmission of airborne sound. Resistance to sound transmission will obviously increase with wall thickness. It is also important to remember that the acoustic performance of a building is related to the capacity of all the elements in the building to reflect, absorb or transmit sound.

7.Resistance to cracking - all masonry units of whatever type are subject to some degree of movement... Masonry derived from fired products such as clay tends to expand over time and concrete masonry tends to shrink over time. The degree of movement in a particular masonry unit is regulated by the SABS, and can be controlled to some degree through the use of control joints. Where concrete masonry has the advantage is that the contraction rates for concrete masonry and concrete are very similar. Since the foundations are concrete, the slabs are concrete, the reinforced walls or frame structures are concrete, the lintels and decks are concrete, not to mention the mortar and plaster covering the masonry, the use of concrete masonry will result in a harmonious relationship within the structure and help in eliminating the cracking problem so prevalent in today's buildings.

8.Fire resistant - concrete masonry is fire resistant. The SABS 0145 Tables 4 & 5 specify the fire resistance ratings for load bearing and non load bearing walls constructed from concrete masonry walls. Obviously the thicker the units the higher the fire resistance rating will be, with the exception being that solid units have a higher rating than hollow units. The class of mortar used will also impact on the fire rating as it is the performance of the wall that is important, not just the materials contained therein.

9.Weatherproof - concrete masonry can be manufactured almost totally waterproof with the addition of specialized admixtures. This is not usually necessary since quality concrete masonry is usually manufactured to a "low suction" tolerance due to its high density. Water penetration of a wall is usually through fine cracks at the interface between the masonry unit and the mortar, and only rarely through the masonry unit or the mortar. The greater the bond between mortar and masonry, the greater the resistance to leakage. The bond depends largely on the "waterproofness" of the brick and the water retention properties of the mortar (which can be improved through the addition of lime to the mix).

10.Availability in Winter - concrete masonry does not have to be baked, but cures naturally over time. The winter rainfall is a much lamented fact of building in the Western Cape, and often leads to a shortage of fired products. Concrete masonry is generally freely available throughout the year, allowing for shorter lead times and better stock control on site.

11.Cost Effective - when looked at from an overall perspective, concrete masonry is completely cost effective. When the initial cost of the masonry, the maintenance cost of the building, the cost of heating and cooling the building, as well as the final salvage value of the building are taken into account, concrete masonry is arguably one of the most effective materials used in construction.

12.Compatibility - concrete masonry is highly compatible with cementitious products, including most paints and sealants.

13.Durability - concrete masonry is a highly durable material, and is manufactured to resist local exposure conditions for the intended life of the building. Durability is generally related to

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compressive strength, which in turn is related to density. Surface protection such as paint and plaster adds tremendously to the durability of any walling material.

14. Environmentally friendly - the use of concrete masonry also benefits the environment and promotes sustainable building practice. Not only is concrete masonry fully recyclable, but leading manufacturers such as Cape Brick are using recycled crushed aggregate in the manufacture of their products. This has major advantages in terms of lessening environmental impact and gives rise to a truly green building product. Concrete masonry manufactured using RCA has possibly the lowest embodied energy of any masonry product available in the Western Cape today.

Conclusion and future scope

Having been involved in an ongoing project in South Africa , which included the construction of a hospital using concrete masonry bricks, it can be safely said that this construction technique will be of paramount importance in the times that lie ahead. The amount of resources available is limited therefore judicious use is a must. The ever increasing population sadly ensures that more forests will be cleared to tend to the growing needs. Development and construction will go hand in hand. This calls for a sustainable approach if we need to preserve any of the resources for our future generations.

Concrete masonry bricks are primarily composed of waste materials as stated above. It's a boon for the construction industry. In other words, it's a win win situation since waste is being recycled on one hand and production costs are reduced on the other with increased strength and safety. Pollution is reduced unlike in the manufacturing of the traditional clay bricks which in evidently adds to global warming.

These construction units will be the building blocks of the future. Awareness should be spread among more and more people regarding the benefits of the concrete units. Ironically these are already being used by the developed countries. Developing countries such as ours need such innovative ways to tackle the population problem effectively and efficiently.

Considering the magnitude and vastness of the construction business in our country, we need to start implementing this technique, which not only would ensure better safer living standards and prove to be cost effective but also reduce the labour requirements thus reducing business costs.

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