BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

AUTOCLAVED AERATED CONCRETE

Introduction

Autoclaved aerated concrete, also called cellular or foam concrete, is the lightest form of concrete available, having dry density in the range of 500 to 750 kg/m³. The technical advantages of the use of aerated concrete members are due to their higher strength to weight ratio, a low thermal conductivity, nailability and good resistance to fire. Its low density permits use of larger building units and this is a distinct advantage in prefabrication. Appreciable savings are effected in foundation loads in multi-storeyed construction. Aerated concrete has found general application in the form of masonry blocks in most of the European countries. In India it is being produced by Hindustan Housing Factory under the trade name of 'Vayutan'. Another factory for the manufacture of aerated masonry blocks is in the process of erection at Ennore, Madras. The production, properties (Table 1), applications of foam concrete blocks, the method of laying and rendering have been covered in earlier Digests.*

Table I—Properties of Foam Concrete

Density kg/m³	Compressive strength kg/cm²	Thermal conductivity Kcal/m/hr/°C
300	7.0	0.06
400	11.9	0.07
500	20.0	0.09
600	29.8	0.11
800	49.7	0.16
1000	59.5	0.21

The scope of aerated concrete in buildings has been extended considerably in recent years by the successful production of autoclaved reinforced units in a variety of forms including structural members spanning upto 6 metres. Such units are licenced to be manufactured soon in India by Siporex India Ltd at Poona. This digest deals mainly with manufacture, properties, applications in building construction and limitations of their use for the guidance of engineers and architects.

Manufacture

Reinforced aerated concrete units are manufactured in the form of slabs or panels by autoclaving a set slurry consisting of fine silicious materials like sand, flyash, shale; a calcareous binder like portland cement, lime, granulated slag etc. and a large proportion of macroscopic pores incorporated by the addition of a small amount of foaming or gassing agent. The reinforcement is in the form of welded steel mats to suit the design requirements. The steel has to be coated with an anticorrossive material. A suitable composition based on cement and rubber latex has been developed at the Central Building Research Institute, Roorkee.

Properties

(*a*) *Compressive strength*

The compressive strength is determined by crushing tests carried out on unreinforced 10 cm cubes cast from the same mix as used for making reinforced units. The specimens are tested in air dry condition. The strength is related to density and compressive strengths for the density range of 500 to 750 kg/m³ are from 21 to 42 kg/cm².

(*b*) *Modulus of rupture*

The tensile strength in bending ranges from 7.0 to 12.5 kg/cm². The actual stresses resisted by the aerated concrete at the tension faces of flexural members, prior to cracking, depend upon the number and diameters of the bars placed near those faces. Cracking is observed to occur between 1.5 and 2.0 times the working load, under which condition the tensile stress can approach 50 percent of the compressive strength of the material.

(*c*) *Shear strength*

The shear strength of aerated concrete is about 1/8th of the compressive strength and it ranges from 2.5 to 5.0 kg/cm².

(*d*) *Bond*

Smooth, round, untreated reinforcing bars have poor bond qualities with autoclaved aerated concrete. The cement-rubber latex coating provides not only protection to steel but also a better bond between the steel and the coating and between the coating and the autoclaved aerated concrete. The bond strength (by pull out test) is of the order of

10 kg/cm². Since it is considered inadequate for the purpose of design, mechanical anchorage in the form of welded cross bars is generally provided.

(e) Modulus of elasticity and creep

The modulus of elasticity for autoclaved aerated concrete with a density of 500 to 750 kg/m³ is 14 to 28x10³ kg/cm². Inspite of its low density and low modulus of elasticity, the concrete is stable under the action of sustained loading. It shows relatively lesser creep deformation than ordinary reinforced concrete units.

(f) Thermal insulation

The thermal conductivity of porous materials depends upon the nature and construction of the material, its density and moisture content. The thermal conductivity of a wall slab of aerated concrete of density 650 kg/m³ has been found to be 0.13 Kcal/m hr°C in air-dry condition and 0.18 Kcal/m hr°C at a moisture content of 4 percent by volume. A 20 cm thick wall of aerated concrete of density 800 kg/m³ has the same thermal insulation value as a 38 cm thick brick wall of density 1600 kg/m³.

(g) Fire-resistance

Reinforced autoclaved aerated concrete has good fire resisting properties. It does not spall during fire on account of its homogeneous structure.

Fire resistance is expressed in standard grades ranging from 1/2 to 6 hours. A 10 cm thick aerated conerete slab gives fire resistance of 2 hours against one hour for 11 cm thick brick wall and 10 cm thick concrete slab.

(h) Sound insulation

The sound insulation of an aerated concrete partition is normally lower than that of dense concrete. However, 20 cm thick autoclaved aerated concrete vertical wall slabs normally used for external walls provide sound insulation of about 40 db which is adequate for residential houses and is comparable to that of single brick masonry wall.

(i) Drying shrinkage

Drying shrinkage of unrestrained specimens has been found to be about 0.04 percent. The main cementing constituent in autoclaved aerated concrete is crystalline in nature and hence dimensionally stable.

(j) Thermal movement

The coefficient of thermal expansion is $8x10^{-6}$ per °C against $12x10^{-6}$ per °C for mild steel reinforcement. Stresses due to thermal movement do not affect the bond significantly since it is mainly provi-

(k) Cracking

There is much less danger of cracking due to dimensional changes than ordinary concrete or light-weight aggregate concrete. Still, movement joints should be incorporated at about every 6 meters in walls.

(l) Workability

The material can be sawn, cut, drilled or nailed easily.

Sizes

Reinforced floor, roof and wall units are manufactured abroad in the range of sizes shown in table 2.

Table 2-Range of sizes

Unit type	Range of dimensions Length (m)	Width (cm)	Thickness (cm)
Roof and floor	upto 6	50—60	7.5-30
Wall(load bearing)	2.25-6	50—60	7.5-30
Partition (non-load bearing)	2.25-6	50—60	7.5-10
Lintels	upto 3.75	25—50	7.5-30

Functional Requirements

Roof slabs are designed to carry live load of 150 kg/m² and 7.5 cm of terracing and other water proofing material. The floor slabs are designed for a live load of 250 kg/m² and a wearing coat of 4 cm concrete. Wall slabs have to carry vertical loads and resist wind pressure.

Lintels are generally produced for span upto 7.75 metres and loads upto 1500 kg/metre length of beam.

Since aerated concrete is as light as timber, the roof and floor slabs require light supporting structure. The assembly of the wall and floor units being dry, decorative treatments, flooring of tile, linoleum or wood blocks can be laid immediately.

Wall panels serve as load bearing members and are easily handled. Outside walls are normally rendered or water proofed. Inside walls require only a thin gypsum coat for a smooth wall surface suitable for painting.

Wall slabs are ideal for partitions. They are light to handle and cover from floor to ceiling.

Applications

For dwellings upto three storeys, reinforced bearing walls, floor and roof slabs. For multistorey buildings, aerated concrete is used as roof slabs, covered by asphalt or roofing felt and also frequently as floor slab. The latter are usually covered with a cement-sand screed over which tiles can be laid. For heavy traffic a 4 cm thick concrete screed is required. Reinforced aerated concrete wall slabs of storey height are used for the outer, usually non-load bearing walls and also for partitions.

The reinforced aerated concrete units are eminently suited for industrial buildings on account of their lightness, thermal insulation and rapid erection. Wall units placed horizontally one on top of another are used for non-load-bearing panel filling. Storey high vertical panels jointed by grout along the vertical edges are used for load-bearing walls.

Handling

The cellular structure of aerated concrete which makes it lighter to handle and easier to work also makes it more susceptible to damage during transport and erection. Reinforced members, if damaged sufficiently to expose the reinforcement, can deteriorate rapidly and accidental breakage cannot readily be repaired. Site operations, therefore, require strict supervision to see that structural members are handled with proper care.

Durability

Aerated concrete walls are satisfactory from the point of view of rain penetration. Test buildings having single skin construction with aerated concrete panels have been under observation for several years. They have indicated that even when external protection was not provided, there was no detectable penetration of moisture in the body of the material presumably due to disconnected pores in the system. But the thermal insulation of the material is greatly impaired by the moisture penetration. It is, therefore, recommended that exposed aerated concrete walls should be rendered or otherwise suitably protected from outside. Internal surfaces may be left untreated. It has been found that cement-lime-sand (1 : 1 : 6) rendering is satisfactory against rain penetration. Roof panels should also be protected with layers of bitumen felt glued with hot bitumen.

Concluding Remaks

The performance of reinforced aerated concrete units has been found to be satisfactory in cold countries of Europe. Though the material has also been used in hot countries like Congo, Cuba, Mexico and Venezuela having climatic conditions similar to that of India, full information on their performance is lacking. The hot climate can cause greater shrinkage and swelling with change in moisture content which can lead to greater incidence of cracking. However, laboratory experiments on volume changes by wetting and drying of aerated concrete specimens have shown that the dimensional changes are only of the order of 0.04 percent which is within tolerable limit.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 86th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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