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BUILDING RESEARCH NOTE 48

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

AUTOCLAVED CELLULAR CONCRETE

Cellular concrete is a lightweight concrete produced by autoclaving a set mix of a ground sand and cement. Lightness is achieved by the use of air entraining or foaming agent, Technical advantages in the use of cellular concrete are its higher strength to weight ratio, 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 multistoreyed construction. Cellular concrete has found general application in the form of masonry blocks in most of the European countries. In India, Hindustan Housing Factory (HINDUSTAN PREFAB LTD.) at Delhi was producing cellular concrete blocks by the name of 'Vayutan' for insulation purposes, but now it has stopped production. One cellular concrete plant with Polish collaboration has been installed by Tamil Nadu Housing Board at Ennore. This factory is producing blocks mainly under the trade name 'Celcrete'.

Scope of aerated concrete in buildings has been extended considerably by the successful production of autoclaved reinforced units in a variety of forms including structural members spanning up to 6 m. One factory using Swedish Technology has also been established in private sector at Poona which is mainly producing reinforced roofing and flooring elements and to a small extent walling units. This note deals mainly with the manufacture, properties, applications in building construction and limitations of its use for the guidance of engineers and architects.

Manufacture

Cellular concrete units are manufactured in the form of blocks, (as shown in the photo

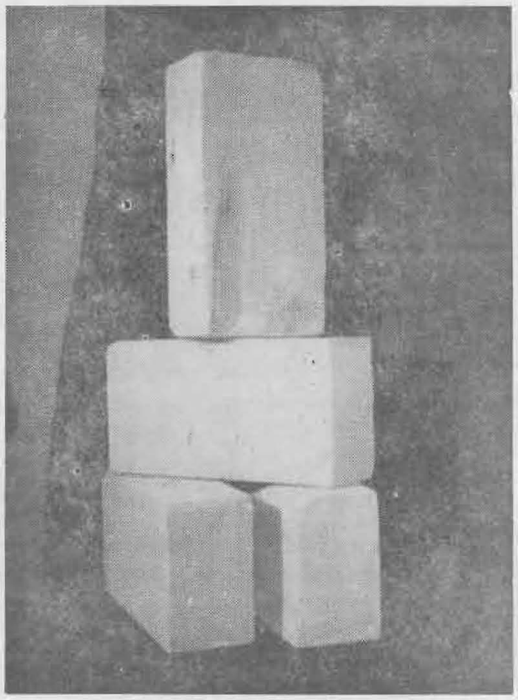
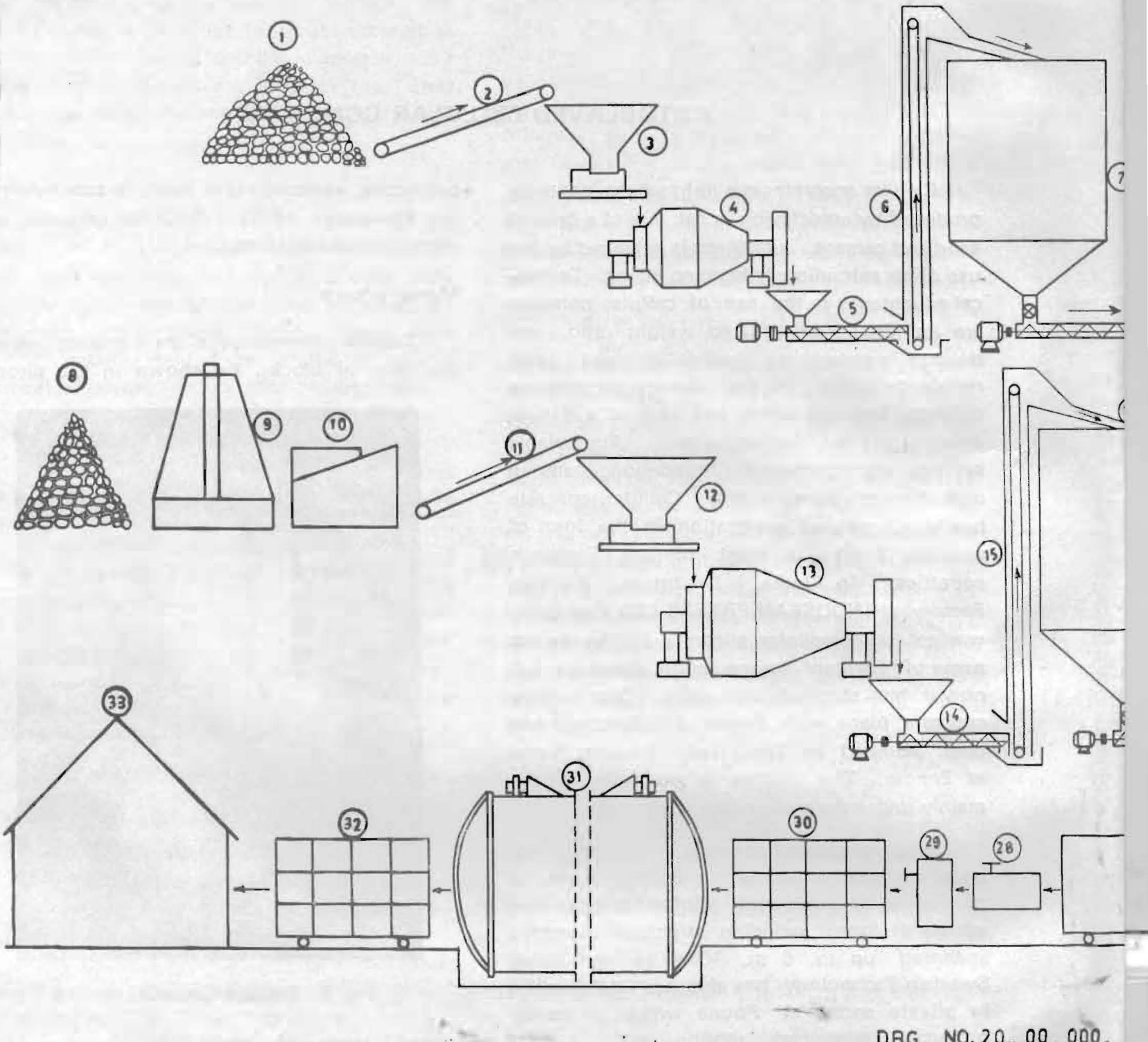


Fig. 1 Cellular Concrete Blocks

graph), reinforced slabs or panels by autoclaving a set slurry consisting of fine silicious materials like sand, flyash, shale; a

1. PROCESS FLOW DIAGRAM F(



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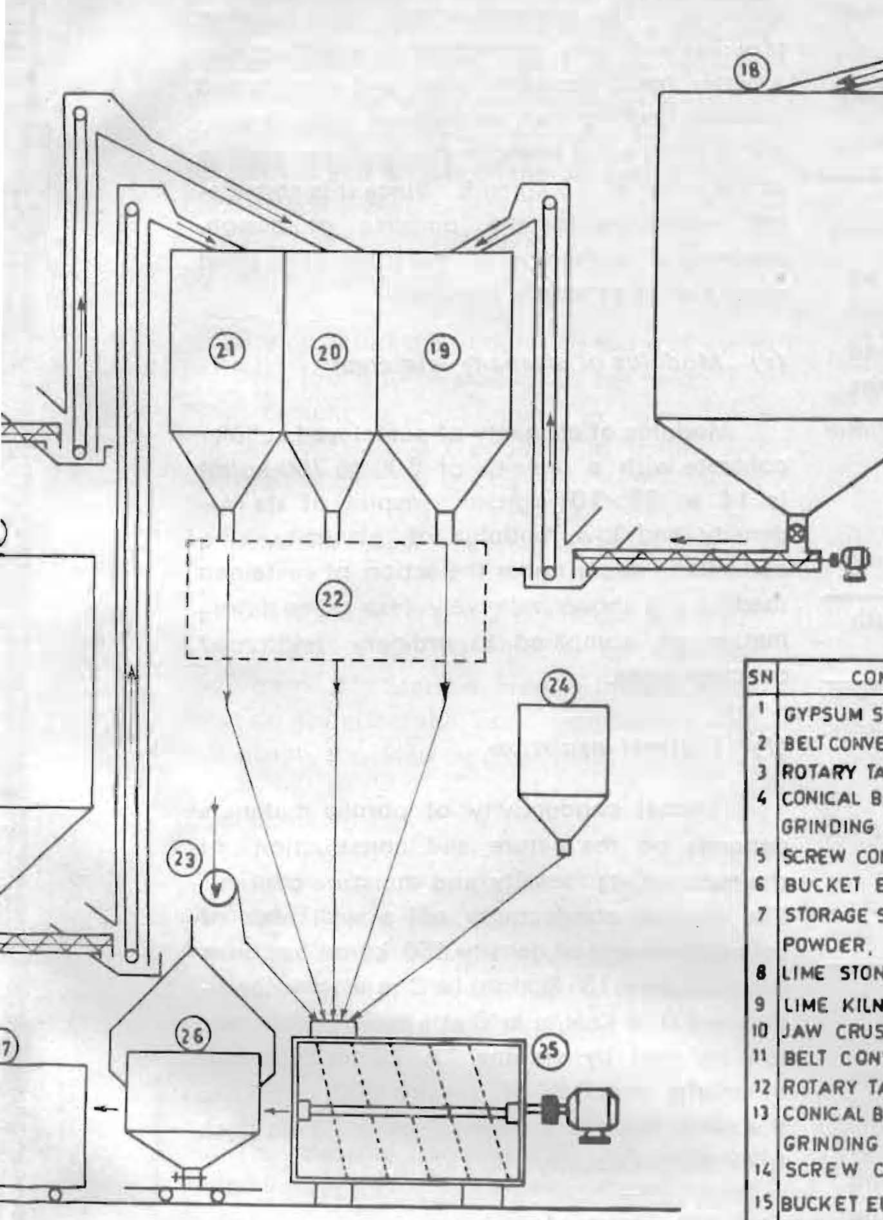
R LIME FLYASH CELLULAR CONCRETE PLANT



LEGEND

SN	COMPONENTS	SN	COMPONENTS
1	GYPSUM STORAGE.	21	SILO FOR LIME POWDER.
2	BELT CONVEYOR FOR GYPSUM.	22	AUTOMATIC WEIGHING ARRANGEMENT.
3	ROTARY TABLE FEEDER.	23	C. F. PUMP FOR WATER.
4	CONICAL BALL MILL FOR. GRINDING OF GYPSUM	24	STORAGE SILO FOR ALUMUNIUM POWDER.
5	SCREW CONVEYOR FOR GYPSUM.	25	MIXER.
6	BUCKET ELEVATOR.	26	TROLLEY FOR CARRYING SLURRY.
7	STORAGE SILO FOR GYPSUM POWDER.	27	MOULD FILLED WITH CELLULAR CONCRETE MIX.
8	LIME STONE STORAGE.	28	LONGITUDNAL CUTTING.
9	LIME KILN.	29	TRANSVERSE CUTTING.
10	JAW CRUSHER.	30	MOULDED COMPONENT AFTER CUTTING.
11	BELT CONVEYOR.	31	AUTOCLAVE.
12	ROTARY TABLE FEEDER.	32	AUTOCLAVED COMPONENT.
13	CONICAL BALL MILL FOR GRINDING OF LIME.	33	STORAGE FOR PRODUCT COMPONENT.
14	SCREW CONVEYOR		
15	BUCKET ELEVATOR		
16	STORAGE SILO FOR LIME POWDER.		
17	HOPPER FOR DUMPING OF FLY ASH		
18	STORAGE SILO FOR FLY ASH.		
19	SILO FOR FLY ASH.		
20	SILO FOR GYPSUM POWDER.		

calcareous binder like portland cement, lime etc. and a large proportion of macroscopic pores incorporated by the addition of a small amount of foaming or gassing agent. Process Flow Diagram For Lime Flyash cellular concrete plant is shown in Fig. 2 Reinforcement is in the form of welded steel mats to suit the design requirements. The steel has to be coated with an anticorrosive material. Central Building Research Institute, Roorkee has developed a process for the manufacture of cellular concrete based on lime and flyash. A suitable anticorrosive material based on cement and rubber late has also been developed.

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 as shown in table 1.

Table 1

Strength of Cellular Concrete

Density Kg/m^3	Compressive Strength Kg/cm^2
300	7.0
400	11.9
500	20.0
600	29.8
700	35.0
800	49.7
1000	59.5

(b) Modulus of rupture

Tensile strength in bending ranges from 7.0 to 12.5 kg/cm^2. The actual stresses resisted by the cellular concrete at the tension face of a flexural member prior to cracking, depend on the number and diameter of the bars placed near to that face. Cracking is observed to occur between 1.5 and 2.0 times the working load, under which condition, the tensile stress can approach 50 per cent of the compressive strength of the material.

(c) Shear strength

Shear strength of cellular concrete is about 1/8th of the compressive strength and it ranges from 2.5 to 5.0 kg/cm^2.

(d) Bond

Smooth, round, untreated reinforcing bars make poor bond with autoclaved cellular concrete. The cement-rubber latex coating provides not only protection to steel but also a better bond between steel and coating and between coating and autoclaved cellular concrete. The bond strength (by pull out test) is of the order of 10 kg/cm^2. 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

Modulus of elasticity of autoclaved cellular concrete with a density of 500 to 750 kg/m^3 is 14 to 28×10^3 kg/cm^2. Inspite of its low density and low modulus of elasticity, the concrete is stable under the action of sustained loading. It shows relatively less creep deformation as compared to ordinary reinforced concrete units.

(f) Thermal insulation

Thermal conductivity of porous materials depends on the nature and construction of the material, its density and moisture content. The thermal conductivity of a wall slab of cellular concrete of density 650 kg/m^3 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 per cent by volume. A 20 cm thick wall of cellular concrete of density 800 kg/m^3 h=s the same thermal insulation as a 38 cm thick brick wall of density 1600 kg/m^3.

(g) Fire-resistance

Reinforced autoclaved cellular 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 cellular concrete 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

Sound insulation of a cellular concrete partition is generally lower than that of dense concrete. However, 20 cm thick autoclaved cellular 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 per cent. The main cementing constituent in autoclaved cellular concrete is crystalline in nature and hence dimensionally stable.

(j) Thermal movement

Coefficient of thermal expansion is 8×10^{-6} per °C against 12×10^{-6} per °C for mild steel reinforcement. Stresses due to thermal movement do not affect the bond significantly since it is mainly provided by cross bars.

(k) Cracking

Danger of cracking due to dimensional changes is much less than that with ordinary concrete or lightweight aggregate concrete, Still, expansion joints should be incorporated at about every 6 m 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. 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 spans upto 3.75 m and loads upto 1500 kg/m length.

Since cellular concrete is as light as timber, roof and floor slabs require light supporting structure. The assembly of 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

As a walling material alternative to the traditional burnt clay bricks, cellular concrete blocks are advantageous in providing better thermal comfort. The blocks can also be used for partition walls in multi-storeyed construction.

For dwellings upto three storeys, reinforced cellular concrete units have widely been used as load bearing walls, floor and roof slabs. For multistorey buildings, cellular concrete has been 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 4 cm thick concrete screed is required. Reinforced cellular concrete wall slabs of storey height are used for the outer, usually nonload bearing walls and also for partitions.

Reinforced cellular concrete units are eminently suitable for industrial buildings on account of their lightness, thermal insulation and rapid erection. Wall units placed horizontally one on top of the other are used for non-load-bearing panel filling. Storey high vertical panels jointed by ground along the vertical edges are used for load-bearlng walls.

Handling

The cellular structure of cellular 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 operation, therefore, require strict supervision to see that structural members are handled with proper care.

Durability

Cellular concrete walls are satisfactory from the point of view of rain penetration. Test buildings having single skin construction with cellular concrete panels have been under observation for several years. They have indicated that even when external protection has not been provided, there has been no detectable penetration of moisture in the body of the material presumably due to disconnected pores in the system. But thermal insulation of the material is greatly impaired by moisture penetration. It is, therefore, recommended that exposed cellular concrete walls are rendered or otherwise suitably protected. 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 Remarks

Performance of cellular concrete blocks and reinforced units has been found satisfactory in cold countries of Europe. The material has also been used in hot countries like Congo, Cuba, Mexico and Venzuela having climatic conditions similar to that of India. 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 change by wetting and drying of specimens have shown that the dimensional changes are only of the order of 0.04 per cent which is within the tolerable limit.

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