BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

FOAMED CONCRETE BLOCKS
Part I

Introduction

Foamed concrete is a lightweight cellular material produced by autoclaving a set slurry consisting of fine silicious materials, a binder and a large proportion of closed macroscopic pores incorporated with the help of foaming or gassing agents. The material is also known as "Aerated" concrete in Sweden and England and "Porebeton" in Germany. In East European countries the cellular material is known by various names like foamed concrete, foamed silicate, gas concrete or gas silicate depending upon the type of binder used and the method applied for pore formation.

Foamed concrete, as precast units or cast *in-situ*. has been extensively used abroad in the erection of houses, blocks of flats and industrial buildings. The material leads to greater productivity in buildings, reduction in foundation loads and in the cost of transport. In India, the material is being manufactured by the Hindustan Housing Factory, New Delhi under the trade name of "Vayutan".

General Methods of Manufacture

Raw Materials : A variety of silicious fines can be used in manufacturing foam concrete, ground quartz sand, shale, fly ash, granulated slag being important ones. The former two are naturally occurring materials and the latter two are industrial wastes.

The important binders used in foamed concrete are portland cement and lime.

Gassing agents used commonly are either organic foaming agents based on resin soap, glue and surface active agents or gas generating agents like fine aluminium powder, zinc dust, calcium carbide, calcium hypochlorite etc.

Process Technology :

Manufacture of foam concrete requires much greater technical knowledge and experience than ordinary concrete. There are two commercial processes for manufacture differing essentially in the method of introducing air cells or voids in the slurry.

(i) *Foaming process :*

The cement and finely ground sand in the required proportion are mixed with water in a high speed mixer to form homogeneous slurry. A solution of a known concentration of foaming agent required for a particular density is prefoamed in a machine and the foam formed is gradually introduced in the slurry. The slurry is then churned slowly so that bubbles are distributed uniformly. The creamy mix is transferred to moulds for casting precast blocks and other products. The material hardens in about 24 hours. The blocks are then steam cured at a pressure of 10-11 kg/sq. cm. for about 16 hours, air dried and stacked ready for use.

This method is being practised in India by the Hindustan Housing Factory, New Delhi. The sizes of the blocks manufactured are 50 cm x 25 cm of any desired thickness.

(ii) *Aluminium powder process :*

In this method finely powdered aluminium metal (about 0.1 per cent of the weight of the solids) is added to the slurry of cement and sand as prepared earlier or to the slurry of lime and fly ash. Aluminium powder reacts with lime formed during hydration of cement or which has been used as the binder. Hydrogen gas liberated by the chemical reaction gets entrapped in the slurry, hence causing the material to foam. The slurry is cast into moulds and autoclaved as described earlier.

The materials produced by the above two methods are similar in properties but the latter method is considered superior on technical and economic considerations.

General Properties

Density : For making foam concrete of any desired density, the fineness and proportions of raw materials and the quantity of the foaming agent are first determined by means of laboratory tests. The proportions used for making 'Vayutan' are shown in Table I.

TABLE I

Density kg/m³	Cement by weight	Ground sand by weight
400	1	1.0
650	1	1.75
800	1	2.00
1000	1	2.20

The amount of water should be sufficient to give creamy mix of suitable consistency. The approximate quantity of water per cubic meter of mix is 190 litres.

Foaming solution of three to four per cent is used for prefoaming.

Autoclaved material may contain moisture content of about 25 per cent and requires air-drying before use. Normally the density of the air dry product varies from 400 to 800 kg/m³ as compared to 2200 to 2400 kg/m³ of dense concrete.

Compressive strength :

Factors influencing strength are quality of materials, proportions of the mix, method of manufacture, curing

conditions, density and the moisture content of the final product. Specimens tested in the saturated condition may reach only 80 per cent of the strength of the same concrete when tested dry. Compressive strength of 'Vayutan' for various densities is reported in Table II

TABLE II

Density (kg/m^3)	Compressive strength (kg/sq.cm.)
300	7.0
400	11.9
500	20.0
600	29.8
800	49.7
1000	59.5

For use in load bearing walls, the minimum strength requirement is 28 kg/sq. cm. in saturated condition as per IS 3590-1966 for load bearing lightweight concrete blocks. At the time of delivery to the site, the average compressive strength of air dried units intended for load bearing walls should be not less than 35 kg/sq.cm and no individual unit should have compressive strength less than 31.5 kg/sq cm based on net area. In the case of blocks intended for the construction of non-load bearing walls, strength may be as low as 21 kg/sq.cm.

Drying shrinkage :

Excessive drying shrinkage is the common cause of cracking and crazing specially in hot dry regions. Foam concrete produced by ordinary air curing has very high drying shrinkage. However, drying shrinkage is largely reduced when the product is cured in high pressure steam. Since foam concrete shrinks more than ordinary concrete, it is best used in the form of precast units. When shrinkage is relatively less important, the material can be placed *in-situ* e.g., for insulation of roofs. Quick drying of *in-situ* foamed concrete should be avoided to prevent cracking which may affect the insulation value.

Precast autoclaved blocks should be stacked in such a manner that free circulation of air takes place. They should be adequately dried for three to four weeks before delivery to the site. During transport and storage at the site before use, they should be kept in dry condition.

Resistance to rain penetration :

'Vayutan' blocks absorb 10 to 15 per cent of water by volume in 24 hours when fully immersed. Permeability of foam concrete is, however, low because the large pores formed by the foam are never filled up with water under the conditions obtaining in practice. When 'Vayutan' blocks are exposed to 99 per cent relative humidity, the moisture absorption is 6.2 per cent. Foam concrete is known to have poor resistance to the diffusion of water vapour. Absorption of moisture by the foam concrete affects its thermal insulating quality also. Hence it is desirable to protect it by a suitable rendering, The composition of suitable mixes for renderings, their application and necessary precautions are discussed in part II of this digest.

Thermal Conductivity :

The thermal conductivity of foam concrete is roughly proportional to the density, so that the lighter products are of greater value for thermal insulation. The thermal conductivity of air-dry foamed concrete 'Vayutan' is reported in Table III.

TABLE III

Density kg/m^3	Thermal conductivity KCal/m/hr/°C
300	.06
400	.07
500	.09
600	.11
800	.16
1000	.21

Sound insulation and absorption :

Foamed concrete does not resist the transmission of air-borne sounds but if its cellular structure is exposed, considerable sound absorption results.

Workability :

A great advantage of foamed concrete is the ease with which it can be cut to shape on the site with ordinary tools. The precast blocks can be nailed and bored like timber. Besides the handling and erection of the units is much easier.

Applications

Precast blocks : The density of foamed concrete blocks for load bearing construction and panel filling is usually a quarter to a half that of dense concrete and for non-load bearing construction, permanent form work and insulation, an eighth to a quarter that of dense concrete. These advantages of foamed concrete, therefore, in each case, reduce the dead load of the structure and permit a reduction in the sizes of the framing members. As for insulation, a 20 cm thick wall of foam concrete of density of 800 kg/m^3 has the same thermal insulation as a 38 cm thick wall of bricks of density of 1600 kg/m^3.

Indian Standard Specification does not exist for foam concrete blocks. However, they may be regarded as suitable if their density, strength and drying shrinkage are within the limits of IS : 3590-1966 Specifications for loading bearing lightweight concrete blocks. Buildings of two or three storeys can be constructed with load bearing single skin walls about 25 cm thick of foam concrete blocks having compressive strength of at least 28 kg/sq cm when tested wet or 35 kg/sq.cm when tested dry. While this strength is adequate for domestic construction, the strength specified for any given purpose should be chosen according to the loads to be carried and the thickness needed to give the thermal insulation. The structural recommendations for load bearing lightweight concrete block masonry are applicable to foam concrete blocks also.

For external walls of cavity construction, the blocks may be used either for both leaves or for the inner leaf only, in the latter case any normal walling may be employed for the outer leaf. If used for the outer leaf, the blocks should be rendered or otherwise protected to reduce water absorption.

Foam concrete blocks should not be used below the level of the damp proof course or in locations subject to continuous dampness.

Non-load bearing slabs or blocks may be used for internal partitions and as in-filling for framed structures. Low density blocks have been extensively employed abroad as an insulation infill for the walls of prefabricated houses and for external insulation of reinforced structures.

Use of *in-situ* foamed concrete is restricted to nonstructural purposes such as for roof and floor screeding, for insulating hot water or steam pipes and for fire protection of structural steel work.

For *in-siiu* foamed concrete the following precautions should be taken :

(a) The screeding should be allowed to harden and dry thoroughly before the water proofing membrane is applied.

(b) If more than casual foot traffic is to be expected, a normal cement mortar should be laid over the screeding or other means of protection should be provided.

Precast foam concrete blocks of density of 640 kg/m³ manufactured by the Hindustan Housing Factory have been mainly used in non-load bearing internal partition walls in buildings. Low density blocks (320 kg/m³) have been used for insulation of roofs and cold storages.

Reinforced foamed or cellular concrete

Reinforced autoclaved foamed concrete members for walls, roofs and floor units etc. have been developed and used extensively in Sweden and other countries. Large sizs flexural members of standard sizes approximately 50 cm wide, up to 6 meters long and 7.5 to 20 cm thick are now being manufactured giving satisfactory performance. The main advantages of large reinforced concrete units are their low weight, thus reducing dead loads considerably compared with ordinary precast concrete members, speed of erection and high inherent thermal i nsulation.

These flexural members have been used for industrial roofing, not only because of their functional suitability but also because of saving in costs resulting from rapid erection. The development of these products is recommended.

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 46th in the series. Readers are requested to send to the Institute their experience of adopting the suggestion given in this Digest.

SfB	Ff 4
UDC	691.32-496

Compiled by C. A. Taneja & Kishan Lal
Published by P. L. De,
Central Building Research Institute, Roorkee.

October 1966