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Soil blocks for rural housing

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"A house is the most visible symbol of a family's identity, the most important possession a man can ever have, the enduring witness to his existence, its lack one of the most potent causes of civil discontent and conversely its possession, one of the most effective guarantees of the social stability".

(Hasan Fathy)

INTRODUCTION:

Shelter is a basic human need but today we are faced with an uncomfortable gap between the need for shelters and their availability especially in the Third World. Between now and the year 2000 we would need over a billion houses to house the poor in developing countries. The housing scenario in India is none too encouraging. Housing shortage in rural & urban areas has reached alarming proportions. The shortfall which was 25.6 million units in 1986 is likely to go upto 39.1 million units by 2001. The problem is more acute in rural areas which account for 75% of the total shortage.

EARTH CONSTRUCTION - A VIABLE SOLUTION:

Housing development has various complex dimensions. An important one is the use of appropriate building technology. One of the solutions which has been stressed time and again is the use of local materials and local skills to produce economic, ecologically compatible and energy efficient buildings. In such an context, earth construction assumes importance. For thousand years earth/mud has been used as a basic material in construction. 3500 years earlier, Harapans built with mud. Even today, 80 to 90% of the rural population lives in houses made of mud (30% in cities). With the onslaught of western oriented values, mud was relegated to the status of a 'poor man's material'. The indiscrete copying of western concepts and values overshadowed our traditional knowledge & building systems which were well adapted to our environment. However, the skyrocketing costs of building material, the concerns about conservation of environment & energy has once again activated revival of interest in mud construction. At the same time, building technologies have been developed to provide optimum efficiency to mud construction. One

such technique is the use of Stabilised Soil Blocks as a substitute for burnt bricks for construction of walls.

STABILISED SOIL BLOCKS:

Stabilised Soil Blocks are a walling material comparable to burnt bricks. They are made by pressing a mixture of soil & stabiliser like cement, lime, chemical etc. in a machine (press) as a suitable moisture content. These Blocks, after curing, can be used as a substitute to bricks in the construction of walls. Unlike bricks, no burning is involved in this process. The improvement in properties in this case is affected by one or more of the stabilisation procedures viz; mechanical, physical and chemical stabilisation.

PRODUCTION PROCESS:

The normal production process for Soil Blocks involves:

Soil Selection & Testing:

A sand and fine gravel content of 80% and a minimum clay content of 10% is generally considered ideal. The soil composition chart (Fig.1) shows the ideal, the recommended and the possible composition suitable for Block production.

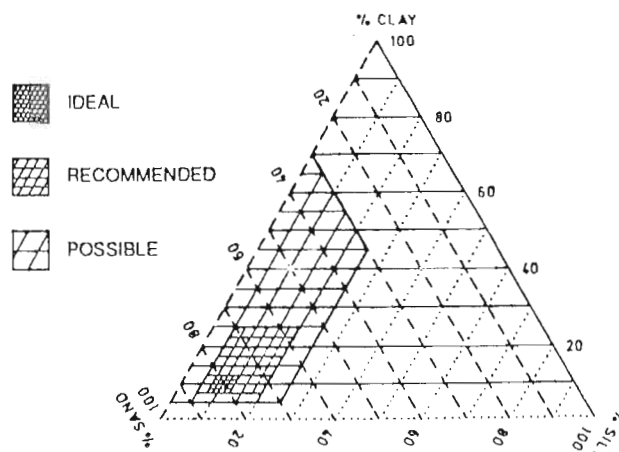


Fig.1 : Soil Composition Chart

Various field tests have been developed for determining the suitability of soils. These include visual examination, touch test, sedimentation test & lustre test to

judge proportion of coarse/fine fractions & smell tests for organic matter. If required laboratory tests such as linear shrinkage, grain size distribution (sieve analysis), Atterberg limits, sedimentation analysis, Proctor compaction tests etc." (Ref. 1)". The best method, however, is trial and error. Sample blocks are made using different soil types & mixes, but using same methods that would be used for full scale production. Performance tests are then made on these blocks to determine the most suitable materials and their proportion.

Selection of Stabiliser Type & Amount:

It is not compulsory to add stabilisers but it is generally recommended to obtain blocks with better strength & durability. Of the various materials used as stabilisers, cement, lime & bitumen are the most common.

Nearly all soils, except those which have an excessive content of organic material can be treated with cement (3% to 19% by weight). The greatest compressive strength is obtained with gravels & sand rather than silts & clays. Soils which have large clay fraction require large quantities of cement. In practice, cement is not used for stabilising clay when liquid limit is higher than 30 percent. Between 2 to 4% of bitumen added to soil-cement as emulsion or cutback makes it waterproof.

Lime is more effective than cement on clay-sand soils & especially on very clayey soils. For ordinary stabilisation between 6% to 12% lime is used. Sandy soils or sand gravel soils are more amenable to stabilisation using bitumen. The quantity of bitumen ranges from 2 to 6 percent.

Soil Preparation (Crushing, Sieving & Mixing):

The excavated soil is ground & screened through a wire mesh to obtain a maximum grain size of 10mm. If the soil has large number of clay lumps, they are broken. The soil is then be mixed intimately with the stabiliser. Cement and lime are mixed in dry state either manually or in a mixer. Bitumen is used as stabiliser in cutback or emulsion form. Predetermined quantity of water is then sprinkled for even distribution and mixed. To

obtain maximum density, soil is compacted at Optimum Moisture Content (OMC). OMC varies from 12-18% in different cases. Water little more than the OMC is added to account for evaporation losses. A simple field test to determine OMC is shown in Figure II. When using cement as binder, only so much material should be prepared as can be used up in about 20 minutes, with lime there is no time limit.

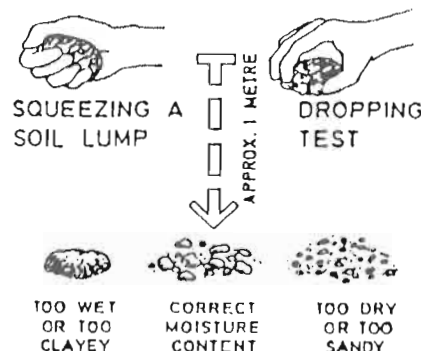


Fig.II: Field Test for OMC

Compaction of Blocks:

Compressive strength, which is the most critical property and the density of block have a close positive correlation. A small increase in density causes a dramatic improvement in compressive strength of the block. This underlines the importance of producing high density blocks. Various methods used for compaction of blocks are:

Hand Moulding : The compaction in this case is achieved by tamping of soil in a mould.

Compaction using Manual Presses: The procedure in this case involves filling the mould(s), compacting the soil using a lever mechanism, demoulding and stacking of blocks.

Production of Blocks using Mobile Soil Block Plant: The mobile soil block plant is a trolley mounted machine powered by a Diesel Engine and consists of a mixer unit and a hydraulic press. The sieved soil is fed manually into the mixer and recommended doses of stabiliser & water are added. Subsequent operations of mixing, feeding to moulds, rotation of mould table, compaction & ejection of blocks etc. are automatic. The Soil Blocks ejected by the machine are removed manually & stacked for curing/drying.

Table-I shows a comparison between various features of manual presses and the Mobile Soil Block Plant. The Soil Block Plant has the advantage of greater compaction pressure and production capacity but is costlier than Manual Press.

Table I: Comparison Between Soil Block Machines

FEATURE	MANUAL PRESS*	MOBILE SOIL BLOCK PLANT**
Weight (Kgs)	100 - 140	2100
Rated Output (Brick size)	1000 Blocks/day	3000 Blocks/day
Compaction pr.	20-30 kg/cm ²	50 kg/cm ²
Energy source	Manual	15 H.P Diesel Engine
Manpower	4 - 6	5
Price (Rs)***	5000-7000	3,00,000

* ASTRA, BALARAM, ITGE VOTH ETC.

** Intra Consolid CLU-3000

***Rs.100 = US \$ 5.80 (19.05.1990)

Drying or Curing:

Unlike traditional hand-moulded mud blocks, stabilised soil blocks are carried to a shaded curing area to prevent excessive rapid surface drying which may cause shrink cracking. Alternatively, the stack can be covered by a plastic sheet & moistened by spraying water. Cement stabilised blocks should be cured for about 21 days - 7 days in stacking yard and subsequently on the constructed wall. In case of lime, curing in stack for a period of 15 to 21 days is necessary. For rapid production, steam curing can be used. The blocks will acquire strength rapidly and will be ready for use on the next day.

TECHNICAL SPECIFICATIONS FOR SOIL BLOCKS:

Blocks can be produced using either Manual Presses or Mobile Soil Block Plant. The advantages in the first case are the lower cost of machine and greater labour-turnover ratio, whereas in the second case, we get better technical properties saving in time, labour & better quality control. Considering various socio-economic parameters and likelihood of acceptance of technology by public, the Council recommended the use of Mobile Soil Block Plant. The physical properties of a block produced by Soil Block Plant are:

Size: 229mm x 114mm x 76mm (Std. Brick)

Block weight: 3.75 Kgs (average)

The most important performance parameters which are used as a yardstick to determine the suitability of blocks are:

- o The block strength to bear the weight of a wall & the superimposed load.
- o Water absorption.
- o Resistance to erosion caused by rain.

The recommended values for these properties as per IS:1725-1982 are as shown in Table-II. The methods for testing compressive strength & water absorption are the same as those used for testing burnt clay bricks (as given in IS:3495:1976).

Table II: Technical Specifications

COMPRESSIVE STRENGTH:	Class Designation	Av. Comp. Strength Kg/cm ²
	20	20
	30	30
WATER ABSORPTION:	Av. after 24 hours immersion	15%
WEATHERING: Resistance to rain impact	Limiting dia. of pit	Max. loss in weight
	1 cm	5%

The resistance to erosion caused by rain impact (weathering) is evaluated by subjecting a block to a continuous spray of water at a constant pressure of 1.5 ± 0.2 kg/cm² for 2 hours and examining the surface for possible pitting. The acceptance criteria are as given in Table II.

SURFACE PROTECTION FOR SOIL BLOCKS:

In principle, surface protection is not necessary for well built structures in stabilised soil. Stabilised earth walls stand up well to bad weather for many years. But rendering & paints may sometimes be desirable from other considerations such as aesthetics, reduction of heat gain by reflection, easy maintenance of surface etc. Some commonly used techniques are:

Rendering: may be in earth, stabilised earth, or a sand-based mortar to which a hydraulic binder has been added: cement or lime or some additive. An exhaustive study of the various plasters was done by Development Alternatives "(Ref. 2)". Lime-surkhi & lime-cement-sand plasters emerged as the most erosion resistance & efficient plasters.

Paint: These include conventional paints, distempers & washes. Washes include cement or lime slurries or bitumen in the form of a cutback. These are applied with a brush or a spray gun.

Impregnation: The surface is impregnated with a natural (e.g. linseed oil) or a chemical (e.g. silicon) product. This confers qualities like impermeability, hardening, colouring etc. Two low cost formulations have been developed at CBRI, Roorkee. Similarly,

consil being marketed by M/s Intra Consolid (I) Ltd is a siliconvinyl toulene acrylate copolymer which is applied to wall in the form of emulsion. The treatment costs Rs. 6/- to Rs. 8/- per sq.m.

ECONOMICS:

The parameters for cost-calculation using semi-mechanised Mobile Soil Block Plant are given below. In case manual presses are used, the cost would be lower due to lesser cost of machine.

- Production rate = 375 Blocks/hour
- Block size = 229 x 114 x 76mm
- Labour = 1 Operator, 4 Unskilled
- Diesel reqd. = 4 Litres/hour
- Machine cost = About Rs. 3,50,000/-
- Repair & Maint. = 5% of cost of machine

The cost of Soil Block has been worked out under two conditions:

Alternative-I: Assuming that machine is made available to development agency on No-cost basis i.e. purely promotional activity.

Alternative-II: Assuming that activity is taken-up on commercial basis, 14% interest on capital & redemption of machine cost in 5 years with zero salvage value.

The cost/thousand blocks works out to Rs. 400 & Rs. 500 as per Alt.I & Alt.II respectively as shown in Table-III.

ADVANTAGES OF STABILISED SOIL BLOCK TECHNOLOGY

Use of Local Materials & Local Skills: This facilitates involvement of people in the construction of their own houses and thus aids decentralisation of construction process.

Economic Character: As seen earlier, stabilised blocks are cheaper than bricks.

Energy Efficient: Replacement of burnt bricks by 4% cement stabilised blocks will lead to a fuel energy saving of 60%.

Ecological Character: Processing of brick is a major source of pollution and also leads to ecological imbalance. These can be avoided by use of stabilised soil blocks.

Susceptibility to Seasonal Changes: There is a shortage of bricks during & immediately after the monsoon period as the switching on of production takes time. On the other hand, soil block production can be started at a short notice.

Thermal Comfort: Earth houses are climatalogically more compatible to live in.

Better Appearance & Aesthetics: The blocks

have better size & shape as they are machine made.

STRATEGY TO POPULARISE SOIL BLOCK TECHNOLOGY

Inspite of the established technology, stabilised soil block have not really found favour in the housing programmes in India which are dominated by brick & concrete. Construction technologies being adopted by the Govt sector are largely based on these materials due to the inherent resistance of the Govt departments to go in for new materials & technologies as these require more initiative, effort, time & dedication. At the sametime, People usually like to follow the methods & materials being used by the Govt departments. This calls for efforts to encourage Govt departments to assimilate such new concepts in their working so as to set an example for People to follow.

As a first step towards promotion of soil block technology, Punjab State Council for Science & Technology (PSCST) is motivating the Department of Rural Development (Construction Wing) to undertake the construction of some buildings such as Panchayat Ghars, Schools, Veterinary Hospitals etc. in the villages as demonstration projects so that the local people can see for themselves the quality & durability of the material. The Council is providing to this department, Mobile Soil Block Machines free of cost as an incentive alongwith training programmes for the use & up-keep of the machine. A feedback mechanism would also be integrated in the project to further refine the technology. Bases on the results of these pilot projects and the responsiveness of the people, these machines would be provided on lease basis to a group of village panchayats so that people can use them for construction of their own houses/ buildings. This would facilitate acceptance of the technology and its widespread use in the rural areas.

REFERENCES:

1. Manual on Earth Construction Technology, UNCH S(Habitat) Nairobi 1986.
2. Cover the Earth: Plasters for Soil Block Buildings, Development Alternatives, New Delhi, 1987.
3. Building Technology Series, No. 2- UNESCAP Bangkok.
4. IS:1725-1982: Standard Specs. for Soil Based Blocks used in General Building Construction.

TABLE III: COST OF SOIL BLOCKS

ITEM	COST FOR 1000 BLOCKS	
	Alternative I	Alternative II
DIRECT COSTS:		
Soil 2.25 m ³ @ Rs. 15/m ³	Rs. 33.80	--
Cement 4%, 3 Bags @ Rs. 80/- per Bag	Rs. 240.00	Same as Alt. I
Diesel @ Rs. 3.56/litre	Rs. 38.00	
<u>Labour:</u>		
1 Operator @ Rs. 40/day		
4 Unskilled @ Rs. 25/day	Rs. 46.70	
(A) TOTAL DIRECT COST:	Rs. 358.50	Rs. 358.50
INDIRECT COSTS:		
Depreciation & Interest on Capital	0.00	Rs. 113.30*
Repair & Maintenance	Rs. 20.00	Rs. 20.00
(B) TOTAL INDIRECT COST:	Rs. 20.00	Rs. 133.00
TOTAL COST (A) + (B) =	Rs. 378.50	Rs. 491.80
	Say Rs. 400/-	Say Rs. 500/-

$$\text{*Depreciation Cost} = \frac{3,50,000 \times 1000}{3.433 \times 9,00,000} = 113.30$$