Prefabrication . . . Building

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THE need for housing is world wide but in developing countries there is an acute shortage of houses. In India it has been estimated that shortage is increasing at the rate of one million units a year. The Government of India and practically all the state governments are grappling with the problem of houses for the masses. More and more funds are being allocated for schemes like — Houses for the Harijans, Houses for Economically Weaker Section and Industrial Workers/Slum Dwellers, etc. etc., still the shortage is on the increase and hence the need for building scientists to evolve new and cheaper building materials and techniques. Prefabrication can play an important role in bridging the gap by providing faster rate of construction.

Prefabrication is being adopted in a big way in highly mechanised and advanced countries. The art of Prefabrication needs a new look from the Indian standpoint because of the need of labour oriented process, restricting the use of machines. The Central Building Research Institute, Roorkee, has done very useful work on prefabrication which has vast scope of application. The systems evolved envisage prefabrication of elements which are light to medium in weight and as such do not involve any handling machines/equipments. An attempt has been made to cover a few of the systems in this paper. Some of these systems are for complete prefabricated housing and the others for flooring and roofing of houses.

A. PREFABRICATED HOUSING SCHEMES

(i) Precast Skeleton Housing System

The system consists of precast reinforced concrete elements — Footings, Columns, Beams, Partially Precast Joists and Doubly Curved Tiles.

The components when erected form a skeleton comprising supports and a roof. The wall claddings can be carried out by the dwellers through self help, using indigenous materials.

Novel features of the system permit the use of overburnt brick aggregate for reasons of economy in regions where brick aggregate is cheaper than the stone aggregate.

The cost of skeleton for the house in Roorkee area is nearly Rs. 50.00 per square metre of plinth area.

(ii) Prefabricated Brick Panel Housing System

The system consists of the following components prefabricated from brick and cement mortar (panels) and precast reinforced concrete members (Fig. 1).

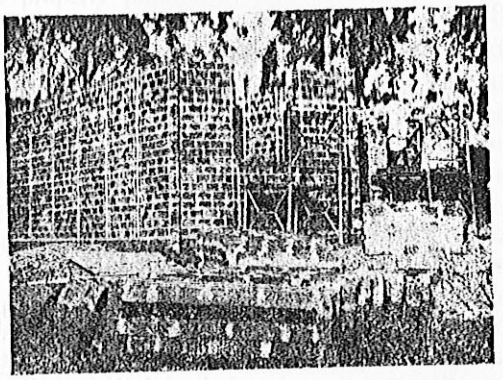


Fig 1. Brick Panel System House under Construction

1. Unreinforced wall panels (515x1040mm) using 18 burnt bricks in cement sand mortar1 : 4.

2. Reinforced roof panels (560x1040mm) using 17 burnt bricks in cement sand mortar 1 : 4 reinforced with two 6mm dia. ms bars.

3. Partially precast R.C.C. joists (130x100 mm section)

4. Precast R.C.C. lintels, slabs and projections 70mm thick.

5. Additional wall panel (500x865mm) to provide flexibilities of planning.

The cost of one room house consisting of a room (2900x3120mm) and a verandah (2230x3350mm) including walling, roofing, flooring, cement plastering and local timber doors and windows is nearly Rs. 2000/- in Roorkee area, as given in the abstract of Cost, Appendix I.

(iii) Holopan System of Housing

The system consists of prefabricated hollow unreinforced panels with reinforced cement concrete grouted columns and prefabricated joists. Basically it is frame and filler type of structure. The wall panels are 70cm x 100cm x 10cm having six hexagonal cavities with semihexagonal ends having shear keys to provide space for grouted columns at the time of construction. The floor/roof panels are also unreinforced concrete elements 100x100 cm x 10cm., with the same hollow section as the wall units. The collar units 1mx15cmx10cm and parapet units 4cmx30cmx100cm complete the system, with provision of precast doors, windows and ventilators, eliminating the use of lintels in the openings.

Use of timber in door and window frames is eliminated. The system may be suitably designed for 2-3 storeyed structures also and the planning is done using a module of one meter.

B. PREFABRICATED ROOF/FLOOR SCHEMES

(i) Waffle Unit (Fig. 2)

The system consists of a grid slab with open box type square/rectangular precast units. It can advantageously be used for spans 6 metres and above. Units are inverted trough shaped square or rectangular in plan. They come generally in two sizes 120x120cm or 90x90cm. A nominal reinforcement in the form of steel wire fabric having 3.15mm dia at 15cm centre to centre both ways is used in the flange. The depth and main reinforcement depends upon the span and the loading. Flange thickness of 90x90cm unit is 3.5 cm average.

The precast waffle units are laid in a grid pattern over a strip of shuttering along the direction of the joints and the cast-in-situ concrete together with the required amount of reinforcement is laid.

The finished slab has a pleasant grid pattern in the soffits.

(ii) Cored Unit

The system consists of precast units almost rectangular in section with two circular hollows along the length, supported over walls or joists. The units are precast structural units and do not require any support during construction, giving a flush ceiling. The normal width of the units is 30cm at the bottom, 25cm at the top and the depth 13cm for a span 2.5 metres to 4.2 metres. The units have top and bottom flush with sides having corrugations and shear keys. The roof/floor may be designed as a simply supported or continuous one way slab. The cored units are erected over the supporting walls/beams and the gaps between the adjacent units are filled with in-situ in the joints wherever necessary.

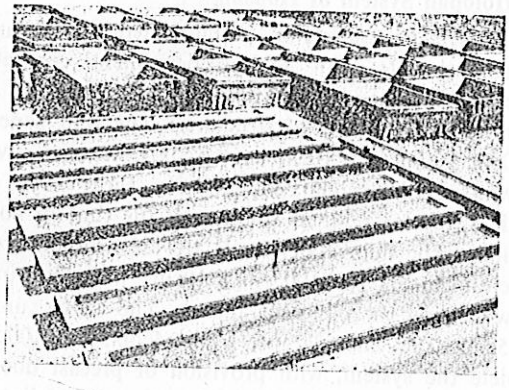


Fig 2. Channel units in the foreground; Waffle units in the background

The units can be precast by the manual process or by the mechanised production process. For the latter system of production a suitable plant has been developed at the Institute, using pressure vibrated technique.

(iii) Channel Unit

The system consists of precast R.C.C. channel units requiring no props during construction. The unit is 13cm thick/deep, 30cm wide at the bottom, 25cm wide at the top with a through 18.75 cm x 10cm on its underside. The roof/floor may be designed as a simply supported or continuous one way slab. Usually two 10mm dia m.s. bars as main reinforcement, with two m.s. 6mm dia supporting bars and 3mm dia stirrups at 30 cm centre to centre and 13 cm depth are adequate for 3 metre spans and normal loading. The depth and reinforcement may be varied according to the span and loading. The cured units are placed on the walls and the joints between the adjacent units are laid with in-situ concrete and negative reinforcement if any.

(iv) Cellular Unit

The system consists of precast cellular units and the supporting joists. The unit is a flat precast hollow unreinforced rectangular element. The supporting joists may be fully or partially precast. Recommended sizes of the unit are (a) 100cmx50cmx10cm with three hollows or (b) 120cmx60cmx7.5cm with four hollows. The hollows are hexagonal and the minimum wall thickness of the unit is 1.5cm. The roof/floor may be designed using rectangular beams without deck concrete or as a composite tee beam with 3cm deck concrete having temperature reinforcement. The tee beam may be used for spans upto 4 metres.

The ceiling has a flush appearance except for the beams or joists at one to 1.2 metres intervals.

(v) Doubly Curved Tile Roof

The system consists of precast doubly curved unreinforced tiles supported with composite tee beams at every tile interval. The recommended size of the tile is 70cmx70cm with 2cm wall thickness. The precast tiles are supported over partially precast joists and the haunches between the adjacent tiles are filled with cast-in-situ concrete. Temporary props are required for the partially precast joists until the cast-in-situ concrete in the haunches matures.

The system is suitable for roofs only.

(vi) Structural Clay Units (Fig. 3)

The system envisages prefabrication of reinforced joist/panel elements using structural clay units. The structural clay unit is extruded in a brick extrusion

machine from plastic clays, dried and fired in a down draught kiln and has hollows about 37% of the overall volume. The same unit overall size 16.5x15.0x19.0cm with three hollows can be used for joists as well as filler element. The joist element is prefabricated by jointing the units end to end in 1:3 cement sand mortar of the desired span length. Using plank shutters on either side M150 concrete is laid with designed reinforcement. Joist elements are cured and erected over the supporting walls/beams @ 30 cm centre to centre, and temporary props provided if necessary. The intervening spaces between adjacent joist elements are filled by laying filler units and 1:3 cement sand mortar and the space between filler unit and the joist should finally be filled with cast-in-situ M150 concrete and cured. The roof/floor may be designed based on conventional methods of working stress or ultimate load design methods.

The panel type construction consists of prefabrication of reinforced slab panels of required length and maximum 60 cm in width. Construction of panels resembles the wall construction except the use of wooden gadget for applying 1:3 cement sand mortar for joints. After laying a course of clay units, designed reinforcement is placed in the longitudinal groove and next courses laid till the maximum height of 60 cm is achieved. Cured panels can be erected over the walls or beams by placing them side by side, and the longitudinal joints bttween two panels pointed on the lower side (ceiling side). The slab panels can be designed by the ultimate load theory as simply supported or continuous slabs using negative reinforcement in case continuity is there.

C. GENERAL:

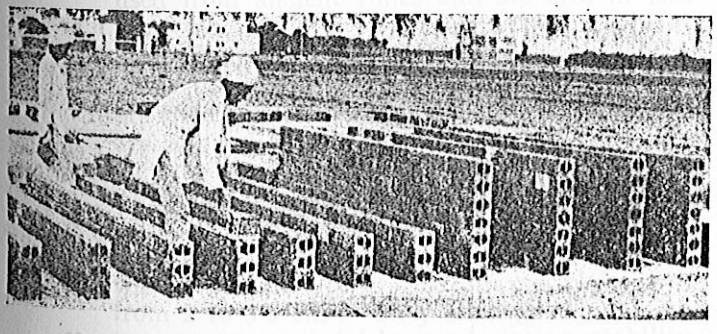
(i) Battery Casting of Wall Panels (Fig 4)

The system consists of precasting full size wall reinforced concrete wall panels, using battery casting technique. Two parent panels are initially cast horizontally and their contact surface is terrazo finished. After curing these parent panels are erected vertically in the framework where they serve as form work for the subsequent casting of panels. Demoulding of the panel is done after 48 hours of casting and the panels are properly positioned, their surface is coated with separating media, reinforcement cage is placed and concrete for two more panels is poured. Necessary provision for doors and windows openings can be made at the predetermined positions, with built in lintels over the openings. The cast panels are lifted with the help of a crane and transferred to the stacking yard for being taken to the site of erection when required. The system involves use of a mobile crane of 5 tonne capacity and telescopic props for erection of panels at the site. The joints between the panels is filled with cast-in-situ concrete.

(ii) Thin R.C.C. Lintel

Thin Lintel is designed as a composite member consisting of 7.5 cm thick precast R.C.C. element and the brick masonry above it, assuming the end conditions to be those of simple supports. The brickwork above the lintel shall be with bricks of 70 kg/cm² strength laid in a mortar not weaker than 1:6 cement sand mortar. Minimum bearing of the lintel is kept 11.5 cm. Maximum span shall be 1.83 metres. For 23 cm thick wall, 23 cm wide lintel with 3 bars 10 mm dia and 6 mm dia binders @ 30 cm centre to centre is found adequate for 1.83 metres span. Minimum height of brickwork above the lintel shall be 46 cm for openings upto 1.83 metres. The reinforcement in lintels wider than 23 cm shall be provided @ 1.03 square cm per 10 cm width, the thickness remaining constant. A central temporary prop is to be provided during construction till the masonry attains adequate strength.

The above description gives a brief information on each of the processes. However the detailed information on all the above processes is available and can be had from the Director, Central Building Research Institute, Roorkee (U.P.).



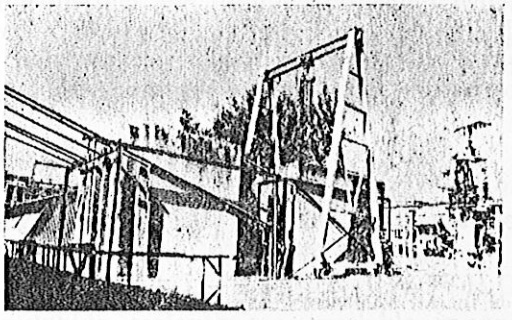


Fig 3 (left) shows panel type floor/roof units in structural clay, while Fig 4 (right) is a view of the Battery Panel casting set-up.

Concrete = 3.39 x 0.13 x 0.1 = 0.044 cu. m.

Cost

Material:

Cement = 0.21 x 0.044 = 0.00924 cu, m x 30 = 0.276 bags @ 15.000/bag = Rs. 4.14

Sand = 0.42 x 0.044 = 0.018 cu. m @ 20.00/cu. m = Rs. 0.36

Stond aggr = 0.84 x 0.044 = 0.037 cu. m. @ 70.00/cu. m. = Rs. 2.59

Mild steel = 11.3 kg @ 2.30/kg = Rs. 25.99

33.08

Labour:

Mason	1/16	@ 10.00	=	0.62
Labour	1/8	@ 5.00	=	0.62
Bhisti	1/100	@ 7.00	=	0.07
Mould		Lump sum	=	0.35
				1.66

1.66

Contractor's profit 10% 34.74

3.47

38.21

Say 38.20

Rate = Rs. 38.20 each

(C) Analysis of Cost for Walling Panel

(Size: 1.05 x 0.515)

Volume = (1.05 + .08) x 0.515 x 0.075 = 0.04365 cp.m

18 bricks = 18 x 0.225 x 0.115 x 0.075 = 0.03493 cu.m

Mortar = Balance 0.00872 cu.m

Add 25% for dry mix 0.00218

0.01090 cu.m

1:4 mix to be used

Cement = 0.0022 cu.m x 30 = 0.066 bags

Sand = 0.0088 cu.m

Cost

Material

Cement	0.066 bags	@ 15.00/bag	=	Rs. 0.99
Sand	0.0088 cu,m	@ 20.00/cu.m	=	Rs. 0.17
Bricks	18 nos	@ 120.00/1000	=	2.16
				3.32

Labour

Mason	1/20	@ 10.00	=	0.50
Labour	1/10	@ 5.00	=	0.50
Bhisti	1/100	@ 7.00	=	0.07
Mould		Lumpsum	=	0.01
				1.08

Total = Rs. 3.32 + 1.08 = 4.40

Contractor's profit 10% = 0.44

4.84

Add for M. Steel hooks

4 x 0.20 = .80 m @ .22 kg/m = 0.176 kgs @ 2.30/kg = 0.39

Total = 5.23

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