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Experimental Precast Concrete House at CBRI, Roorkee

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The article describes the construction of a small experimental precast concrete house at the Central Building Research Institute, Roorkee. The components used are light enough for manual handling and the technique compares favourably in cost with traditional construction.

A two-roomed single storey tenement, being characteristic of the modest residential requirement of a middle class Indian family, was chosen for this experiment. Verandahs were provided at the back and front of the house, and a kitchen and bathroom were also provided (*Fig* 1). A planning grid with a module of 60 cm was chosen, in accordance with which the dimensions of the rooms and other units were determined. This was necessary for the rationalisation of the component sizes and to keep the number of types of components to a minimum. The whole house was split into small components, a judicious combination of which, with a few additional ones, could produce different sets of rooms and verandahs, etc. For the variation of the component sizes a 10-cm module was adopted but certain violations had to be made.

For the walls a pillar and panel construction was selected. The pillar took the load so that the non-load bearing panels could be of large size. Two leaves of panels enclosing a cavity of 6·75 cm continuous through the pillars were provided so that thermal insulation could be improved and moisture penetration to the inner leaf prevented (*Fig* 2). For the roof, a T-beam and partly precast slab units offered the best solution as it avoided shuttering and retained the economy of the T-beam. The roof of the rooms was kept at a higher level than that of the verandahs, etc.

To have the full verandah length of 360 cm unobstructed by pillars both at the front and the back where the bearing conditions for the beam were in sharp contrast, and yet to have a light beam for manual handling, the beam was designed in two halves in the width, with grooves and holes at the ends. The detail is shown in *Fig* 3. Side beams for the front verandah were of the same section. Bolts embedded in the appropriate pillars could facilitate the fixing of angle iron cleats to support the lower roof beams.

Adequate clearances were provided for the joints. All the members were reinforced, except the wall panels which too can be reinforced against any anticipated

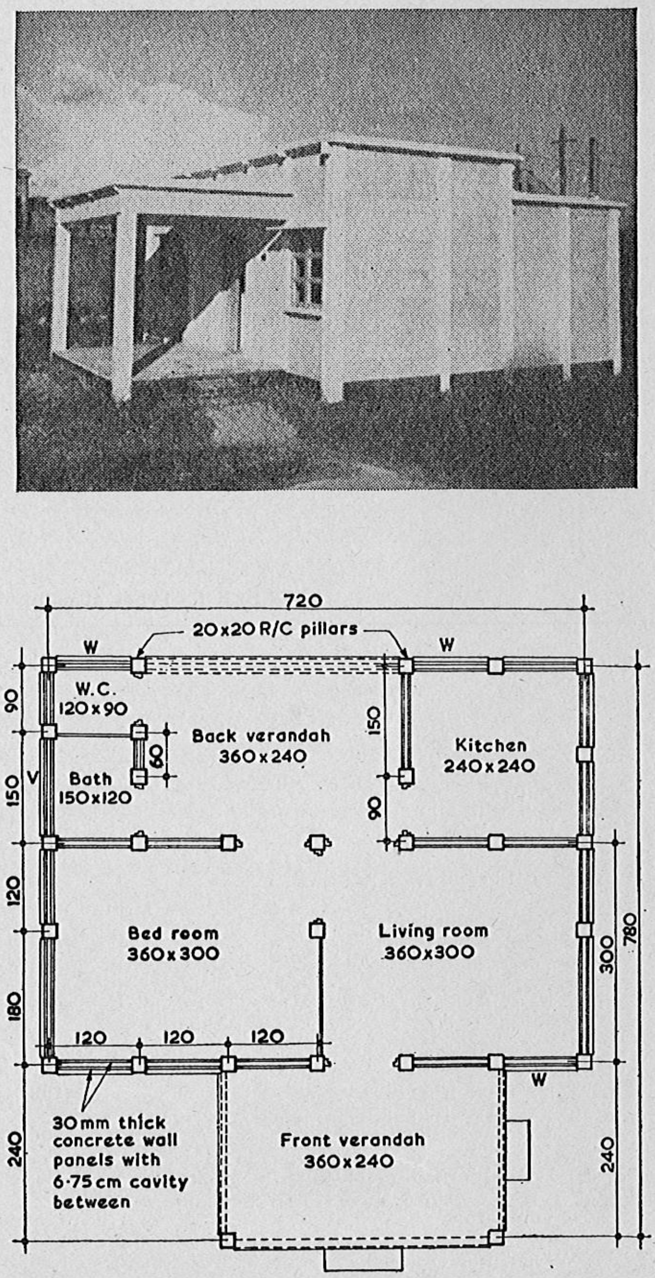

Fig 1 A view of the experimental precast concrete house described in this article together with its plan

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lateral thrust at a nominal increase in cost. The different types of components resulting from these deliberations are indicated in *Table* 1.

Moulds

The cost of moulds shares a sizeable part of the overall cost of the building and their repetitive use alone can reduce it. An attempt was, therefore, made to have a minimum number of moulds and to cast the various types of components by interchanging their parts. Also, in order to release the moulds quickly for further casting, it was decided to cast the components as far as possible directly on a level platform. All moulds were made of timber. However, at places where the ends of the timber grain were to come in contact with concrete, *e.g.* in the pillar mould, a galvanized iron sheet lining was provided. Some of the moulds used are illustrated in *Figs* 4 *and* 5. All the moulds except those for the pillars, the window sill, and the lintel-cum-sunshade were simple. Since in the pillar a central hollow core and cavities along various faces were to be left, its mould was more complicated.

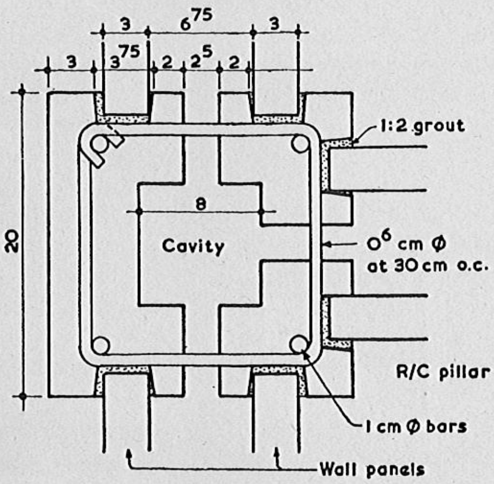

Fig 2 Showing details of the pillar and panel construction

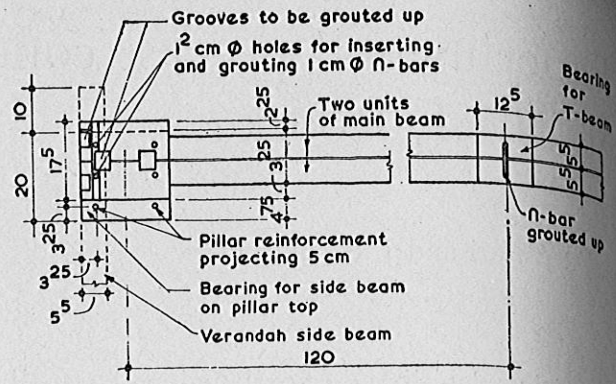

Fig 3 Detail of the "split" verandah beam

Casting

For casting components in the shortest period with a limited number of moulds a schedule was prepared. The total casting period was roughly 40 days. A pan type vibrator was used. The members were cured and each type was marked and stacked separately, near the site of erection, taking care that undue stresses would not be set up in any unit, specially the split beam.

TABLE 1 Types of components used in building the house

Serial no.	*Component*	*Types**	*Size*		*Average weight, kg.*	*Total number*
			Maximum, cm	*Minimum, cm*		
1.	Pillars	11	380 × 20 × 20	290 × 20 × 20	268	29
2.	Wall panels	14	160 × 40 × 3	40 × 25 × 3	45–7	374
3.	Roof beams	4	340 × 12 × 5	250 × 12 × 5	35	12
4.	Rectangular beams	2	340 × 12 × 15	250 × 12 × 15	126	4
5.	Verandah main beams	1	380 × 35 × 5·5	—	179	4
6.	Verandah side beams	1	250 × 35 × 5·5	—	104	2
7.	Roof panels	7	137·5 × 40 × 5	115 × 20 × 5	45–19	117
8.	Door and window frame posts	5	199 × 9 × 6	91 × 9 × 6	18	29
9.	Window sills and tops	2	100 × 25 × 8	100 × 50 × 8	46	8
10.	Door and window shutters	4	195 × 46·5 × 4	90 × 46·5 × 3	32	11
11.	Ventilators	2	130 × 37 × 13	40 × 25 × 13	5	2
12.	Angle iron cleats	3	20 × 8 × 5	—	1·3	11
	Total					603

* Details of individual types not included

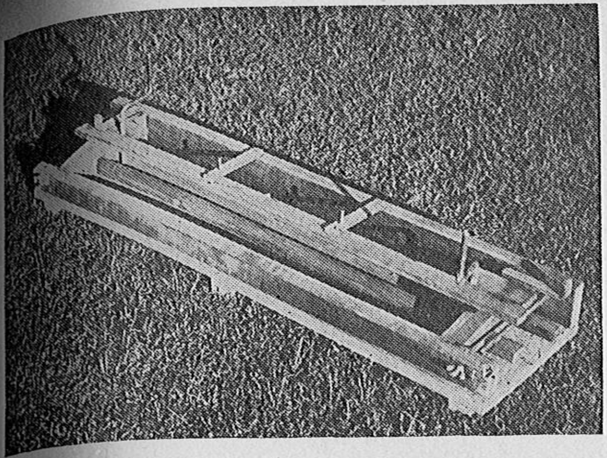

Fig 4 Mould for the window sill

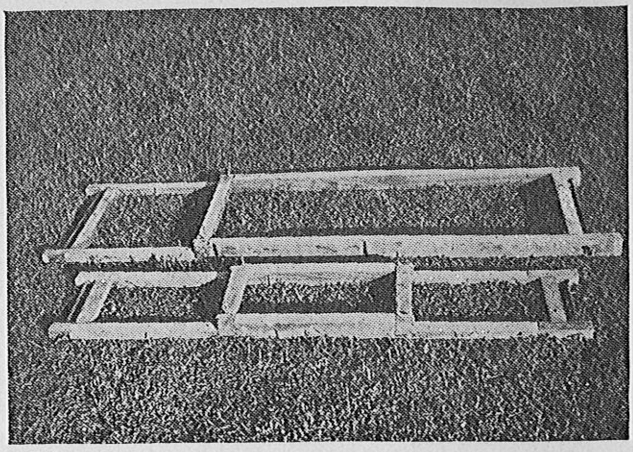

Fig 5 Moulds for roof panels

Erection

Foundation trenches for plinth walls under the wall panels and square pits for the pillar foundations were dug in continuation and to two different depths as required by the drawings. The concrete blocks for the pillar foundations had a tapering hole to receive the end of the pillar, its bottom being finished precisely to the required level. Concrete was also laid in the strips of the trenches.

After the concrete in the pillar foundation had attained sufficient strength, erection of the pillars was started from a corner. The lower end of the pillar was brought close to the foundation hole and then gradually inserted into it, while the other end was lifted up to the vertical. The little allowance in the dimension of the hole facilitated rotational and sideways movement for accurate alignment and plumbing of the pillar. The space around the pillar in the foundation hole was grouted up with concrete while it was kept propped. Next the plinth walls between the pillars were raised and their tops finished with an outward slope to drain out any water entering the wall cavity.

When some pillars had been erected and the plinth masonry raised, sliding of the wall panels between successive pillars, staggering the horizontal joints in the two leaves, was simultaneously taken up according to a predetermined scheme. Each panel was lifted to the top of the pillars, its ends inserted in the grooves of the pillars on either side, and the panel slowly lowered into position (*Fig* 6). A small quantity of mortar was applied to the top of every panel to remove the unevenness of bearing. It was found that the actual height of the wall panels should be about 2 mm less than the nominal to ensure obtaining the correct height of all using mortar bearing. The grooves in the pillars encasing the ends of the panels were also filled up with mortar. Lifting up and sliding down every panel was somewhat cumbersome and an easier method was evolved and successfully tried in a few bays. The panel length was so modified that it was slightly less than $S + D$, where S is the clear space between the two pillars and D the groove depth. The panel was held at the desired level at a small angle with the wall, one end was pushed into the groove, then the panel was rotated to the line of the wall and pulled into the groove at the opposite end to distribute the clearance equally at both the ends. The space in the grooves was then filled with mortar.

The door frames were fixed by embedding in the plinth masonry a 2-cm length of the bottom of the vertical posts and placing the top member on them. For assembling the window, first the sill was slid into position like a wall panel, the vertical posts placed, and then the top-cum-sunshed slid on top. In the case of doors and windows, both the dowel bars were grouted and parts of the pillar grooves on both the sides of the vertical post were filled with concrete. The walls above them progressed as beneath.

When the ceiling level of the lower roofs — roughly 240 cm — was reached, the outer leaf of the walls common to both the roofs was interrupted and others continued, as shown in *Fig* 7. The split main beams of the two verandahs and the side beams of the front verandah were hoisted, placed in position, and secured to the pillar tops by inserting into the holes of the beams the projecting pillar reinforcement and grouting (*Fig* 3). The angle iron cleats were fastened to the pillar faces and the secondary beams of the lower roofs — in fact the partly precast T-beams — were positioned and propped in the centre. The roof panels of the lower roofs were laid as per a predetermined scheme, and the *in-situ* concrete was laid over the secondary beams, embedding the negative reinforcement. After the lime concrete terracing on the lower

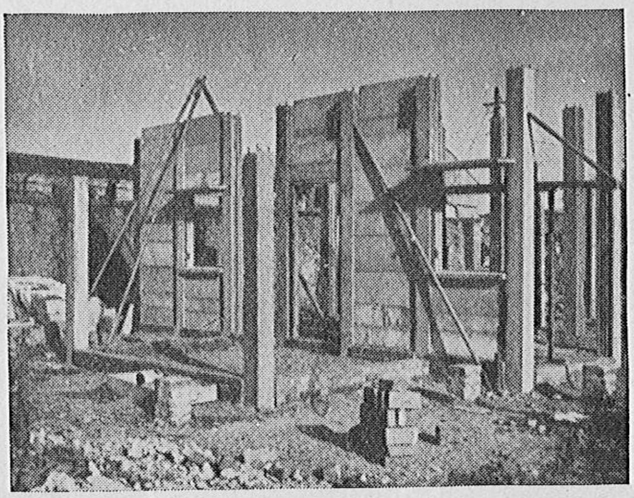

Fig 6 Insertion of wall panels between pillars in progress

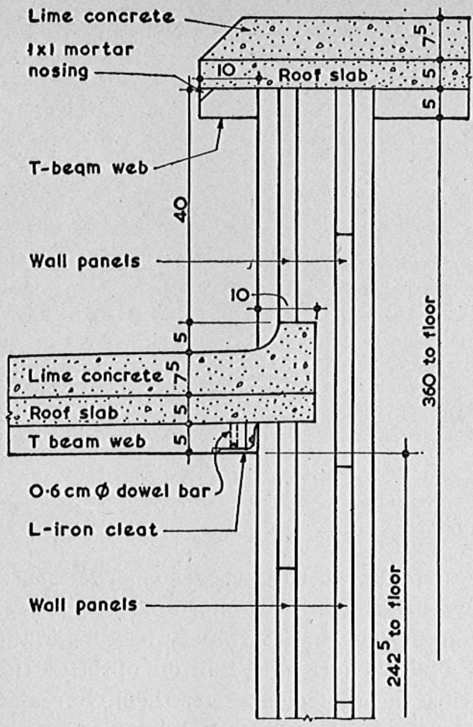

Fig 7 Completing the roof of the building

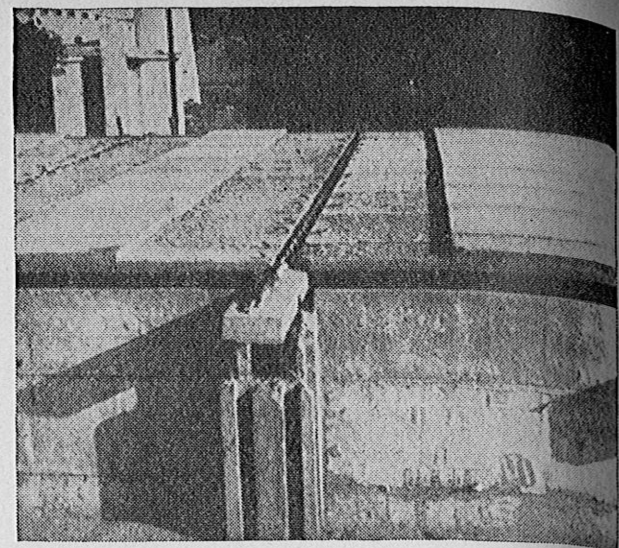

Fig 8 Showing interruption of the outer leaf of the wall at lower roof level

roofs had been laid, the outer leaf of the wall panels, interrupted by these roofs, was completed. Then the roof of the rooms was completed in a similar manner (*Fig* 8).

Sanitary fittings, *in-situ* concrete flooring, and fixing of the door shutters and finishings were started simultaneously and were soon completed. Electrification of the house had not been contemplated at first but was decided upon later. Using masonry drill bits, holes could be drilled in the concrete components and wiring was done. The total erection time was about three months and all the erection was done manually.

Economics of cost

The total plinth area of the house is 50·5 m². The total cost including services was Rs 7,026, which works out to Rs 138·90 m². The actual cost of materials was Rs 2,503·45, labour Rs 2,993·26, services Rs 1,360·58, and moulds assuming 10 uses Rs 168·71. The quantity of cement used was 112 bags or 113 kg/m² of plinth area. The quantity of steel used was 658 kg or 13 kg/m² of plinth area. While the cement used is less than in a similar traditionally built house, the steel quantity is nearly the same.

Conclusions

The design is simple and can be adapted for mass production. The erection presents no difficulty and all the operations can be accomplished manually through semi-skilled workers. Erection is further simplified by adopting the alternate method suggested for assembling the wall panels as there is a considerable saving of labour and time in this. This house compares favourably in cost with traditional construction and there is a saving of nearly 25 per cent in cement consumption.

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