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A Precast Reinforced Concrete Scheme for Floors and Roofs

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SYNOPSIS

The paper describes the various criteria considered in the choice of a precast scheme for floors and roofs and discusses in detail the scheme developed comprising precast reinforced hollow box type units called cored units. These are structurally complete in themselves and provide a flush ceiling.

A scheme for special situations arising in service areas consisting of W.C. and bath and in cantilever portions such as balconies and chajjas is also described.

1. INTRODUCTION

1.1 Roofs/floors constitute about 25 percent of the building costs and any saving in this item will have substantial influence on the total cost of the building. The very nature of construction of R.C.C. roof/floor slabs requires the erection of formwork before laying the concrete and dismantling it later. There is a delay in the construction at each floor level due to the need of different trades coming in for providing shuttering, centering, laying reinforcement etc. The cost of the shuttering works out to about one-third the cost of the slab. In prefabrication as the shuttering is replaced by moulds which can be used more number of times than the shuttering, there will be saving in this item. Due to the repetitive nature of the work, the productivity will be more. In prefabricated construction, it is also possible to introduce cores in the precast units to reduce the material consumption and selfweight. If the floor/roof units are precast and kept ready, then as soon as the walls reach the floor level, the units can be laid and the construction above can proceed without delay.

1.2 The various criteria to be considered for the selection of a precast scheme for roofs and floors is discussed in the paper. Based on these considerations a reinforced concrete scheme comprising hollow box type units called 'Cored Units' has been developed at the Institute. These units have high stiffness-weight ratio, are structurally complete in themselves, provide flush ceiling and reduce the construction time. The method of casting these units and their use in buildings is described. A scheme for special situations arising in service areas consisting of W.C. and baths and in cantilever portions such as balconies and chajjas is also discussed.

2. CRITERIA FOR SELECTION OF A SCHEME

2.1 Keeping in view the availability of materials, handling and transport facilities and skills of the labour and with a view to ensure that the selected scheme finds wide acceptability, the following criteria have been laid down.

2.2 One of the criteria for the selection of the roofs and floors is that the ceiling should be flat. From the point of view of appearance and cleanliness a flat ceiling was preferred over a ribbed ceiling. Thus the use of units with flush bottom was preferred over the use of channel shaped or T shaped units laid adjacent to each other or joist and filler block construction. The latter necessitates the use of two types of units and calls for plastering and unless light-weight concrete filler blocks are produced in this country, may not be economical. From these considerations, a roofing scheme with single type flat units laid adjacent to each other has been selected.

2.3 Another point to be decided was whether to have a composite construction or to have a fully precast construction. In the composite construction, the units are partially precast and insitu deck concrete is laid above them. This type of construction has the advantage that it imparts monolithicity to the structure. It is also possible to embed service pipes and other fittings in the insitu concrete. Also the partially precast elements are lighter than fully precast units. However, the speed of construction is slower in this case and the units are to be propped till the insitu concrete laid above attains strength. Considering all these points a scheme with fully precast elements have been arrived at for rooms in general, and a partially precast scheme for service areas where pipes and other fittings are to be embedded.

2.4 Production technology is the other point to be decided. Considering the conditions prevailing in India at present, a unit which can be produced at site is preferred over a unit which can be produced only in a factory equipped with costly and elaborate equipments. The casting techniques and the materials to be used have been selected so that the units can be produced anywhere in the country.

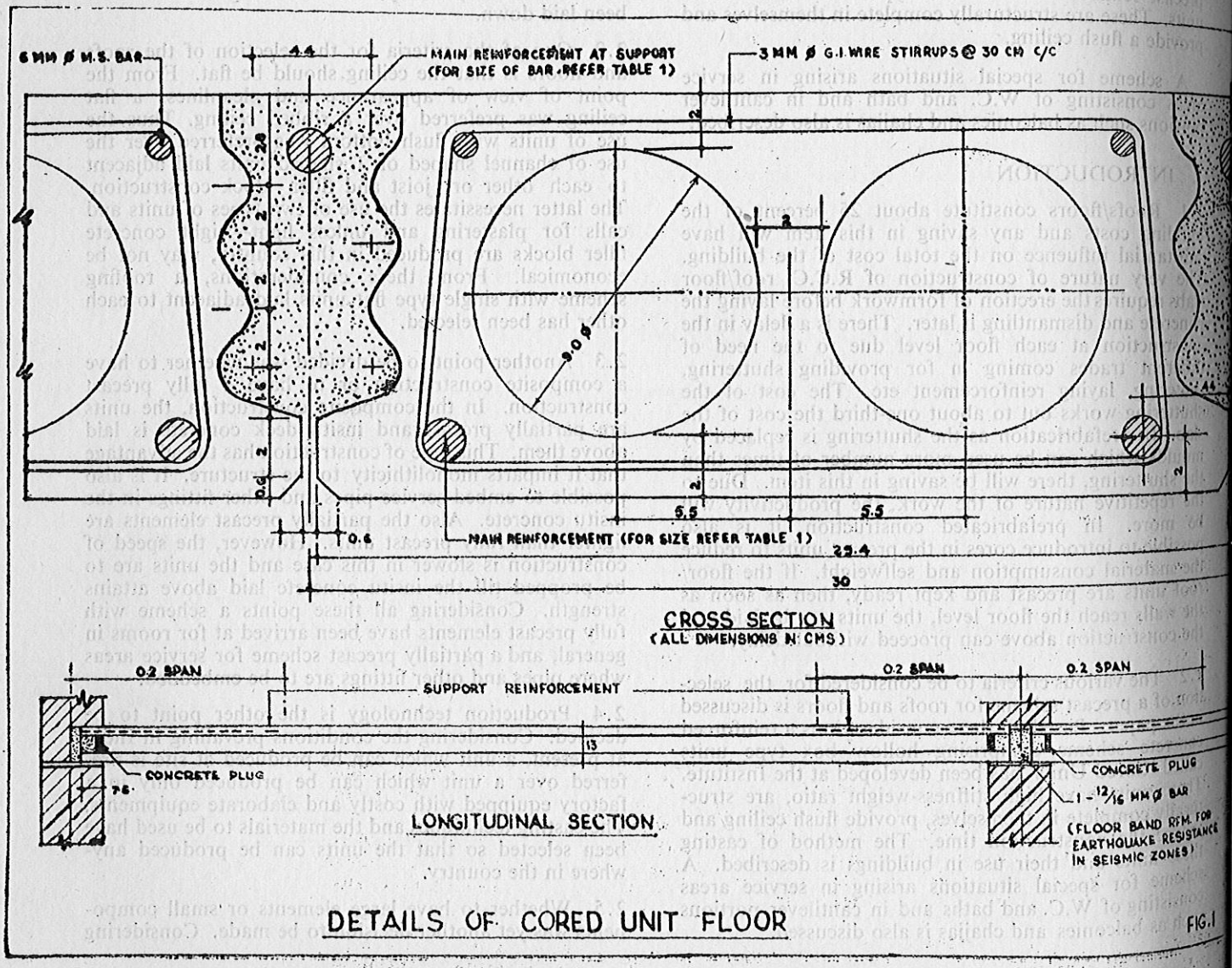
2.5 Whether to have large elements or small components was yet another decision to be made. Considering

the handling equipments and transport facilities available, it was decided to keep the size and weight of the elements small, so that they can be handled manually or by light equipments available. Hence hollow precast units (Fig. 1) having lengths equal to span of the room and having a width of 30 cm and a depth of 13 cm have been selected. These box type units are strong both in flexure and torsion. The shape of the units has been so worked out as to provide room for placing negative reinforcement and to pour concrete insitu for providing a shear key between the adjacent units. For a length of 3.5 m., these units weigh 150 kg. The loads and spans being moderate in residential buildings, an R.C. scheme has been selected in preference to a prestressed scheme.

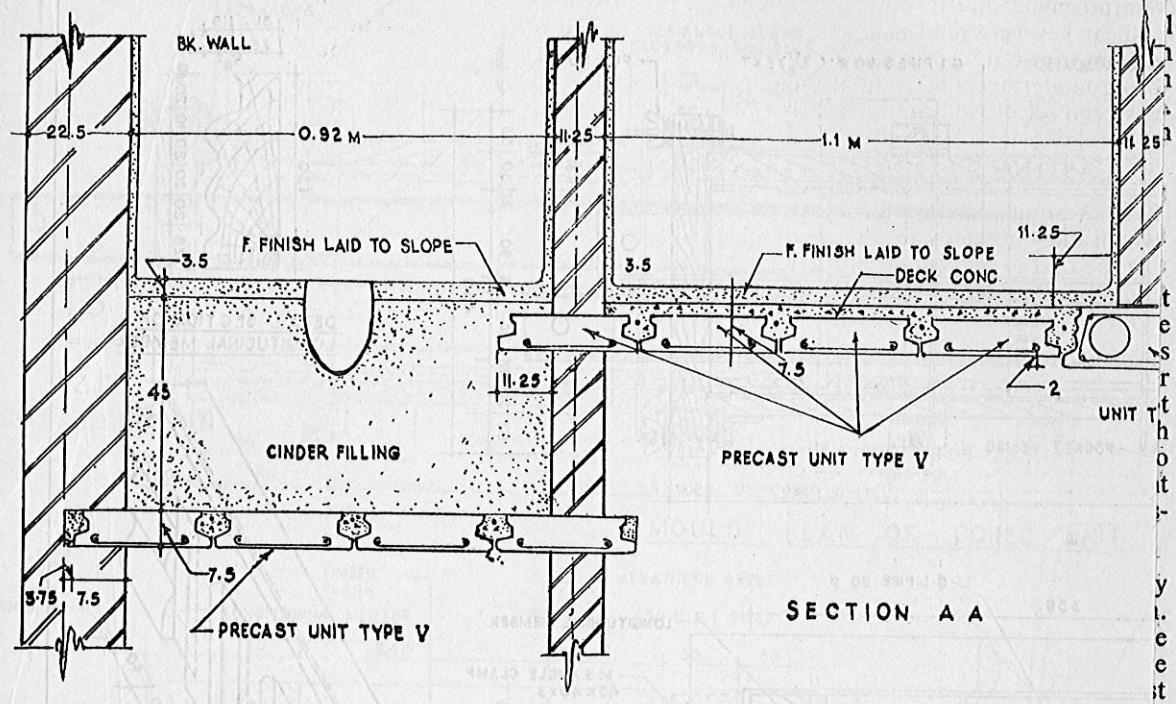
3. CASTING OF UNITS

3.1 A simple casting technique has been worked out, which does not require any mechanical aids. The units can be cast at the site of construction in timber or steel moulds. It is also possible to produce them on a mass scale in a factory. The details of the mould for casting units are given in Fig. 2. The mould has two side frames and two end pieces having cores of required shapes. The reinforcements are provided as per design requirements. The units are cast on a cement concrete platform which is finished level and smooth. Three coats of paraffin wax and kerosene oil mixture are applied over the casting platform for three consecutive days on a new casting platform and then painted with grease-kerosene oil mixture before the casting of units. The fresh coat of wax-kerosene oil has to be applied only after about ten castings while the grease and kerosene oil coat should be applied before every new casting.

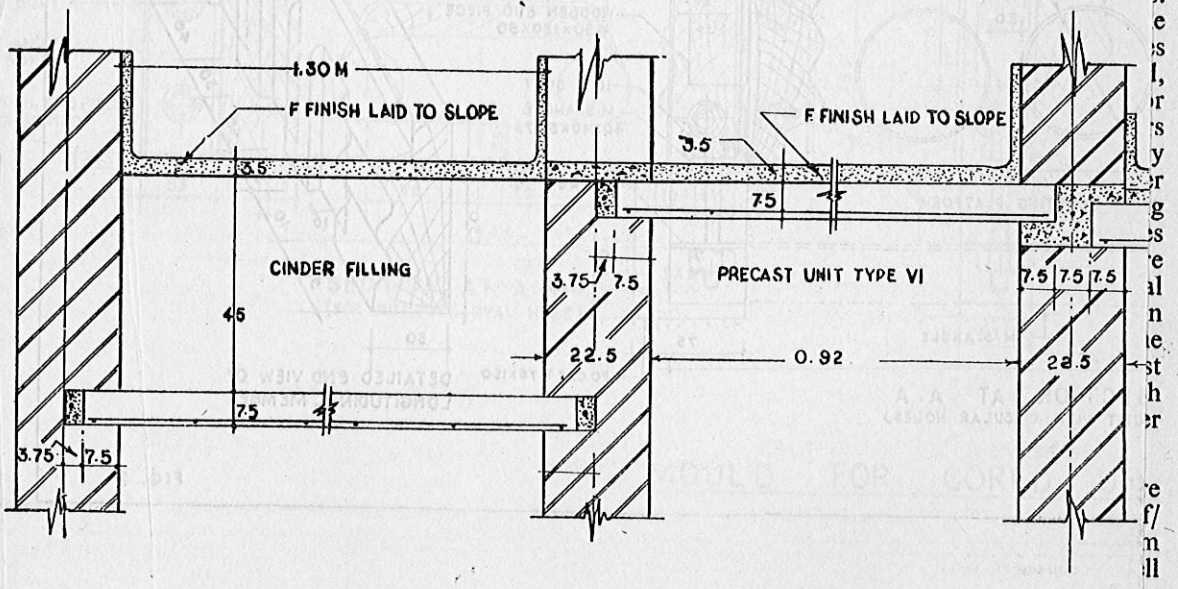
3.2 For casting units with circular cores, after keeping the reinforcement and assembling and fixing the mould, two G.I. pipes with 9 cm external diameter are introduced through the end pieces of the mould. Concrete is filled in from the top and compacted with the help of a plate vibrator. The top of the unit is finished rough. About an hour after casting, the pipes are removed by rotating them radially and pulling out axially. Precast concrete plugs 9 cm. dia. and 3.5 cm. thick are inserted

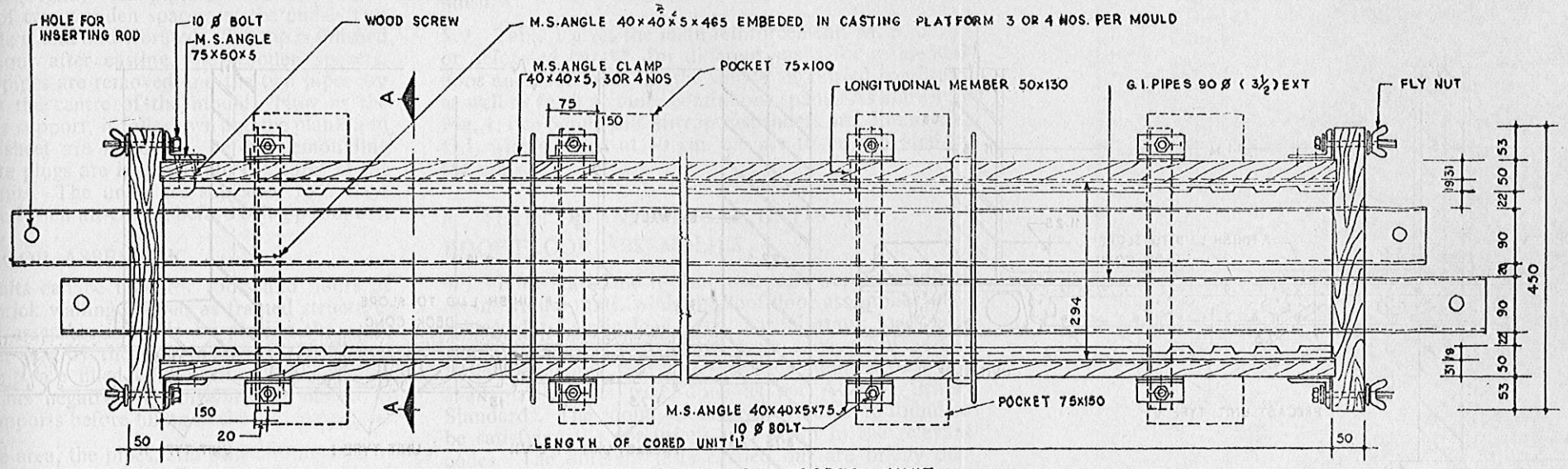


DETAILS OF CORED UNIT FLOOR FIG. 1


BK. WALL
22.5
0.92 M
11.25
1.1 M
11.25
F. FINISH LAID TO SLOPE
3.5
3.5
F. FINISH LAID TO SLOPE
DECK CONC
11.25
7.5
2
UNIT T
45
11.25
CINDER FILLING
PRECAST UNIT TYPE V
7.5
3.75
7.5
PRECAST UNIT TYPE V

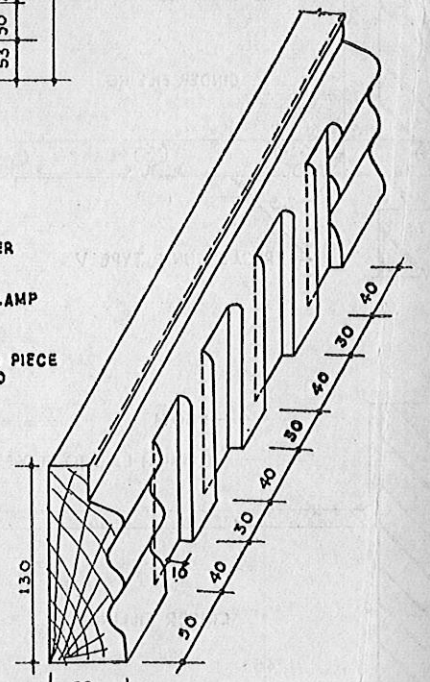
SECTION A A


1.30 M
F FINISH LAID TO SLOPE
F FINISH LAID TO SLOPE
3.5
3.5
7.5
CINDER FILLING
3.75
7.5
PRECAST UNIT TYPE VI
7.5
7.5
7.5
45
22.5
0.92
22.5
7.5
3.75
7.5



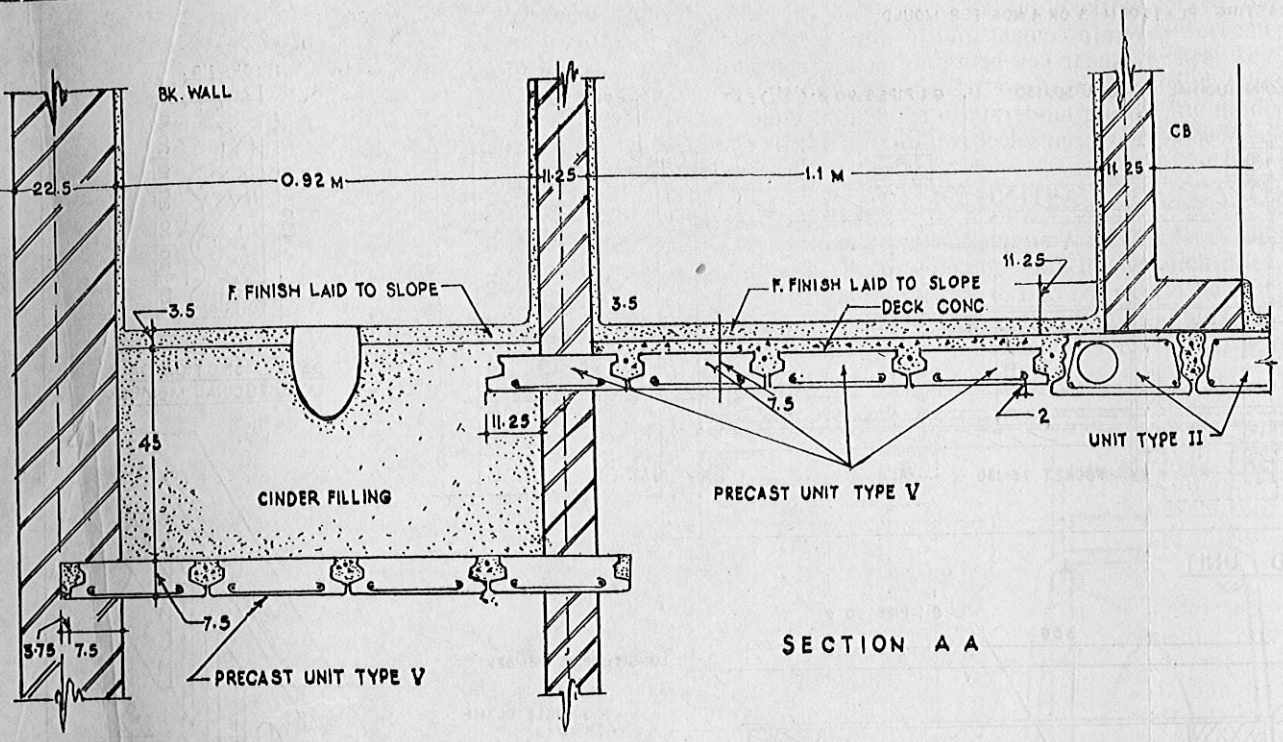
MOULD PLAN OF CORED UNIT

DETAIL SECTION OF LONGITUDINAL MEMBER

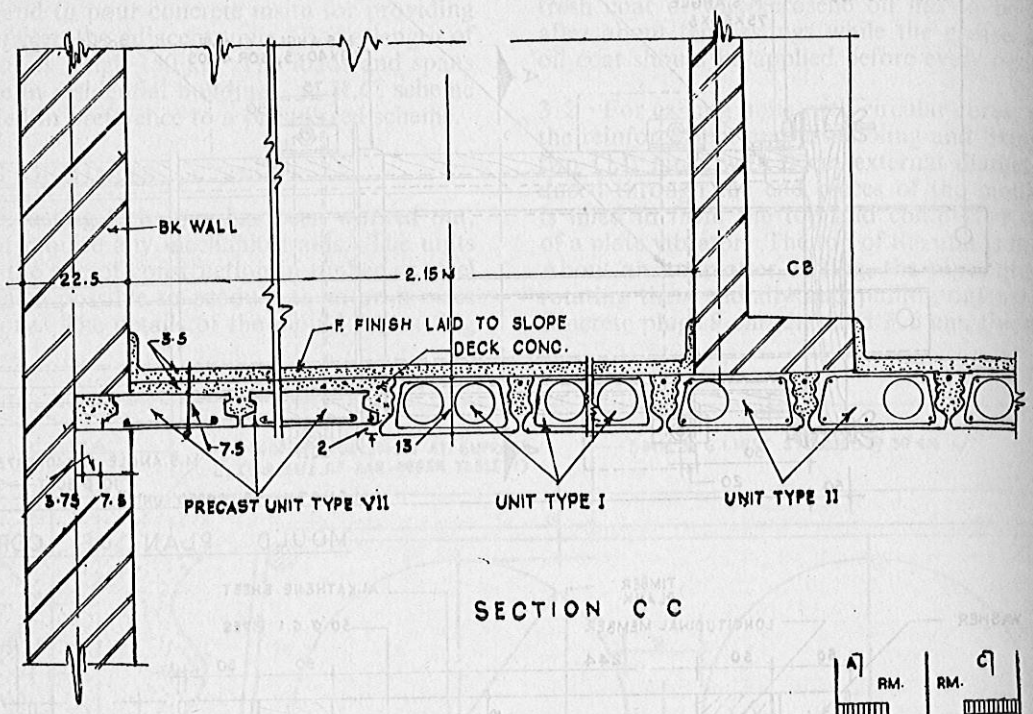


MOULD FOR CORED UNIT

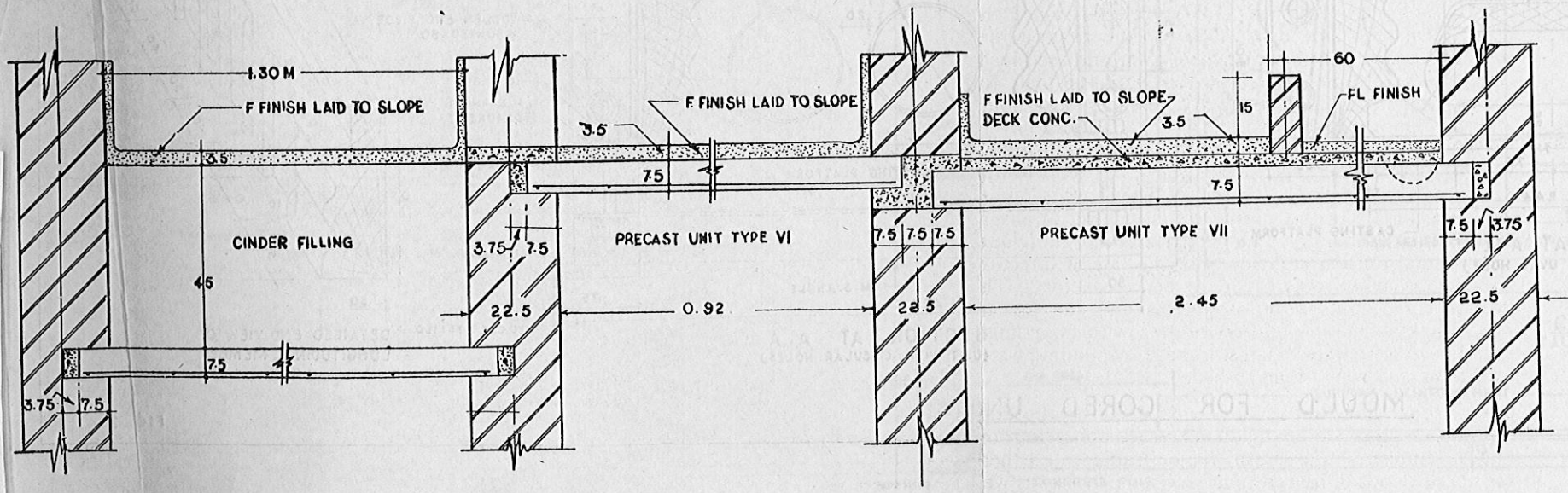
FIG. 2



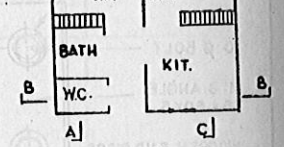
SECTION A A



SECTION C C



DETAILS OF SERVICE AREA



KEY PLAN
(SHOWING POSITION OF SECTIONS)

NOTE

FOR SECTION LINES REFER FIG. 13

ALL DIMENSIONS, UNLESS OTHERWISE STATED ARE IN CMS

FIG 3

into the cores and fixed at a distance of 7.5 cm. from the ends of the unit as shown in Fig. 1. The mould can be dismantled 3 hours after casting.

3.3 For casting units with oval core, the bottom layer of the concrete is laid first. Two G.I. pipes 5 cm. dia. are introduced and the plank and alkathene sheet are provided over it (Fig. 2). The pipes are held in position with the help of two wooden spacers at the ends. Top layer of concrete is laid and vibrated. The top is finished rough. One hour after casting, the wooden spacers, separating the pipes are removed and the two pipes are pulled towards the centre of the mould. Now as the plank looses its support, it falls down and the plank and the alkathene sheet are removed. Before demoulding precast concrete plugs are inserted into the cores at the ends of the units. The units are subjected to 7 days water curing and then air-curing before being put in use.

4. ROOF/FLOOR ASSEMBLY

4.1 Cored units can be used for roofs and floors of conventional brick walling as well as framed structure. The roof/floor assembly is made by placing the units along the span one by the side of other. The joints between the units are filled in by insitu concrete. For continuous spans negative reinforcement is placed in the joints at supports before filling in the insitu concrete.

4.2 In service area, the pipes, and other fittings are to be provided and in most cases W.C. pan is to be provided flush in level with the general floor level so that the supporting slab has to be sunk. Therefore, in these areas precast R.C. solid planks are to be used. The details for providing the floor trap etc., are given in Fig. 3. In water closets the space around the pan is filled with brick-bat coba/light-weight concrete/light aggregate and flooring is laid above. In kitchens and baths, the ceiling of the solid planks and the cored units is kept flush and the traps are provided over the planks. The general floor level is maintained by providing cinder in between the flooring concrete and insitu concrete. The flooring shall be laid in bays 1.2 m. square such that the bay line coincides with the joint between the units.

4.3 Cantilevers in roof/floor can be either in the direction of span of units or across it. The cantilevers along the span of units can be provided by projecting out reinforcement from units and casting the cantilever portion insitu. Alternatively, the units can be cast in lengths equal to length of unit plus cantilever length. The cantilever portion can be cast as a tapered solid one. The cantilever across the span of unit is provided by replacing the cored unit by precast solid planks for a distance sufficient to provide restoring moment required to overcome the overturning moment caused by loads over the cantilever portion. Reinforcement is provided over these planks and projected out for cantilever length and then, insitu concrete is laid. The cantilever across the span can also be provided by projecting the beams, supporting the units and the placing cored units over the projected beam in the usual way.

5. DESIGN

5.1 In the design of precast flooring/roofing schemes the various stages of loading and support conditions available are to be considered. In stage I, the units are to be designed as simply supported for self weight and weight of the concrete in the joint between the units, insitu deck concrete, if any, and part of live load *i.e.*, construction load, coming over it. In stage II, the units can be designed as continuous for the loads which will be coming after the concrete in the joints have attained strengths, *i.e.*, the live load and floor or roof finish.

5.2 Table 1 gives the main reinforcement, M. S. bars* or deformed bars**, for different spans for residential floor and roof loads for the simply supported condition as well as for 3 or more continuous spans. As shown in Fig. 1, two 6 mm. dia. stirrup suspenders and 3 mm. dia. G.I. wire stirrups at 30 cm. c/c are to be provided in the units.

6. TESTS ON INDIVIDUAL UNITS AND ROOF/FLOOR ASSEMBLIES

6.1 Both static and impact load tests were carried out on individual units, while the roof/floor assemblies were subjected to static load tests, partial static load tests and impact load tests. Tests were carried out as per Indian Standards, and wherever such standards are not available the tests were done as per ACI or British Standards. The roofing/flooring schemes were found to be satisfying the conditions laid down in the relevant codes. The different tests carried out are briefly described below.

6.2 Static load tests were carried out on simply supported precast units with full dead load above them. The maximum deflection at midspan after 24 hours due to a test load of twice the design live load and the residual deflection, immediately on removal of the test load were found to be within the permissible limits. The failure occurred at a load more than twice the design dead and live loads. The roof/floor assemblies were also tested by subjecting them to an imposed load, equal to 1.25 times, the specified imposed load for design which was maintained for one day. 24 hours after the removal of the load, the floor showed a recovery of more than 75 percent of the maximum deflection under load, thus satisfying the relevant clauses of load testing of structures as per the Indian Code. The roof assemblies were also tested against partial static loading to ensure sufficient cross rigidity and cooperation of individual units under concentrated loads in the lateral direction and the behaviour was found to be satisfactory. The precast cored units floor assemblies and the precast solid plank assemblies for service area with floor finish above them were tested against leakage by ponding water over them and were found to be leakproof.

6.3 Though none of the codes prescribe any procedure for impact testing of individual precast units or roof/floor assemblies, it was considered desirable to test them for impact loads during the construction process, as well as in actual use. Hence the individual units, as well as roof/floor assemblies were subjected to impact loads by

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* Mild steel conforming to IS: 432-1966.

** Cold twisted plain or deformed bars conforming to IS: 1786-1961.

dropping a head load of bricks from a height of 1.7 m. The units with circular cores remained undamaged while the units with oval cores developed hairline cracks. In the later case also when the top skin thickness was increased to 4 cm. the unit was undamaged. In both the cases the performance of the floor assembly with finish was all right. Thus the precast units with floor finish above them, can withstand the impact load, to which it is normally subjected.

7. COST ECONOMICS

The savings in adopting the cored unit roofs as compared to an R.C.C. slab for a span of 3.5 m. are given in Table 2.

8. CONCLUSIONS

8.1 The tests carried out on precast units and floor assemblies have proved the structural adequacy, and the field trials carried out have proved their adaptability, and practicability. It is a simple scheme using precast units which besides saving in materials and cost, results in speedier construction. The precast cored units are economical for residential spans ranging from 2.5 m. to 4.5 m. For longer spans and heavier loads, prestressed units will be economical.

8.2 The expenditure for housing in India at present is estimated to be Rs. 33,000 crores. The roof/floors cost about 25 percent of the total cost of construction and compared to the traditional insitu R.C. construction an economy of 15 percent can be achieved by the use of the precast scheme described here. The adoption of this scheme will result in considerable savings in material and cost for the nation besides providing speed of construction.

9. ACKNOWLEDGEMENT

This paper forms part of the research work carried out at the Institute and is published with the approval of the Director.

TABLE 1 — MAIN REINFORCEMENTS IN UNITS AND IN THE JOINT BETWEEN UNITS AT SUPPORT FOR RESIDENTIAL FLOOR/ROOF LOADS

Effective span in metres	Main reinforcements in units								Main reinforcement at support			
	Simply supported span				3 or more continuous spans				3 or more continuous spans			
	M.S. bars or Deformed bars				M.S. bars or Deformed bars				M.S. bars or Deformed bars			
	No.	Dia. mm.	No.	Dia. mm.	No.	Dia. mm.	No.	Dia. mm.	No.	Dia. mm.	No.	Dia. mm.
4.5	2	14	2	12	2	12	2	10	1	14	1	12
4.0	2	12	2	10	2	10	2	8	1	12	1	10
3.5	2	12	2	8	2	10	2	8	1	12	1	8
3.0	2	10	2	8	2	8	2	6	1	10	1	8
2.5	2	8	2	6	2	8	2	6	1	8	1	6

NOTES:— (1) For all other details refer Fig. 1.
(2) A superimposed load of 350 kg/m² has been considered in the design.

TABLE 2 — SAVINGS IN COST AND MATERIALS COMPARED TO TRADITIONAL R.C. FLOOR

		R.C. floor	Cored unit floor	
		Quantity	Quantity	Saving
Cement	Kg/m²	40.1	28.8	28
Steel	Kg/m²	7.1	6.9	2
Cost	Rs/m²	33.6	27.6	17