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UDC 624:91.002.22

BUILDING RESEARCH NOTE

64

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

PREFABRICATED FLOOR/ROOF USING STRUCTURAL CLAY UNITS (Joist and Infill Scheme)

The floor/roof scheme described in this Research Note comprises of structural clay units which are used both as an element of joist and filler. Clay unit designated as filler also takes part in the structural action.

Structural clay unit is extruded in a brick extrusion machine from a plastic clay whose composition is : clay 25 to 30%. silt 30 to 40% and sand 35 to 40%. The extruded product is fired in a down draught kiln at a temperature of about 1020°C.

Overall size of the clay unit is 165×150×190 mm with three rectangular hollows (Fig. 1). It has got small rectangular serrations on its outer faces to provide better joint with mortar and concrete. The volume of hollows is about 37 per cent of the total volume. Dimensions of the unit have been so chosen that one joist and filler combined correspond to a width of 30 cm or one planning module.

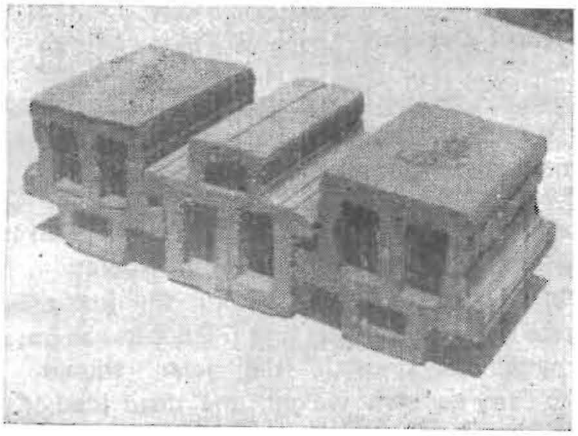

Fig. 1. The Clay Unit
1426 P.P.

Construction Method

The joist member is prefabricated first. The stages of prefabrication are shown in figure 2. Clay units are placed on a precasting platform end to end and

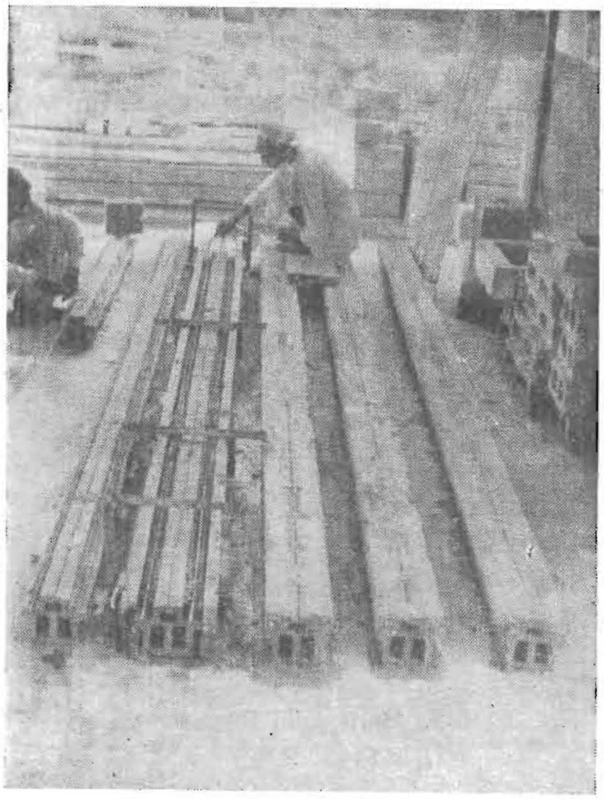

Fig. 2. Different Stages of Prefabrication of Joists
1482,83 P.P.

jointed with 1:3 (cement:sand) mortar. The units are placed with wider base on the platform and a row of these is built up to the desired length of the joist Two wooden planks, cleaned and oiled, are then placed on the two sides of the joist and are held tight with the help of m.s. clamps. Designed reinforcement is then placed within the two hollow spaces between the plank and the tile ensuring proper cover at the top. The hollow spaces are filled to the top level of the clay unit with concrete of M-15 grade. This makes the joist complete. Side planks are removed after 45 to 90 minutes depending on the weather. The joists are water cured for 7 days and air-cured for another 21 days. After about 4 days of casting, the joists may be inverted and shifted to stacking yard for making room in the casting yard. Joists weigh about 80 to 90 kg and can be handled easily by four men. For uniform support over bearings the bearings should be perfectly levelled. For this, a levelling pad of cement-sand mortar may be required. The joists are placed at 30 cm centre to centre distance and in the intervening space structural clay units of the same design are placed with 1:3 mortar in the joints (Fig. 3). While placing the filler units, the joints in joist member and filler units should be broken by use of half length units. Space between the joist and filler rows is then filled with M-15 grade concrete (Fig. 4), Temporary props for supporting the joist should be provided if needed from design consideration. If necessary, negative reinforcement as needed over support should be provided before filling the space with concrete. The completed slab should be cured for 14 days. The floor or roof treatment, as the case may be, may then be laid over it.

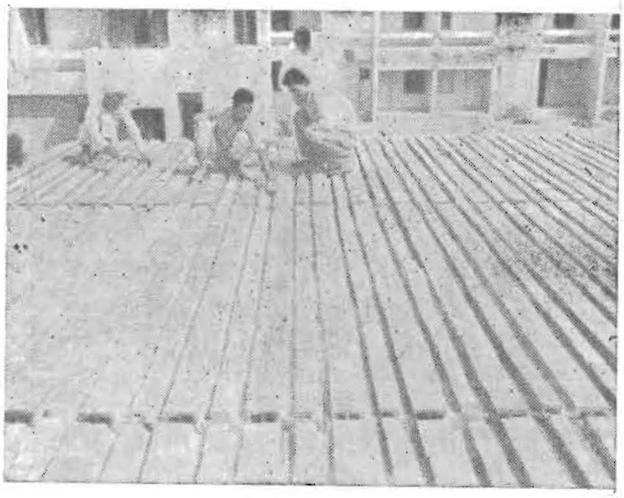

Fig. 3. Clay Units Laid Between Joists
1448. P.P,

Fig. 4. Placing Concrete in the Clay Unit Slab Assembly
1446 P.P.

Structural Design

This slab can be designed just like reinforced concrete slab both by the ultimate load and working load methods as given in IS 456-1964.

In the structural design of this type of slab two stages of loading are taken into consideration. In the first stage of loading when the insitu infill concrete between the joist and filler units has not set and attained strength, the joist should be able to carry its own weight, the dead load of the filler units and infill concrete and some incidental live load as a simply supported beam. In cases where the joists are not sufficiently strong to carry this load, intermediate propping under the joists must be provided. In stage II loading when full load is acting on the slab under appropriate end condition, the joist and filler assembly together should carry the load.

An illustrative design for a slab by ultimate load theory is given in Appendix I.

Construction Details

The details for provision of balcony, services etc., that are generally met with in buildings can be provided as described below :

(i) Cantilever projection in slab may be in the direction of the span of the slab or across it. For cantilevers along the span, necessary reinforcement should be provided in the space between the joist and filler before laying the infill concrete. For cantilever across the span R.C.C. beam support has to be provided (Fig. 5).

(ii) In bath and kitchen, 100 mm floor traps are to be fitted in the filler zone. One filler unit is omitted at the place where the trap is to be fitted. The trap is placed in position and concreting is done.

(iii) To accommodate W.C. pan so that the finished floor level of W.C. may be either flush with or, 30 to 40 mm below the general floor level, the joist and filler assembly as a whole is depressed by the desired depth. W.C. pan is placed over the floor assembly and surrounding space is filled with lean concrete and finally finished with I.P.S. or mosaic flooring as per requirement (Fig. 6).

(iv) Fan hook should be located in the filler zone and is fitted at the desired place by omitting a filler unit. Two arms of the fan hook are supported and fixed with concrete in the top hollow of adjacent filler units (Fig. 7).

(v) Wooden plugs and Junction box are placed in the filler zone by omitting one or more filler units and subsequently concreting the space (Fig. 8).

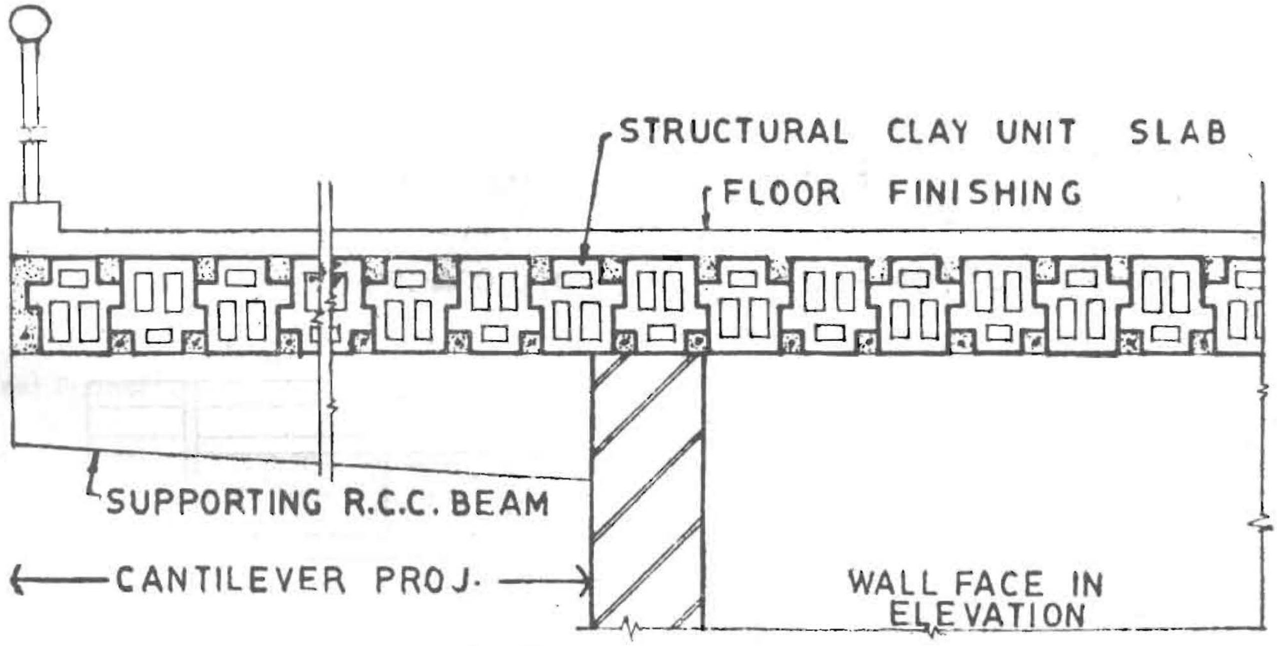

Fig. 5 Detail of Cantilever

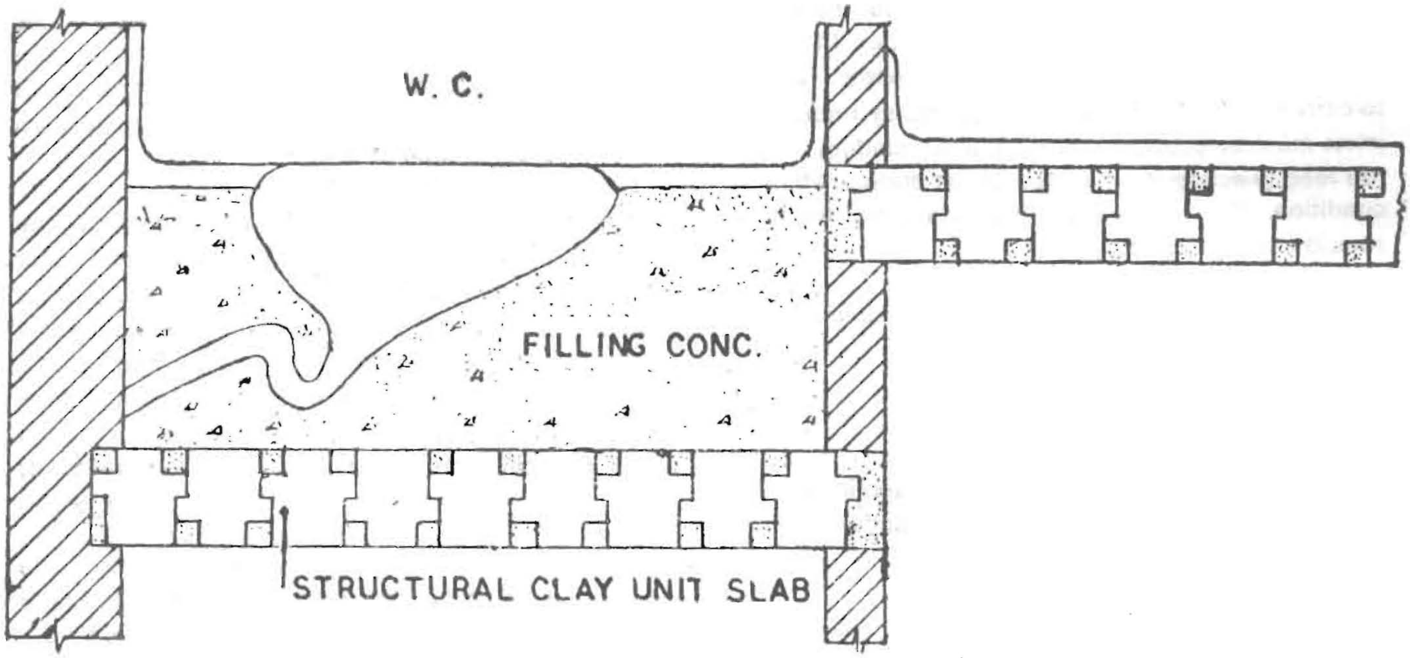

Fig. 6 Detail of Service

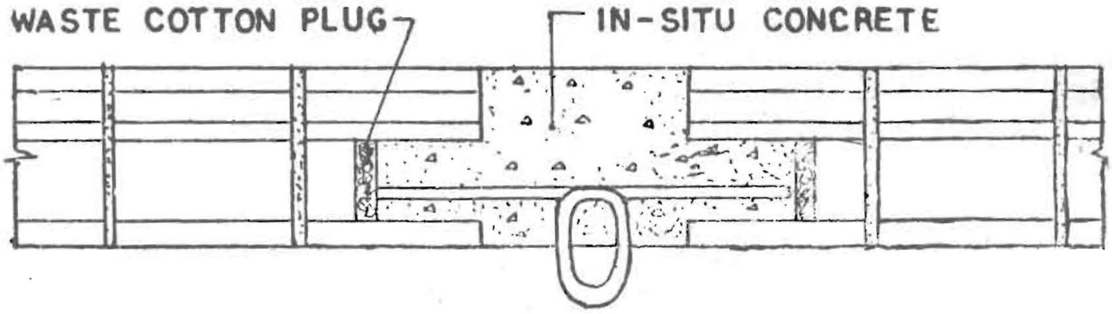

Fig. 7 Detail of Fanhook Fixing

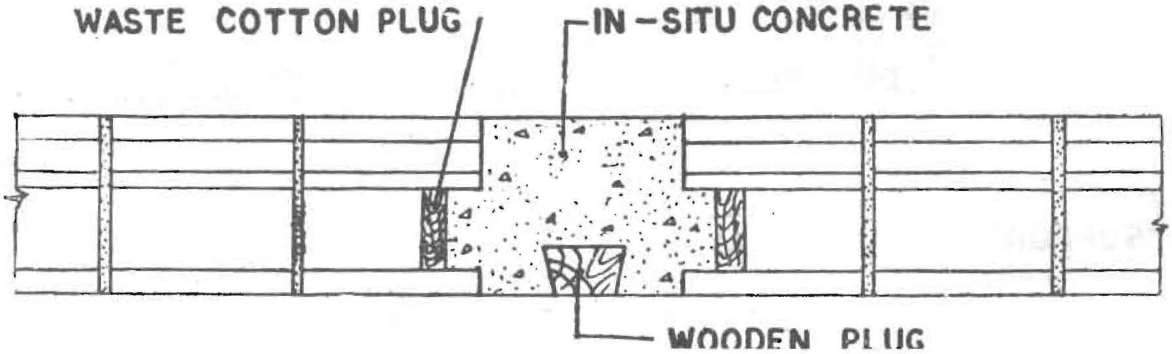

Fig. 8 Fiping Detail of Wooden Plug

(vi) Concealed electrical conduit is to be placed inside the bottom hollow of the filler unit. At the draw off point, in-situ concreting is to be done.

Precautions

(i) Clay units should be immersed in water for 20 to 30 minutes and, be skin-dry at the time of being used.

(ii) Thickness of mortar on the cross joint should be as small as possible not exceeding 12 mm.

(iii) While inverting precast joist or transporting the same, uniform force is to be applied.

Test Results

Average crushing strength of the clay units was about 20 N/mm² (on the net area). A number of test slabs were load tested to failure and the ultimate load behaviour was found satisfactory. Partial load test was also carried out and it was found that even though there was no distribution reinforcement, such a slab was able to transfer the shear in the direction transverse to the span. The slab was found quite strong from the consideration of impact load which may generally occur in a building.

Thermal Performance

The slab behaved much better than 100 mm thick reinforced concrete slab as far as thermal insulation is concerned. Comparative figures of thermal performance of this type of floor and R.C.C. floor with different finishing courses are given in table 1.

Cost Economics

The consumption of labour for prefabrication and assembly of a floor panel 3.6×3.3 metres is as follows :

(i) Labour required for laying 10 joists each 3.6 metres long.

(a) Mason ... 0.8 manday
(b) Mazdoor ... 1.6 mandays

(ii) Labour required for filling 10 joists with concrete after placing reinforcement in position and including curing and shifting to the stacking yard within 100 metres.

(a) Mason ... 0.7 manday
(b) Mazdoor ... 1.4 mandays

Table 1

Comparative Thermal Performance Data

S. No.	Type of slab	Index* (TPI)	Class
1.	(a) 100 mm thick R.C.C. slab.	226	E
	(b) 150 mm thick structural clay unit slab.	183	D
2.	(a) 100 uum R.C.C. slab plus 100 mm lime-concrete.	134	C
	(b) 150 mm structural clay unit slab plus 100 mm lime concrete.	125	B
3.	(a) 100 mm R.C.C. slab plus 75 mm mud phuska plus 50 mm brick tiles,	110	B
	(b) 150 mm structural clay unit slab plus 75 mm mud phuska plus 50 mm brick tiles.	105	B

*Thermal Performance Index
A—Good, B—Fair, C—Poor, D—Very poor
E—Extremely poor

(iii) Labour required for transporting within 100 metres and erection fo 10 joists in position.

(a) Mason ... 0.5 manday
(b) Mazdoor ... 2.0 mandays

(iv) Labour required for placing filler units including laying of concrete and filling the mortar joints from ceiling.

(a) Mason ... 2.0 mandays
(b) Mazdoor ... 4.0 mandays

Overall cost and consumption of materials in clay unit slab have been worked out for an interior span in a continuous slab of 3 bays each of 3.6 meters span and compared with a corresponding 100 mm thick R.C.C. slab spanning one-way and an interior panel of a two way R.C.C. slab of 3.6×3.3 metres. Comparative cost and consumption of cement and steel in clay unit slab and R.C.C. slab are given in table II.

Table II

Comparative Cost and Materials Statement for Clay Unit Slab and R.C.C. Slab

Flooring Schemes	Overall		Materials			
	Cost Rs./m²	Saving %	Cement bags	Saving %	Steel Kg	Saving %
1. 100 mm R.C.C. slab (one-way interior span)	35.00	26 (1 vs 2)	0.650	46 (1 vs 2)	7.79	54 (1 vs 2)
2. 150 mm structural clay unit slab*	25.80		0.348		3.56	
3. 100 mm R.C.C. slab (two-way interior panel).	30.24	14.5 (2 vs 3)	0.65	46 (2 vs 3)	4.91	27 (2 vs 3)

Appendix I

Illustruative Example for Design of Structural Clay Unit Slab

To illustrate design of clay unit slab by limit state method as per IS : 456-1978, let us consider a floor slab spanning over 3 or more continuous spans of 3.5 m each. The loads will be as follows :

Stage of loading	Item of Loading	Working Load (N/m²)	Limit State Load (N/m²)	Limit State Load per 300 mm width (N/m)
I	Self weight of clay unit slab	2000	2400	720
	Incidental live load	750	900	270
II	Self weight of clay unit slab	2000	3000	900
	Superimposed dead load	1000	1500	450
	Live load	2000	3000	900

*Selling price of clay units has been assumed as Rs. 230/- per thousand including delivery at construction site.

Stage I

The joist should be able to carry the load as a simply supported member

$$B.M. = (720+270)\ \frac{3.5^2}{8} = 1516\ N-m$$

$$S.F. = 720 + 270) \times \frac{3.5}{2} = 1732\ N$$

Stage II

B.M. at support next to end support

$$= \left(\frac{450}{10} + \frac{900}{9}\right) \times 3.5^2 = 1776\ N-m$$

B.M. at middle of end span

$$= \left(\frac{900}{8} + \frac{450}{12} + \frac{900}{10}\right) \times 3.5^2 = 2940\ N-m$$

$$S.F. = (0.5 \times 900 + 0.6 \times 450 + 0.5 \times 900)$$

$$\times 3.5 = 4095\ N$$

Let 10 mm dia bars be used in the joist.

Then

$$d = 140 - 15 - 5 = 130\ mm$$

$$\frac{x_u}{d} = \frac{0.87 \times 250 \times 2 \times 78.5}{0.36 \times 15 \times 300 \times 130} = 0.16 \text{ and } x_u = 21\ mm$$

Hence, the Section behaves as flanged section, since depth of flange is 20 mm only.

$\frac{D_f}{d} = \frac{20}{130} = 0.15 < 0.20$ (D_f is the overall depth of flange)

$$\frac{D_f}{x_u} = \frac{20}{21} = 0.95 > 0.43$$

Therefore $y_f = 0.15 \times 21 + 0.65 \times 20 = 16.15$ and

$$M_u = [0.36 \times 0.16\ (1 - 0.42 \times 0.16) \times 15 \times 255 \times 130^2 + 0.45 \times 15 \times 45 \times 16.15\ (130 - \frac{16.15}{2})] \times 10^{-3}$$

$$= 4071\ N-m > 2940\ N-m$$

Hence, the section is safe both at midspan and support.

$$\text{Limiting shear stress} = \frac{4095}{130 \times 130} = 0.24\ N/mm^2$$

The allowable value is 0.35 N/mm^2 and hence safe in shear

Stage-I

In stage I, only the joist member is active

$$\frac{x_u}{d} = \frac{0.87 \times 250 \times 2 \times 78.5}{0.36 \times 15 \times 125 \times 130} = 0.39,\ x_u = 51\ mm$$

$$\frac{D_f}{x_u} = \frac{20}{51} = 0.39 < 0.43$$

Therefore,

$$M_u = [0.36 \times 0.39\ (1 - 0.42 \times 0.39) \times 15 \times 45 \times 130^2 + 0.45 \times 15 \times 80 \times 20 \times 120] \times 10^{-3}$$

$$= 2635\ N-m > 1516\ N-m$$

$$\text{Limiting shear stress} = \frac{1732}{45 \times 130} = 0.23\ N/mm^2$$

Hence, the joist is safe for carrying stage I loading also and there is no need of intermediate propping.

Printed at :
Anubhav Printers, Anaj Mandi, Roorkee

Copies : 3000

Prepered by : S.C. Chakrabarti, N.C. Mazumdar
Published by :
Central Building Research Institute, Roorkee, India
First Published in Sept. 1973 as B.D. No. 105
Revised as B.R.N. 64, Feb. 1988