CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

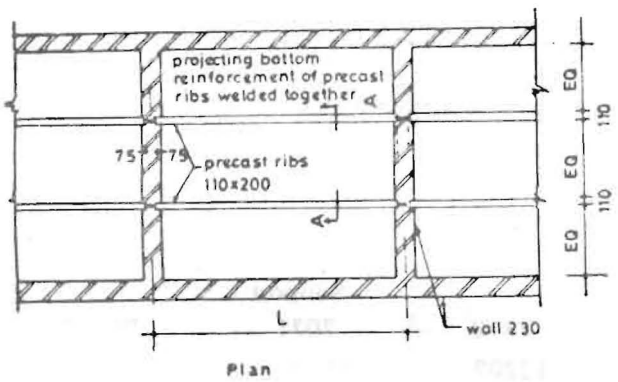
B. R. N. 5

THIN R.C. RIBBED SLAB FOR FLOORS AND ROOFS

Thin R.C. ribbed slab consists of precast R.C. ribs 110 × 200 mm spaced at 1200 mm c/c with 50 mm thick cast-in-situ R.C. flange above (Fig. 1). It can be used for floors and flat as well as sloping roofs in single and multi-storeyed residential and other types of lightly loaded buildings. In case of heavily loaded floors and roofs, the size and reinforcement of the ribs and flanges will have to be increased. Conventional floor/roof finish has to be used above the ribbed slab, as the case may be. Ceiling plaster can be omitted in low cost constructions. In situations, where very good finish is called for, ceiling should be plastered.

STRUCTURAL DESIGN

The structural design may be carried out as per limit state method given in IS:456-1978, 'Code of Practice for Plain and Reinforced Concrete'. The ribs are designed as rectangular beams to support the weight of concrete in the flange, the shuttering and the live load of workmen and equipments during construction. They act as Tee beams for full design loads, after the concrete in the flanges has attained strength. The flange is designed as a continuous slab spanning the ribs. To keep the deflections within permissible limits, the span/depth ratios



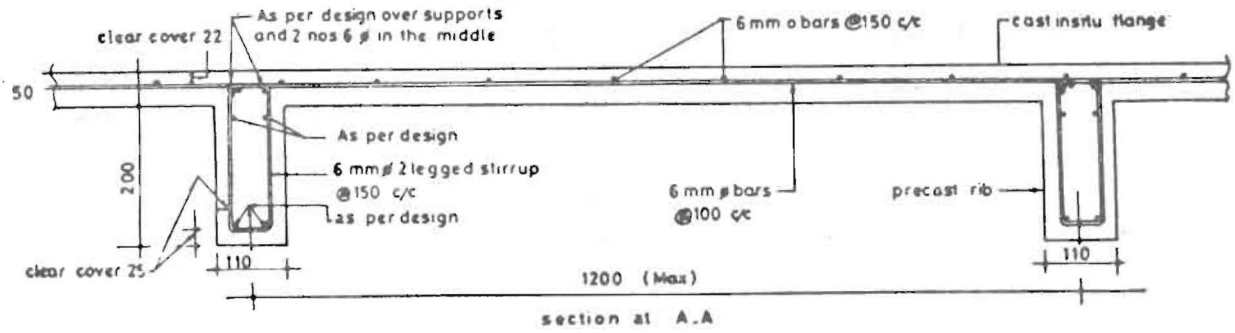


Fig. 1 Thin R.C. Ribbed Slab

for the flange and the rib have been kept as per relevant provisions of IS : 456-1978. To control flexural cracking, the spacing requirements for reinforcement as given in the code have been complied with. To ensure monolithic action of precast ribs with cast in-situ flange, stirrups in the ribs are projected into the cast-in-situ concrete of the flange. Relevant provisions of IS : 3935-1966, 'Code of Practice for Composite Construction, have been satisfied. A ready-made design table is given in Table 1.

CONSTRUCTION

Precasting and Erection of Ribs :

The ribs are precast, preferably in steel moulds (Fig. 2) over a casting platform. Alternatively, these can be cast in timber moulds. Mould oil is applied on the casting platform and inner sides of the mould and reinforcement cage is kept in position with the required cover. To provide holes in the ribs, 25mm square M.S. hollow box sections are inserted through square holes in the longitudinal members of the mould. Concrete used is grade M 15 with 20 mm and down, graded coarse aggregate. The concrete shall be thoroughly compacted by needle vibrator having 25mm dia pin and the top surface shall be finished rough. When ordinary portland cement is used, the ribs shall be demoulded by sliding the longitudinal pieces of the mould away from the precast rib, three to four hours after being cast. In case, portland pozzolana cement or any other slow setting cement is used the time of demoulding shall be increased. The ribs shall be kept covered with wet gunny bags for 72 hours Afterwards they shall be slid horizontally on the casting platform to break the bond with platform and transported to the curing yard or tank. After two weeks of water curing, the units shall be allowed to air dry for another two weeks, before being used in any construction. The precast ribs shall be placed in 115mm wide recesses left in the wall at specified spacings.

Assembly of Shuttering Panels :

Plane simple shuttering panels made of timber framing and plywood panelling covered with G.I. sheets (Fig. 3) are used for casting the flange portion. At least 20 reuses can be expected from G.I. sheet lined shuttering. Alternately, steel shuttering panels may be used in which case, the number of reuses shall be more. Width of the shuttering panel is kept as the clear distance between ribs with a clearance of 5 mm on both sides and the length is preferably kept in modules of 300 mm i. e., 1200, 1500, 1800 mm etc. A combination of these can be used to suit the span of the room. Even

Table 1 : Moment and Shear Resistance of Ribs with Different Reinforcements

No. and Dia. of Bar	Moment of Resistance (Nm)				Shear Resistance (N)
	With Mild Steel (f_y = 250 N/mm²)		With High Strength Deformed Bars (f_y = 415 N/mm²)		
	At Mid Span	At Support	At mid Span	At Support	
2— 8 mm	—	—	7812	7071	28155
2—10 mm	7281	6525	12207	10273	30158
2—12 mm	10297	8729	17198	10917	31899
2—14 mm	13883	11281	23000	—	33168
2—16 mm	17923	14889	29518	—	34377
2—18 mm	22362	18926	—	—	34409
2—20 mm	27464	—	—	—	34250

Note : The moment and shear resistance values given above are based on limit state method given in IS 456-1978.

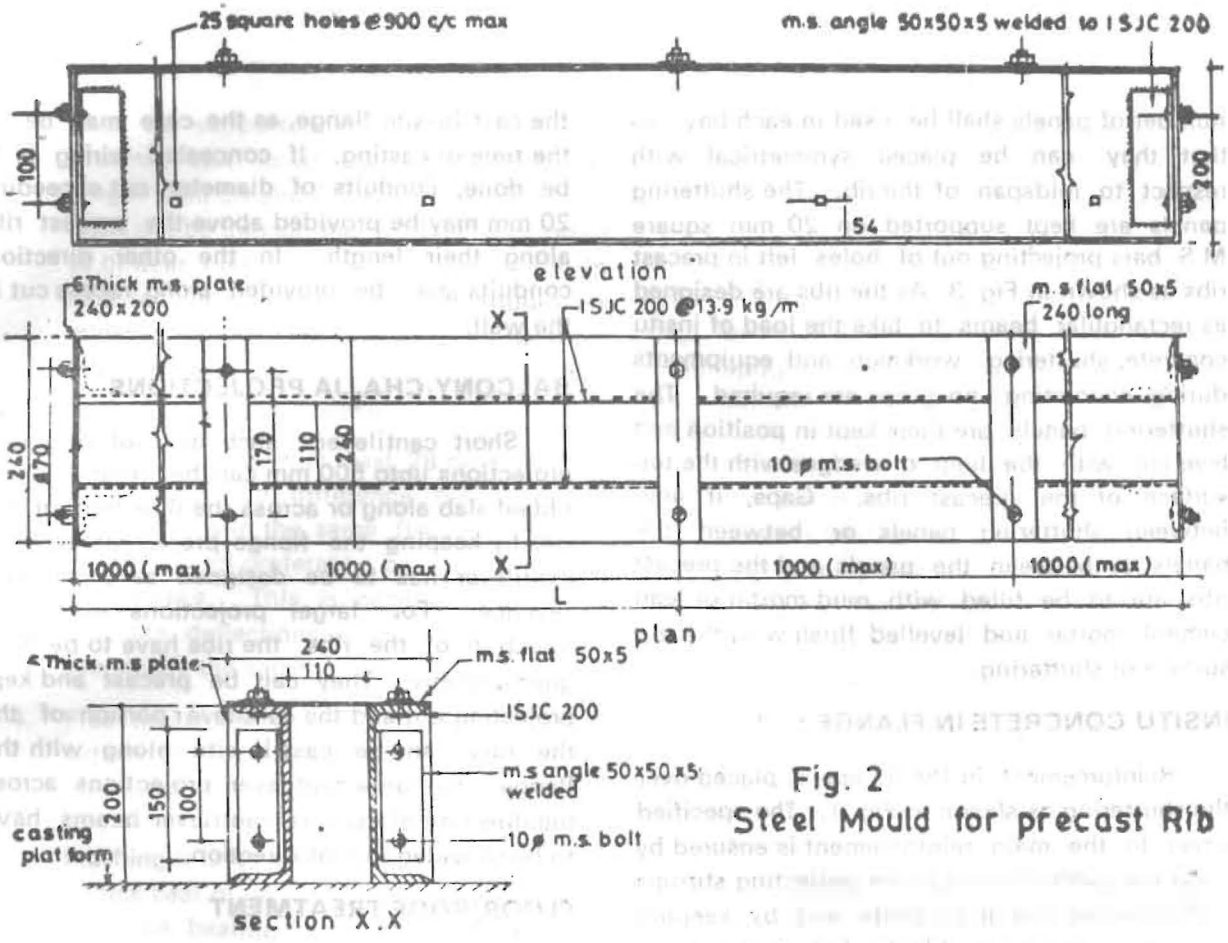
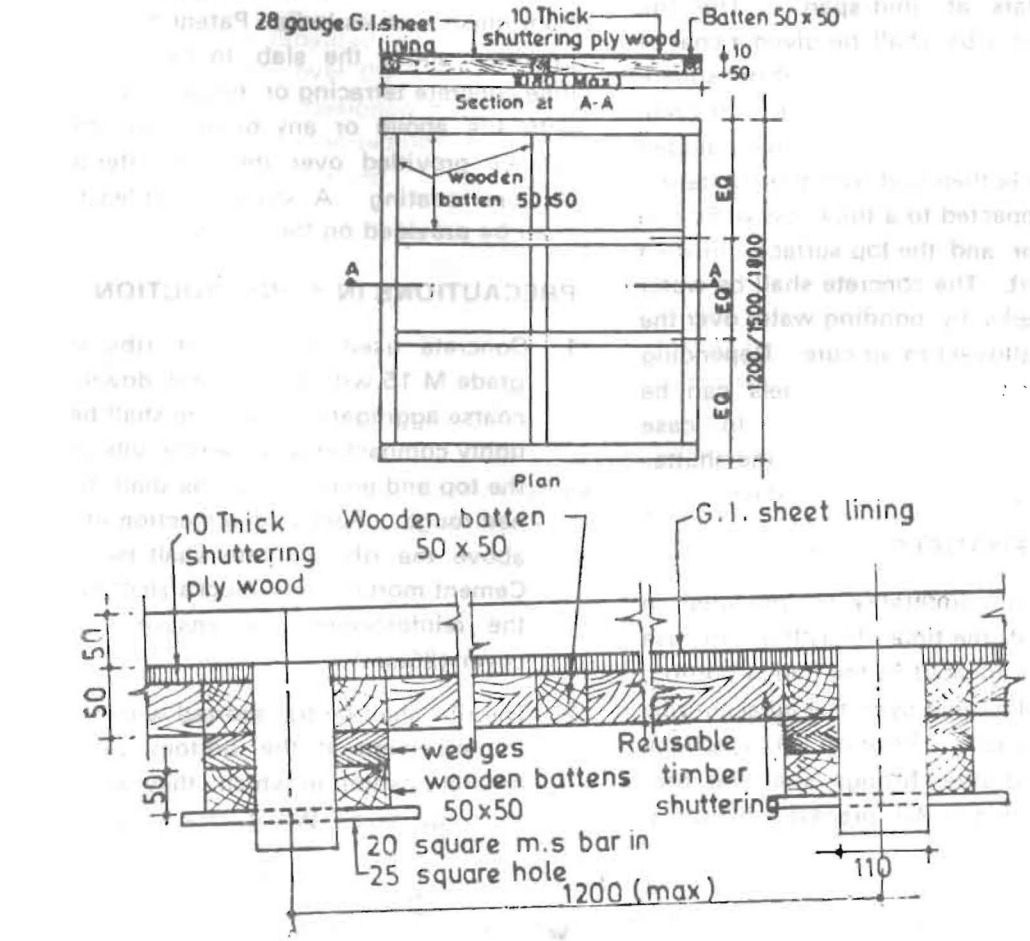


Fig. 2
Steel Mould for precast Rib



Shuttering in position

Fig. 3. Timber Shuttering for Thin R.C. Ribbed Slab

number of panels shall be used in each bay, so that they can be placed symmetrical with respect to midspan of the rib. The shuttering panels are kept supported on 20 mm square M.S. bars projecting out of holes left in precast ribs as shown in Fig. 3. As the ribs are designed as rectangular beams to take the load of insitu concrete, shuttering, workmen and equipments during concreting, no props are required. The shuttering panels are then kept in position and levelled with the help of wedges with the top surface of the precast ribs. Gaps, if any, between shuttering panels or between the panels or between the panels and the precast ribs are to be filled with mud mortar or lean cement mortar and levelled flush with the top surface of shuttering.

INSITU CONCRETE IN FLANGE :

Reinforcement in the flanges is placed over the shuttering as shown in Fig. 1. The specified cover to the main reinforcement is ensured by tying the reinforcement to the projecting stirrups of the precast ribs at supports and by keeping cement mortar cover blocks below the main reinforcement bars at mid-span. The top surface of precast ribs shall be given a coat of cement slurry with 0.25 Kg of cement per square metre of area, just before concreting. Concrete of grade M 15 with 12 mm and down, graded coarse aggregate is then laid over the shuttering and ribs and compacted to a thickness of 50 mm by a plate vibrator and the top surface, finished with wooden float. The concrete shall be water cured for two weeks by ponding water over the flange and then allowed to air cure. Depending upon the weather, the shuttering panels can be removed after about three days. In case portland pozzolana cement is used, the shuttering panels shall be removed after 5 days.

FITTINGS AND FIXTURES

Fan hooks shall preferably be provided in the precast ribs at the time of casting. In case the fan is to be located in the flange portion, the fan hook shall extend over the adjacent ribs and rest over them. Position of electrical junction boxes and other fittings shall be pre-planned and provided in the precast ribs or in the cast-in-situ flange, as the case may be, at the time of casting. If concealed wiring is to be done, conduits of diameter not exceeding 20 mm may be provided above the precast ribs along their length. In the other direction, conduits shall be provided along recess cut in the wall.

BALCONY/CHAJJA PROJECTIONS

Short cantilevers, such as roof or chajja projections upto 500 mm can be provided in the ribbed slab along or across the direction of the ribs by keeping the flange projected out. The cantilever has to be designed as per normal practice. For larger projections along the direction of the ribs, the ribs have to be designed suitably. They can be precast and kept projecting out and the cantilever portion of the the ribs can be cast-in-situ along with the flange. For large cantilever projections across the direction of the ribs, cantilever beams have to be provided in that direction.

FLOOR/ROOF TREATMENT

In case of ribbed slab floor, conventional floor finish such as Indian Patent Stone can be provided above the slab. In case of flat roofs, lime concrete terracing or mudphuska treatment with tile above or any other proven treatment can be provided over the slab, after applying bitumen coating A slope of at least 1 in 50 shall be provided on the roof top.

PRECAUTIONS IN CONSTRUCTION

1. Concrete used for precast ribs shall be grade M 15 with 20 mm and down, graded coarse aggregate. Concrete shall be thoroughly compacted by a needle vibrator and the top and ends of the ribs shall be finished rough. Specified projection of stirrups above the rib concrete shall be ensured. Cement mortar cover blocks shall be tied to the reinforcement to ensure specified cover (25mm).

2. The ribs shall be transported with the main reinforcement at the bottom, i.e., in the natural position in which they will be used in structure. While transporting, they

shall be supported at the two ends (at a distance not more than 0.15 time the length from the ends) and midspan. The ribs shall not be transported or kept supported at or near midspan only, at any stage. In case fan hooks have been provided near midspan, the ribs shall not be kept supported on the fan hooks at any stage, as this may cause cracks in them.

3. Only ribs cured for at least 28 days shall be used. The age difference between two adjacent ribs in the same floor or roof of a building shall preferably be not more than two weeks. This is necessary to ensure that the deflections of adjacent ribs are practically the same.

4. Free movement of the ribbed slab over supporting walls/beams shall be ensured by plastering the bearing area of the flange and ribs with 1:3 cement : sand mortar, finishing it level and smooth and providing a thick coat of lime wash or polythene sheet over the bearings and vertical sides of the ribs.

5. The ribs shall be provided with a minimum bearing of 75 mm over the walls/beams, in case the ribs are designed as continuous. In case of simply supported ribs, the bearing shall be 100 mm minimum.

7. The shuttering panels shall be kept supported so that they do not move horizontally or vertically during concreting. Gaps, if any, between the panels and the ribs shall be thoroughly packed before concreting. Mould oil shall be applied to the panels before concreting.

8. Cement : sand mortar cover blocks shall be tied to the reinforcement to maintain the required cover to flange reinforcement.

9. When thin R C. ribbed slab construction is done in coastal areas or in any corrosive environment, the concrete cover to the reinforcement has to be increased as suggested in IS : 456-1978, and / or the reinforcement shall be coated with anti-corrosive paints.

10. Concrete for the flange shall be grade M 15 with 12 mm and down, graded coarse aggregate and shall be compacted using a plate vibrator.

11 Proper curing of the slab shall be ensured by ponding water over it or by continuous spray.

12. It is advisable to provide roof projection around the building to prevent leakage at the junction of walls with roof. In case parapet wall is to provided just above the wall below, the junction between the roof finish and the parapet wall shall be treated as per relevant code provisions.

13. In case no roof treatment is provided over the slab, expansion joints shall be provided in the roof slab at a closer spacing as recommended for thin unprotected slabs in IS : 3414-1968, 'Code of Practice for Design and Installation of Joints in Buildings'.

ALTERNATE CONSTRUCTION METHOD

In case, the construction of R.C. ribbed slab floor/roof with precast ribs and ready made shuttering panels is not possible due to some reason or the other, the construction may be done with traditional shuttering. In such cases the ribs need not be designed as rectangular beams to carry the load at the construction stage. They shall be designed as Tee beams for the final stage of loading. In this case the depth/reinforcement in the ribs may work out to be less than that of precast rib. Also the longitudinal reinforcement bars provided inside the precast ribs at top to take handling stresses can be avoided the cost of concrete/reinforcement in the R.C. ribbed slab is likely to be less in case of cast-in-situ construction. However, the cost of shuttering will be more in this case. The overall saving is likely to be slightly less, when traditional shuttering is used. Hence, only in exceptional cases, where due to some reason or the other, the use of precast ribs and ready made shuttering panels is not feasible, use of traditional shuttering is recommended.

STRUCTURAL TESTS

Deflection recovery test was carried out on the thin R.C. ribbed slab as per IS : 456-1978 and it passed the test. The maximum measured deflection was only 1 in 2164 the span. The slab was also subjected to ultimate load test. The loading was stopped at 1.25 times the design ultimate load, due to problems of keeping the loading blocks further.

Though codes of practice do not give any procecure for testing slabs against impact, tests were carried out to check the impact resistance of the slab. A gunny bag filled with 400 N of sand was dropped from a height of 1500 mm. No damage was observed. A 50 N weight was dropped from a height of 1200 mm over an area of 700 mm^2. Though indentation of about 2mm was noticed at the top of the slab, where the weight struck it, no other damage was observed. The slab was subjected to further impact test by pounding 'Haldi', one of the hardest materials used at home in a 'Hamam Dasta'. No cracks or other signs of weakness developed during the test. Hence this slab is safe against impact and vibrations normally expected in residential and office buildings.

FUNCTIONAL PERFORMANCE

Themal performance indices (for T.P.I., refer C.B.R.I. Building Digest No. 94) of the ribbed slab and the conventional slab with the same roof treatment above are given below :

	Slab with treatment above	T.P.I.
a)	50 mm R.C. ribbed slab with 90 mm thick lime concrete above	167
b)	50 mm R.C. ribbed slab with 75 mm thick mudphuska and 50 mm thick brick tiles above	134
c)	100 mm thick R.C. slab with 90 mm thick lime concrete above	134
d)	100 mm thick R.C. slab with 75 mm thick mudphuska and 50 mm thick brick tiles above	110

With the same treatment above, ribbed slab is only slightly inferior to 100 mm thick conventional slab.

In multistoreyed buildings, impact noise produced by foot wear, movement of furniture, activities in the kitchen etc., is a source of nuisance and calls for insulation against impact noise in the intermediate floors. Impact Noise Rating (I N.R.) number is an indication of the degree of impact noise insulation provided by a floor For comparison, the ratings are given below :

Slab	I.N.R.
50 mm thick R.C. slab	-17 db
120 mm thick R.C slab	-16 db

The thin ribbed slab and the conventional slab have practically the same impact noise rating.

Ponding tests and observations during rains, carried out on the ribbed slab without any treatment above show that it is leakproof.

50 mm thick R.C.C. slab of size 1080 × 1080 mm, with 30 mm thick Indian Patent Stone flooring over it was subjected to fire resistance test as per IS : 3809-1979 'Specification for Fire Resistance Test of Structures'. The fire resistance of thin R.C. ribbed slab in respect of thermal insulation criteria was found to be 1 hour and 40 minutes, whereas the fire rating required for a residential floor is 1 hr.

In thin R.C. ribbed slab, the flange portion being insitu with the design reinforcement provided continuous in the two perpendicular directions, the slab ties the longitudinal and crosswalls, together and behaves similar to cast-in-situ R.C. slab to resist forces due to earthquakes and wind loads. Strengthening measures such as lintel bands, vertical steel at corners and junctions of walls etc., shall be provided as in the case of cast-in-situ slab.

MATERIAL AND LABOUR REQUIREMENT

Based on the experience gained from experi mental construction of thin R.C. ribbed slab scheme, the basic data of labour and materials required for the construction was worked out and is given below, Using this data and knowing the prevailing rates of materials and labour at a place, the cost of construction can be

worked out.

BASIC DATA OF MATERIAL AND LABOUR REQUIREMENT

1. Fabrication of Shuttering Panels (for 10 sq.m. of area)

(a) Materials

i) Timber (sal wood) battens of 50 × 50 mm ... .. 0.153 m^3
ii) Shuttering plywood 10 mm thick ... ... 8.9 m^2
iii) G.I. sheet 28 gauge 13.5 m^2
iv) Sal ballies average 75 mm dia and 3000 mm long. .. 1.5 Nos.
v) Screws, nails, etc. LS. ... .. Rs. 25.00

(b) Labour

i) Carpenter ... ... 1.5 manday
ii) Mazdoor ... . 1.5 manday

Note : (i) One set of shuttering with G I. sheet lining can be used at least 20 times.

(ii) Wastage @ 10% has been added in the quantities of materials given above.

II. Fabrication of mould for precast rib of 3600mm span (1 No.)

(a) Materials

i) M.S. Channel-ISJC 200 (3600mm long, 2 Nos) 100 kg.
ii) M.S. angle iron 50 × 50 × 5mm (50mm long, 8 Nos.) 6 kg.
iii) M.S. plate 3mm thick 200 × 240mm size, 2 Nos.) 2.4 kg.
iv) 10mm dia. m.s. bolts with nuts (50mm long) 8 Nos.
v) Welding charges L.S. Rs. 7.00
vi) 20mm sq. M.S. bars 300mm long 5 Nos. 1.5 m

(b) Labour

i) Fitter/Mechanic ... 0.5 manday
ii) Mazdoor ... 1.0 manday

Note : A steel mould can be reused for 100 castings at least

III. Precasting of rib (110mm × 200mm and 3600mm long, 1 No.)

Quantity of concrete . . 0.0792 m^3

(a) Materials

Cement ... 0.503 bag
Coarse aggregate (20mm & down, graded) ... 0.07 m^3
Sand ... 0.035 m^3
High strength deformed bars ... 10 84 kg.
Mild steel reinforcemeet ... 6.45 kg.
25mm sq. M.S. conduit pipes 100mm long, 5 Nos... 0.5 m
Sundries and binding wire L.S. Rs. 2.00

(b) Labour

Mason ... 0.05 manday
Bar bender ... 0.50 manday
Mazdoor ... 0.40 manday

(c) Miscellaneous

Cost of mould per use .. As per item II
Cost of mould oil L S. ... Rs. 0.50
Vibrator and mixer charges L.S. ... Rs. 0.50
Electricity charges (for vibrator and mixer)... Rs. 0,50
Cost of platform charges per casting . ... Rs. 0.50
Water charges for concreting and curing ... Rs. 0 30

(d) Total cost of one precast rib ... (a+b+c)

Note : (i) The number of precast ribs required for 10 m^2 area will depend upon the plan and is to be taken as per drawing.

(ii) The quantity of steel required will vary depending upon loading, span and continuity condition. The reinforcement given here is for a roof having continuous spans of 3600 mm c/c with precast ribs spaced @ 1200 mm c/c. Two ribs can serve an area of 12.96 m^2.

IV. Transportation, erection and assembly of precast rib (1 No.)

(a) Labour

Mason ... 0.05 manday
Mazdoor ... 0.2 manday
T & P L.S. ... Rs 2.00

V. Erection and removal of shuttering (for 10 sq. m. area)

(a) **Labour**

Carpenter	...	0.44 manday
Mazdoor	...	0.88 manday
T & P and sundries including wedges, cement slurry, etc. L.S.		Rs. 4.00

VI. Providing and laying of reinforcement (for 10 sq.m. area)

(a) **Materials**

Mild Steel bars	...	37.70 kg.
Sundries, binding wire etc. L.S.		Rs. 2.00

(b) **Labour**

Bar bender	...	0.6 manday
Mazdoor	...	0.6 manday

VII. Insitu concreting and curing (for 10 sq m. area)

Quantity of concrete ... 0.53 m^3

(a) **Materials**

Cement	3.5 bag
Coars aggreate (12 mm and down)	0.445 m^3
Sand	0.223 m^3

(b) **Labour**

Mason	0.15 manday
Mazdoor	1.00 manday

(c) **Miscellaneous**

Mould oil. T & P etc. L.S.	Rs 5.00
Vibrator and electricity charges L S.	Re. 1.00

SAVINGS IN MATERIALS AND COST

Comparison of consumption of materials and cost of construction of thin R.C. ribbed slab scheme with conventional R.C. slabs is given below. In case of A, the comparison has been given for a 3600×3600 mm size two way spanning, continuous slab and in case of B, for a one way spanning, simply supported slab. They have been designed as per limit state method and mild steel has been used as reinforcement.

A. Comparison in case of two way spanning continuous slab.

Item	Cement (kg/m^2)	Steel (kg/m^2)	Cost
Conventional slab 100mm thick	32.0	7.82	
Ribbed slab, 68mm av. thickness	23.7	7.51	
Saving	26%	4%	22%

B. Comparison in case of one way spanning simply supported slab.

Item	Cement (kg/m^2)	Steel (kg/m^2)	Cost
Conventional slab 140mm thick	44.8	8.77	
Ribbed slab, 68mm av. thickness	23.7	7.52	
Saving	47%	14%	30%

It can be seen that the adoption of R.C. ribbed slab scheme in place of conventional R.C. slab will result in a saving of 26 to 47% in steel and 22 to 30% in cost. Apart from this, there is a saving of 30 to 45% in aggregates. The scheme eliminates the use of props to a great extent. Being similar to the conventional construction, it will be easy for the site engineer to adopt this type of construction and hence, it will be readily acceptable to him. Thus thin R C. ribbed slab scheme is ideally suited for repetitive type of construction of floors and roofs for low cost houses and other buildings.

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