BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

INEXPENSIVE ROOFS FOR SMALL HOUSES

Introduction

For a small house, a flat roof offers many advantages over a pent one. Amongst the various forms of flat roofs, R. C. C. roof has superceded almost all others, because of its monolithic nature and its ability to cover any given size or shape of room. Unfortunately its cost (Rs. 2.50 to 4.00 per Sft.) is high and constitutes from 25% to 30% of the cost of a building. The ever increasing demand for low-cost houses cannot be met, unless this cost is reduced. This digest describes three forms of flat roofs of a composite nature (partly precast and partly cast in-situ) which have shown considerable promise as economic alternatives to R. C. C. slabs for spans upto 14 ft.

Types of Roofing Units

All the three forms consist of units which are curved in shape and fully precast. The curved form obviates the need for steel reinforcement, while precasting ensures better quality-control of the concrete. The units are placed on partially precast beams of rectangular or trapezoidal shape, which are suitably anchored to the supports and covered on top with a layer of in-situ concrete. The in-situ layer of concrete fills up the haunches and contributes to the structural strength of the composite roof. A protective coat of lime concrete or other suitable treatment is added for thermal insulation and resistance to rain penetration.

The types of units are :-

(a) Precast curved hollow units of guna tiles (country tiles) encased in concrete (Fig. 1)

(b) Precast curved hollow plain cement concrete units with an air space-(Fig. 2)

(c) Precast doubly curved tiles of plain cement concrete. (Fig. 3)

Precast Curved Hollow Unit of Guna Tiles

This type of unit is 3'-7½" long, 10" wide and 3" deep. Each unit weighs about 90 lbs and can be easily handled by two persons, It is cast on a curved concrete masonry platform (Fig. 4). Two rows of guna tiles are arranged in the form of an arc of a circle or a parabola. Concrete 1 : 2 : 4 (with 3/8" aggregate) is then poured to a thickness of 1/2". After 24 hours or so the units are removed and cured.

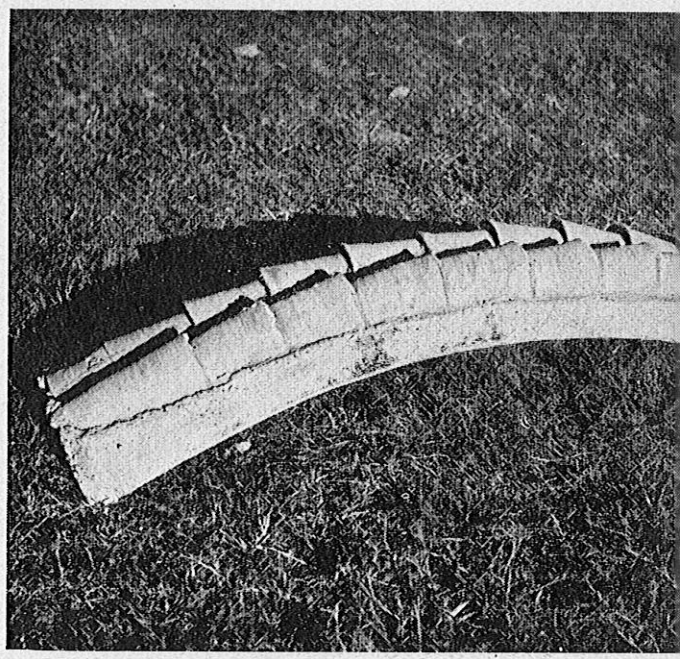

Fig. 1

The supporting beams are trapezoidal, 6" wide at bottom, 3" wide at top and 5" deep. The beam reinforcement consists of 2 to 3 bars of 1/2" dia. (depending upon the span) with 1/4" dia stirrups projecting to provide bond with insitu concrete. The beams are designed as T-beams and laid 4' on centres. The end beams are anchored to the supports and units are laid in between to the correct fit. The haunches are then filled in with cement concrete 1 : 2 : 4 of the same consistency as the beam upto the depth of the flange. Concrete is cured and the protective treatment is laid as required.

Precast Curved Hollow Unit with an Air Space

This unit is 3'-7½" long, 12" wide, 5" deep with a central rise of 4½". It has a web thickness of ½"-3/4"

and weighs about 80 lbs. It is cast on a masonry platform in three operations. First, the bottom 1/2" thick concrete (1 : 2 : 4 with 3/8" aggregate) is laid and finished smooth (Fig. 5). Next the partition boards are laid and the vertical sides of the units filled to 3/4" thickness. The partitions are lifted out after 3 hours and curved forms are introduced for pouring 1/2" top concrete. The concrete is allowed to cure for 24 hours

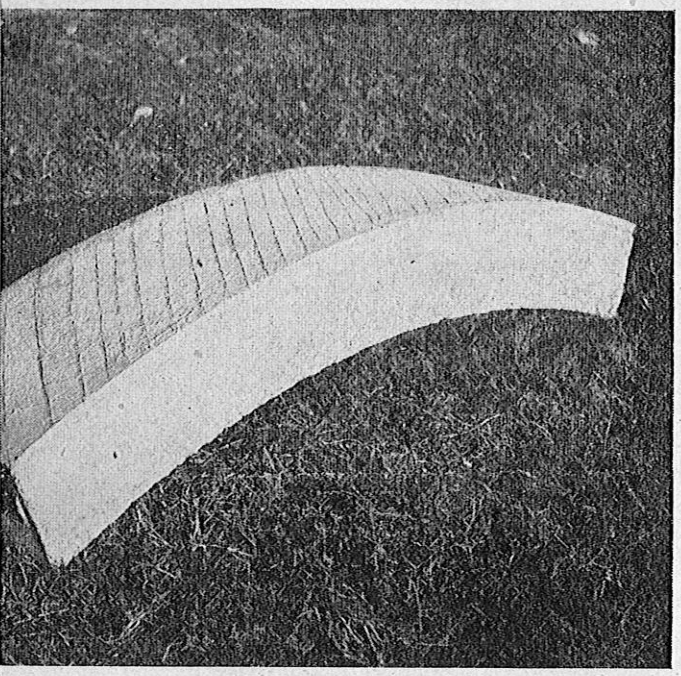

Fig. 2

and the curved frames are then removed by pulling them out from the end opening. Curing is continued till the units can be handled without damage.

The size of the beams, the method of laying the units and finishing are similar to those as for Guna tile units.

Precast Doubly Curved Tile

This unit has a double curvature to minimise the tensile stresses in the body of the tile. The size of the tile is restricted 2'-3" each way for easy casting and handling and to do away with the need for edge reinforcement.

The tile is cast on a level masonry platform with the help of a wooden form to which hessian cloth is fixed. The form is placed on the platform and a frame 3/4" thick is placed on it (Fig. 3). Cement Concrete 1 : 2 : 4 (with 3/8 aggregate) is poured to a depth of 3/4" thickness and compacted. The form is then lifted and supported at the corners. The hessian cloth sags giving the

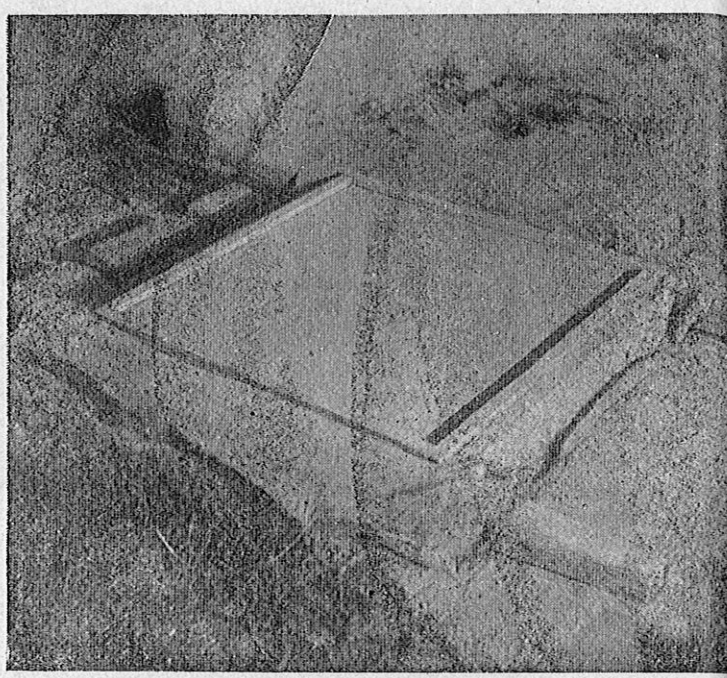

Fig. 3

tile the required shape. Concrete is filled in around the edges, the top frame removed and the tile finished smooth as required, In fair weather, the tile is removed for curing after 24 hours.

The tile weighs about 60 lbs. It is laid on rectangular partially pre-cast beams and in-situ concrete is poured on the top along the length of beams to form

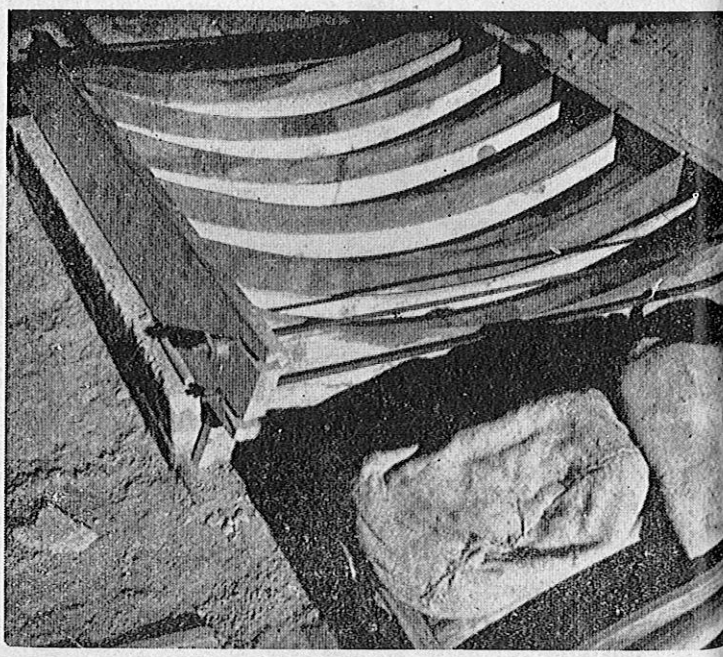

Fig. 4

the compression flange of the composite beams. Only 1/2" depth of concrete is poured in haunches at right angles to the direction of the beam. The roof is finished as for other units.

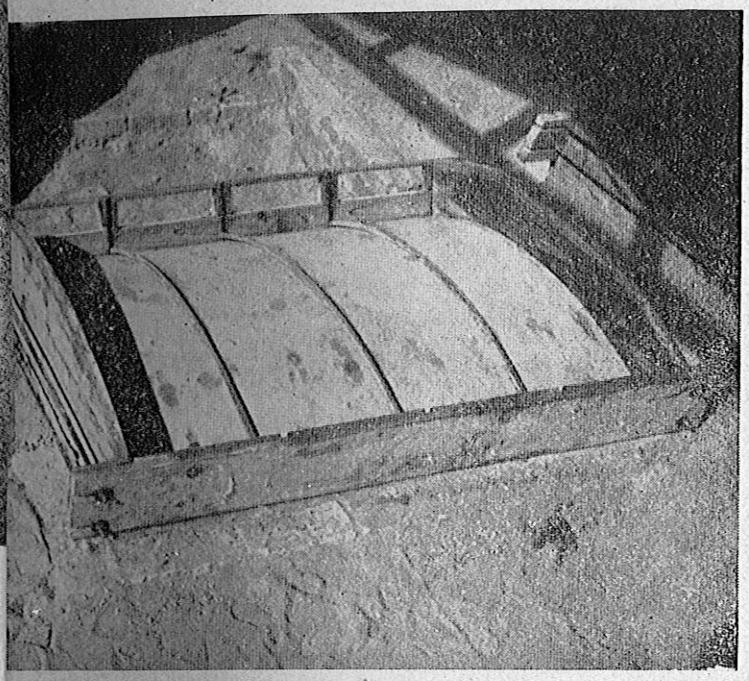

Fig. 5

Loading Tests

The results of the tests of static and impact loading are summarised in Table I.

Table I—STRENGTH OF UNITS

Type of unit.	Static load lbs/ Sft.	Result	Impact load	Result
Precast curved unit of Guna tile	450	Unit did not fail	90 lbs. from a ht. of 8 ft.	Local failure of Guna tile... Bottom concrete remained intact.
Precast curved hollow unit with air space	450	Unit did not fail	90 lbs. from a ht. of 9 ft.	Fine cracks appeared on the side.
Precast doubly curved tile	210	Unit failed	60 lbs. from a ht. of 4 ft.	Unit broke to pieces.

These results indicate that guna tile units and the hollow units have adequate strength, but the doubly curved tile is weak. Accordingly the behaviour of the composite roofs under weights dropped from progressively increasing heights upto 10'-0", was studied. The results of the tests conducted on prototype roofs (complete with the protective treatment) of 12' span are summarised in Table II.

TABLE II—TESTS ON PROTOTYPE ROOFS

Form of Roof	Static load lbs/ Stf.	Maximum deflection observed in the beams	Remarks	Impact	Result
Using Precast Curved Units of Guna tiles	250	0.4"	Roof remained intact	90 lbs. from a ht. of 10 ft.	The roof remained in tact
Using Precast Curved Hollow Units with air space	180	0.25"	Roof remained intact.	-do-	-do-
Using Precast Doubly Curved Tiles	180	0.3"	Roof failed after 7 days of sustained loading due to settlement of wall.	-do-	-do-

The results indicate that the composite roofs are adequately strong for residential buildings.

Cost Analysis.

Table III gives a comparison of the requirements of steel and cement for these units for a roof of 12' span.

TABLE III—COMPARATIVE ECONOMICS

Type of roof	Cement lbs/Sft	Steel lbs/Sft	%Saving cement	%Saving in steel
4" thick R.C.C. slab ...	7.6	2.20	...	...
Precast hollow units of guna tiles ...	5.5	1.0	28	55
Precast PCC hollow unit ...	6.6	0.8	13	63
Precast doubly curved tile ...	5.8	1.20	24	46

This shows that maximum saving in steel is achieved with precast curved hollow units, while the maximum saving in cement is obtained by using precast hollow units of guna tiles. However doubly curved tiles are likely to result in maximum economy.

Conclusion.

The three forms of roof described in this digest are suitable for low cost housing schemes and other small buildings, where the spans do not exceed 14 ft. and roofs are not likely to be subjected to heavier live loads than normally met within residential buildings. Their main advantages consist of reduction in use of scarce materials, doing away with expensive form work, saving in time of erection at site and ease of construction. The techniques of manufacture do not require any special skill, although better results are obtained after the artisans become familiar with the processes.

There is a demand for short notes, summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need this Institute will bring out a series of Building Digests from time to time and the present one is the fifth in the series.

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