BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

A PREFABRICATED INSULATED HUT FOR HIGH ALTITUDES

Prefabricated huts are in demand for living at high altitude snow bound areas. They are especially useful for housing troops at these locations during the severe Himalayan winter. The hut described in this digest provides comfortable living conditions at 12,000 ft. to 17,000 ft. altitude and is light, sturdy and portable.

The following considerations have been kept in view in its design and development.

(a) It should be able to withstand heavy wind velocity of 100 m.p.h. and 6′ of snow.

(b) The maximum weight and size of the component should be such that it can be air landed/air dropped in remote areas inaccessible by road.

(c) Simplicity of design and ease of erection.

(d) The roofing, walls and floor should be provided with sufficient thermal insulation against severe cold.

(e) The maximum weight of the component should not exceed 35 lbs., taking into account the reduced efficiency of men due to high altitude and cold weather; the maximum length of the member should not exceed 6′-6″.

(f) It should be light and completely portable.

(g) Parts should be interchangeable to a large extent so that the loss of parts in air dropping may not hold up the erection.

General description

The hut developed at the C.B.R.I. is a prefabricated circular cylindrical structure 24′ long, 13′-6″ wide and 9′ high at the centre.

The end walls, roof and floor of the structure are made of prefabricated sandwich panels and are supported by M.S. angle frames consisting of arches and bracings.

The hut consists of four bays formed by five arches spaced 6′-$\frac{1}{4}$″ apart. Each arch is a part of circle of radius 6′-9″ and the central angle 214.24°. It is stiffened by internal bracing as shown.**

The roofing sandwich panel consists of an aluminium sheet on the outside, a plywood sheet on the inside with polyurethane rigid foam in between. An aluminium foil laid on the inner side acts as a vapour barrier. The details of the panel are given below :

(i) Size—1′6″ (along the curve) × 6′ 0″ long $3\frac{3}{16}$″ thick.	
(ii) Thickness of aluminium sheet	18 gauge
(iii) Thickness of plywood	$\frac{1}{8}$″
(iv) Thickness of aluminium foil	400 swg.
(v) Thickness of Polyurethane foam	3″

The properties of the polyurethane rigid foam used as an insulating agent are as follows :

Density	1.8 to 2.2 lb/cft.
Thermal conductivity	0.25 B.Th.U/sq. ft./hour/inch/F°
Compression strength	15 to 20 p.s.i.
Coefficient of linear thermal expansion	$5—10 \times 10^{-5}$ at 20°—50°C-

The floor panels are 6′ long, 1′-4$\frac{1}{2}$″ wide and $3\frac{3}{4}$″ thick. These are made out of $\frac{1}{2}$″ thick plywood on the inside and $\frac{1}{4}$″ plywood on the outside with 3″ of thermocole in between with aluminium foil on the inner side to act as a vapour barrier. The wall panels are $3\frac{3}{8}$″ thick. The construction of the wall panels is similar to that of floor panels except that $\frac{1}{8}$″ plywood is used on the inside. But the panels are of varying sizes to accommodate windows and door.

Four fixed windows 2′ × 1′ with double wall of perspex sheet are provided at the ends. An additional central window panel 2′ × 2′ is provided opposite to the door end. A 4′ × 4′ storm lobby encloses the external door, forming an air lock and a partial screen. Ventilation is provided by four louvred and shuttered ventilators on the end walls.

Two rows of two bunks on each side provide sleeping accommodation for 8 men. The upper bunks can be lowered to serve as back rest for the lower bunk used for sitting during the day.

Analysis of the structure

The arch is divided into 16 equal parts and is assumed to be hinged at the base for purposes of analysis. The analysis is carried out for two cases.

(i) dead load + snow load
(ii) dead load + wind load

For each condition of loading, the equivalent point loads on the arch are worked out. The nature and the intensity of wind pressure at different regions on the arch segment are calculated from "draft Indian Standard Code of Practice for Structural Safety of Buildings" (Revision of IS : 875-1957). The horizontal reactions at the hinge level are worked out with the help of the formulae given in the book by A.J.S. Pippard* and the bending moment and the shear force were obtained for all the points on the arch. The cross-section was arrived at by considering the critical value of the bending moment with the help of the I.S.I. handbook for structural engineers No. 1 (1959). An open web type section has been chosen for the arch. The top and bottom chords of this section are expected to resist the bending moment, while the lacing is designed to take up the shear only.

*A.J.S. Pippard—'Studies in elastic Structures," Edward Arnold & Co. London (1952)
** Drawing available on request.

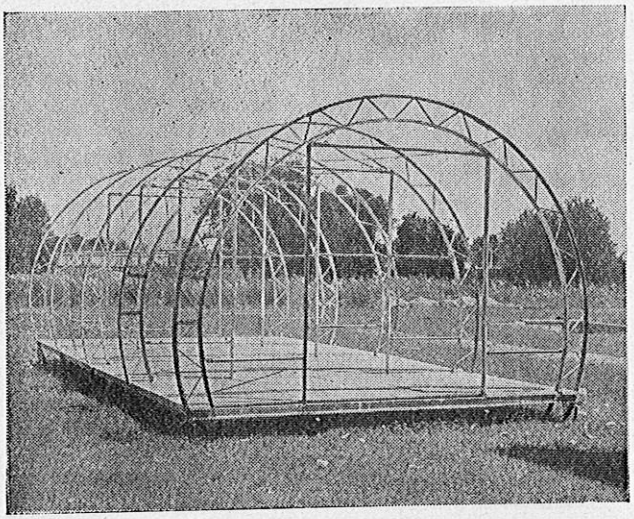

Fig. 1 Structural skeleton of the hut with the flooring in position.

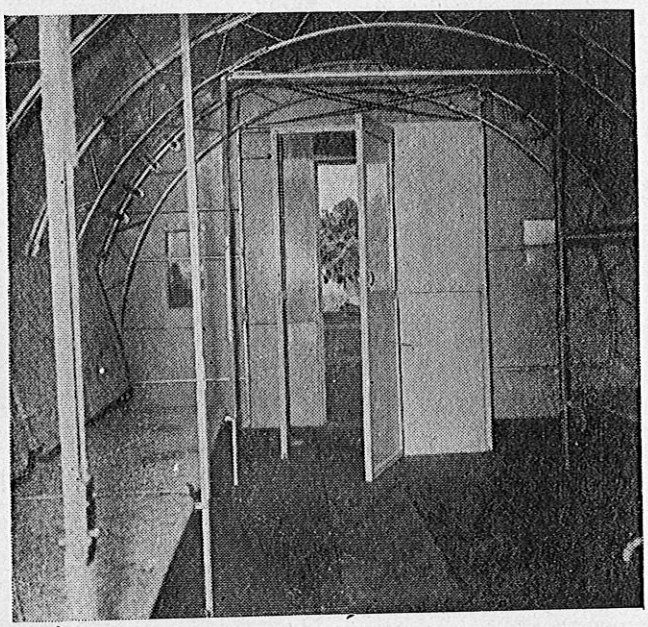

Fig. 2 Interior view of the hut with storm lobby. Top bunk is lowered down to serve as back rest.

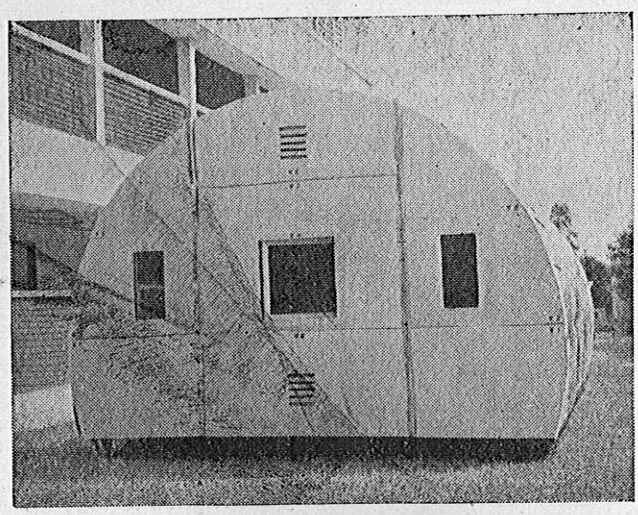

Fig. 3 Elevation from the window side.

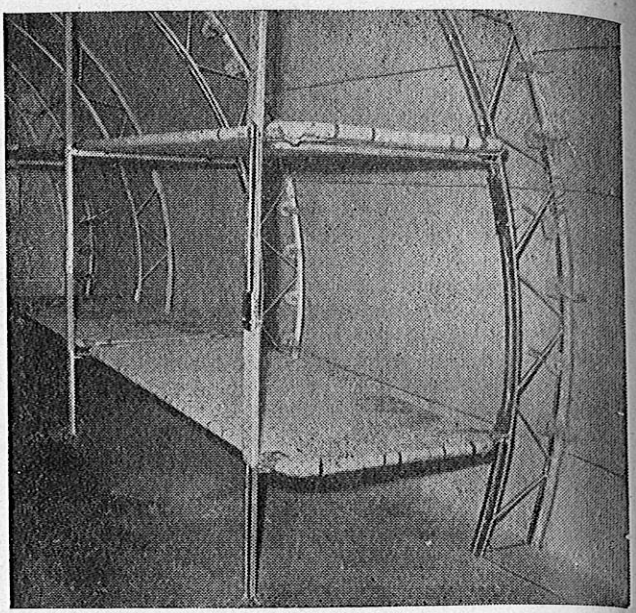

Fig. 4 Bunks at two levels.

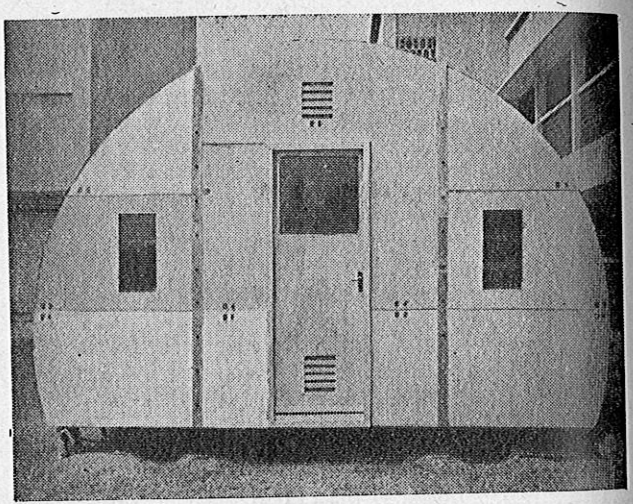

Fig. 5 Elevation from the door side.

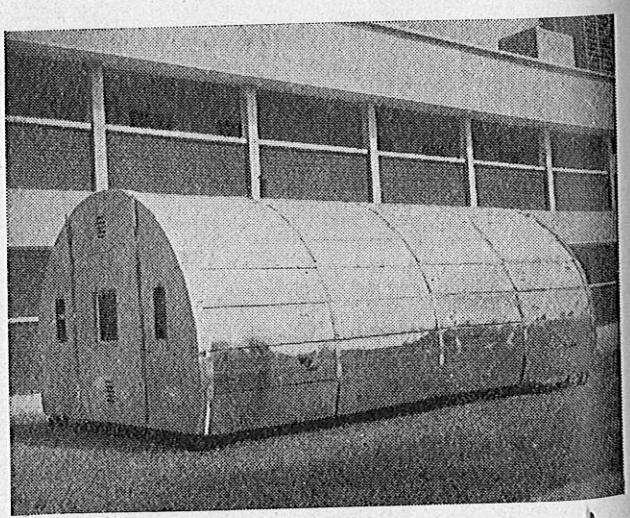

Fig. 6 Completed view of the hut with sandwich panels. Aluminium strips used to hold down the panels with the skeleton are seen.

The horizontal members of the bracings resist lateral sway of the frame besides giving support to the bunks. The bottom most horizontal members support flooring panels spaced 6′ apart.

Design data and assumptions

1.	Weight of the roofing panel	20 lbs.
2.	Weight of the arch	6 lbs/ft.
3.	Depth of snow assumed all over the circumference.	6′ max.
4.	Maximum velocity of wind	100 m.p.h.
5.	Live load on the floor	100 lb/sq. ft.

The arch is supported on the ground by spikes driven through the base plate which is connected to the arch. Wherever the ground condition permits, concreting may be done in place of spikes. The depth of the footing can be arrived at from uplift considerations. In case, the spikes are provided, steel guy ropes may be used to hold down the hut at suitable intervals. In view of the restrictions laid down on the size and weight of the member, the arch has been split up into five segments which are joined by bolts and fish plates. Similarly, the vertical member is divided into two pieces and the floor member into three pieces as shown. (drawing available on request)

Erection of the hut

Foundation

The foundation for the hut consists of base plates and spikes. A levelled piece of ground 28′ × 16′ is selected and the positions of the base plates are marked.

Framework

Five frames each consisting of a circular arch and horizontal and vertical members are assembled on the ground by joining the various units by $\frac{1}{4}''$ bolts. Frames are then erected in position and the spikes are driven into the ground. To maintain the correct spacing and to give lateral stability, M.S. Flat tie members are inserted between the arches.

Cladding

The roofing panels are placed from springing towards the crown. Bottom most panels rest on the cleats provided on the arch. The panels can be laid simultaneously in all the bays. Tar plastic is used to seal the joints between the roofing panels. The panels are finally held in position on the arches by aluminium strips and roofing bolts. Eighteen panels are required to roof one bay.

Flooring

The flooring consists of plywood panels sandwiched with Thermocole. They are fitted in between the horizontal bottom members of the arches. The flooring panels are provided in two sizes.

Endwalls

The bottom most panels of the endwalls rest on the floor angles. They are placed in a particular sequence marked on them. The endwalls are tied to the arches by aluminium strips and bolts.

Weight of the hut and its components

(i)	Arch segment	30 lbs.
(ii)	Roofing panel	20 lbs.
(iii)	Walling panel	20 to 40 lbs.
(iv)	Flooring panel	35 lbs.
	Total weight of the hut	2.5 Tons

Fig. 1 to 6 show various views of the completed hut.

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 is bringing out a series of Building Digests from time to time and the present one is the Twenty fourth in the series.

UDC 725.92.002.22

Prepared at the Central Building Research Institute, Roorkee October, 1963.

Asia Press, Delhi-6.