BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

PREFABRICATED STEEL HUT

The prefabricated steel hut (Fig. 1) described in this Digest is composed of identical lattice members for truss frames and purlins and utilises clamp arrangements for sliding roofing and cladding sheets. This results in obtaining a light hut which is easy to transport, erect, dismantle or reerect with very high recoverability of materials.

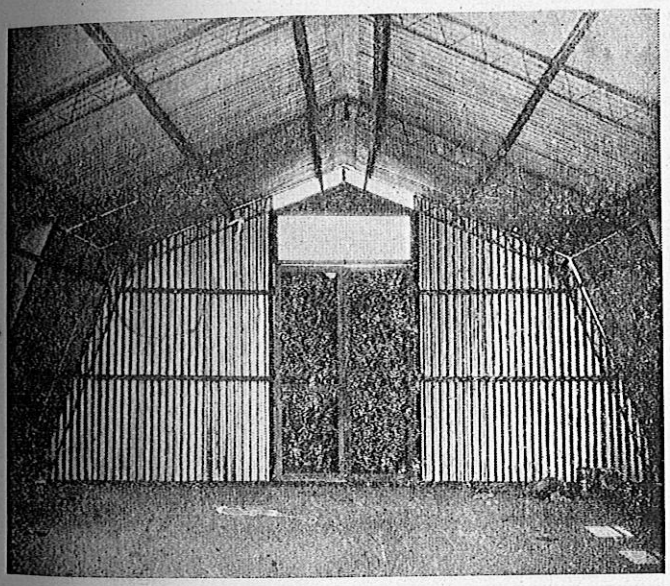

Fig. 1

Design

The hut has a span of 6.4 meters and a height varying from 2.21 meters at eaves to 3.2 meters at the ridge. The lattice members are bolted to form Mansard type frames which are erected 2.41 m on centres giving a bay area of approximately 15.6 sq m Any number of bays can be provided to suit the requirements. The standard hut is 9.76 meters long and consists of four 2.44 meters bay with two gable ends. The hut may be used for any purpose such as offices, stores, living accommodation hospitals or shelters required in any emergency.

The hut has been designed to withstand wind velocities upto 130 km/per hour and snow loads of 100 kg/m^2. The design of the structural frame is based on Dr. Ing. A. Kleinlogel's formulae for rigid frames*. This shape of the frame has been chosen to minimise the stresses induced in members, which are 85.5% less than those induced when the lower chord is kept vertical. No advantage has been taken of the stiffening effect of the cladding to permit the use of any locally available materials such as A. C. sheets, aluminium sheets, thatch, bamboo lath and plaster. The standard hut, however, consists of C.G.I. sheet roof covering and cladding, and plywood or hardboard ceiling and lining. For cold climates, three to five centimetre thick insulation such as polystyrene boards or mineral wool can be placed in the cavity in between the external cladding and the inner lining as well as the roof and the ceiling.

The standard arrangement of doors and windows provides adequate light and ventilation for normal use. However, the position of doors and windows can be varied to suit the intended use. For instance, windows may be provided in all bays of the hut including the gable ends to gain more light and ventilation, or doors may be provided off centre to provide greater space on one side.

Material and Cost

The cost of the hut depends on local prices. Since frames would be usually fabricated at a central depot, transportation costs form a significant proportion of the cost. The cost for the end bay is higher than that for the intermediate bay so that huts having greater number of bays become relatively cheaper in plinth area cost. The requirements of materials per truss frame and purlins are shown in Table I.

*"Rigid Frame Formulae" by Prof Kleinlogal (1952 Edn.) Crosby Lockwood & Sons Ltd. — Page 366, Frame 97.

TABLE 1—**Materials required for the fabrication of each built up frame and purlin**

S. No.	Description	Size: Length	Size: Breadth	Size: thickness depth	Nos.	Remarks
I.	*Intermediate frame*					
1.	M.S. Flat	7′—11—$\frac{3}{8}$″	2″	$\frac{1}{4}$″	4	
2.	-do-	7′—7$\frac{1}{4}$″	2″	$\frac{1}{2}$″	4	
3.	$\frac{1}{4}$″ M.S. bar	21′—6″	—	—	4	
4.	M.S. Plate	7″	6″	$\frac{1}{4}$″	8	
5.	Bolts $\frac{3}{4}$″ dia.	1$\frac{1}{2}$″	—	—	12	
6.	Bolts $\frac{1}{4}$″	6″	—	—	8	These are foundation bolts to be embedded in concrete.
II.	*Additional material for end frame*					
1.	*L—Iron* 2″×2″×$\frac{1}{4}$″					
	(a) Bottom tie	6″—8″	—	—	3	
	(b) Horizontal bracing.	5′-11-$\frac{7}{8}$″	—	—	2	Middle horizontal bracing.
	(c) Upper bracing.	4′—9$\frac{3}{4}$″	—	—	2	
	(d) Vertical posts.	8′—11″	—	—	2	
2.	M.S. *Flat* (a)	9″	2″	$\frac{1}{4}$″	4	Joints of bottom tie
	(b)	2″	2″	$\frac{1}{4}$″	12	L-Iron ends.
	(c)	4″	2″	$\frac{1}{4}$″	2	Bottom of vertical posts.
3.	$\frac{3}{4}$″ *dia. bolts*					
	(a) 1$\frac{1}{2}$″ long	—	—	—	8	
	(b) 1″ long	—	—	—	12	
III.	*Purlins*					
1.	M S. Flat	8′—2″	1$\frac{1}{2}$″	$\frac{3}{16}$″	2	
2.	$\frac{1}{2}$″ dia. M.S.	22′—4″	—	—	1	
3.	Bolts $\frac{3}{8}$″ dia.	7″	—	—	2	Two lengths of purlins are fixed with one bolt.

(Dimensions are shown in F.P.S. units as actually used)

The cost may be estimated on prevailing rates. Based on the requirement of the materials (as at table II) and the prices at Roorkee (1963), the cost of a standard four-bay hut comes to about Rs. 86.00 per square metre of the floor area.

TABLE II—**Materials required for a complete hut of 4 bays.**

S. No.	*Item*	*Quantity*
A.	*Steel*	
1.	M.S. flat 2″×$\frac{1}{4}$″	340 Kg.
2.	M.S. flat 1$\frac{1}{2}$″×$\frac{3}{16}$″	350 Kg.
3.	M.S. flat for cladding and lining, clamps etc.	90 Kg.
4.	$\frac{1}{4}$″ dia. M.S. bars	117 Kg.
5.	(a) M.S. plate $\frac{1}{4}$″ thick	48 Kg.
	(b) M.S. Sheet 22 B.G.	9 Kg.
6.	(a) C.G.I. sheets—24 gauge 10/3×10′—0″ long—40 nos. 10/3× 8′—0″ long—30 nos. (b) Plain G.I. sheets 24 gauge 3′—0″×8′—0″ 6 Nos.	1.57 tonnes
7.	*Bolts*	
	(a) $\frac{3}{4}$″ dia. 1$\frac{1}{2}$″ long	60 Nos.
	$\frac{1}{2}$″ dia. 6″ long	40 Nos.
	(b) $\frac{3}{8}$″ dia. 1″ long	24 Nos.
	—do— 1$\frac{1}{2}$″ long	16 Nos.
	—do— 7″ long	60 Nos.
8.	M.S. Angle 2″×2″×$\frac{1}{4}$″ for end bays and 1″×1″×$\frac{1}{4}$″ for windows.	295 Kg.
9.	For temporary foundation, in place $\frac{1}{2}$″ dia. 6″ long bolts.	
	(a) M.S. Plate $\frac{1}{4}$″ thick	30 Kg.
	(b) $\frac{5}{8}$″ dia. M.S. round	41 Kg.
	(c) $\frac{1}{2}$″ dia. 1$\frac{1}{2}$″ long bolts	5 Kg. (40 Nos.)
B.	Timber – Deodar	0.12 C. Meter
C.	Sundries	
	(i) Wood screws	1 gross
	(ii) Nails (Springs)	2.25 Kg.
	(iii) Glass 18 Oz 26″×16″	24 Nos.
	(iv) Anticorrosive Paint	5 liters.
D.	*Materials for lining, insulation, etc.*	
1.	6 mm plywood 8′ × 4′ or building boards	60 nos.
2.	Thermocole or Lloyds wool	126 Sq. meter
E.	*Flooring*	
	(a) Cement	22 bags
	(b) Sand	80 Cft.
	(c) $\frac{3}{4}$″ stone aggregate	160 Cft.

(Dimensions are shown in F.P.S. Units as actually used)

Weight and Volume

The total weight of the frames including doors, windows and C.G.I. sheets in roofing and cladding for a 4 bay hut comes to about 2 tonnes. The approximate volume of these materials is about 4.25 cu. metre and they can be readily transported in one 3 ton truck. The internal lining and ceiling (6 mm boards of 2.44 m × 1.22 m size) weighs about one tonne and occupy

about 1.5 cu metre of space. The lining and ceiling materials can therefore be accommodated in a one ton truck. The components of the hut can also be air dropped, if suitably packed.

Description of Components

Structural framework

Structural framework (fig. 2) consists of lattice members for frames and purlins. The truss frame members are received in individual packages at site. They are opened out on a reasonably level ground and the four members are bolted together to form portal frame of Mansard type with rigid connections at the ridge and knee. All components of the frames as also the purlins are interchangeable.

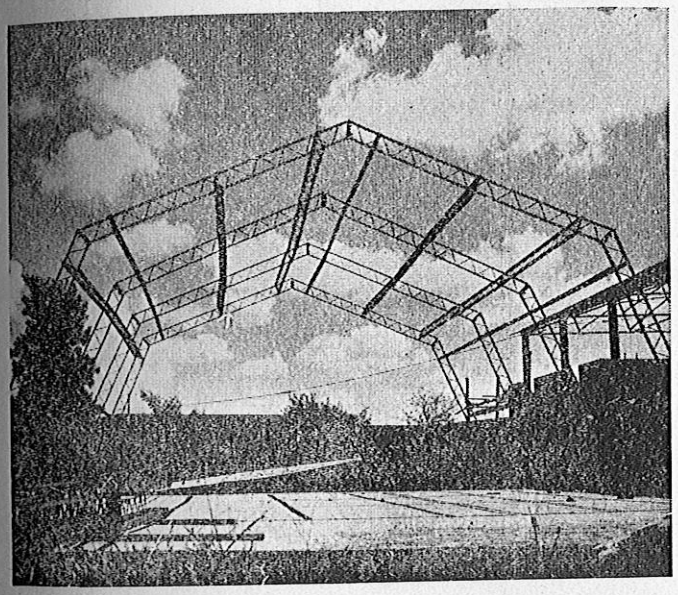

Fig. 2

Intermediate Frames

The intermediate frame consists of four lattice members each of a trapezoidal shape of 2.44 m × 2.34 m. × 12.7 cm . The members are built up of M.S. flats of appropriate lengths welded to two M.S. plates. The lacing consists of M.S. bars, 6.35 mm dia., welded to the M.S. flats. Each lattice member weighs 14.4 kg.

End Frames

The end frame has an additional base member built up of three pieces of 5.08 cm × 5 08 cm × 6 35 mm angle-iron joined together with fish plates and bolts and two vertical posts (L 5.08 cm × 5 08 cm × 6.35 mm) for fixing the door shutters. Two horizontal ledgers (5.08 cm × 5.08 cm × 6.35 mm) are affixed to the posts to carry the cladding, lining and insulation.

Purlins

The purlins are made of 2 Nos. 3.81 cm x 0.48 cm x 2.49 m long M.S. flats with lacing of 6.35 mm diameter bar, and are bolted to the frames. Each purlin weighs 10 kg.

Foundations

The frames can be erected on a prepared concrete foundation or spiked to the ground. Concrete foundations are provided for long term usage, while spiked foundations are provided for a short period usage, say 3-6 months, or where sufficient facilities or time for providing concrete foundations are not available.

Doors and Windows

Doors of any size can be provided by changing the spacing of the vertical members according to requirements. The window frames are made of angle-iron, 25 mm x 25 mm x 6 mm. Windows can be fixed in any bay, but when fixed on opposite sides in the adjacent bays, better distribution of light is obtained at an economical cost. Louvred windows are desirable in hot climates, to provide an escape for hot air near the roof.

Roof and side cladding

The C.G.I. sheets are of 24 SWG having clamp hooks, made out of 2.54 cm x 3.18 mm M.S. flat, welded to them. The sheets are held on the purlins by means of these clamps. This arrangement avoids unsightly holes and speeds up erection and dismantling. It is advantageous to use 3 metre long C.G.I. sheets for the roof so that the 0.69 m long overhang provides full protection to windows in rainy weather. The roofing sheets also have similar clamps welded at top of the sheets for holding the ridge pieces.

Lining and Ceiling

Any building board or plywood of 2.44 m × 1.22 m × 6 mm thick can be used for this purpose. These boards can be fixed on the purlins, by means of metallic clamp hooks which are screwed on to them.

Floor

It is preferable to have a 7.50 cm thick (1:3:6 cement concrete floor laid on a 10 cm thick hard core of 6.3 cm graded stone or over-burnt brick aggregate. In areas where high sub-soil water level is obtained a layer of building paper or bitumen for preventing rise of dampness may be provided over the hard core. Finished floor level must be at least 9 cm above ground level for proper overlap of the cladding sheets with

concrete. In cold climates, it is preferable to have a timber floor and in such a case the inner lining is fixed after the completion of the floor.

Insulation

Insulation materials such as polystyrene boards, mineral wool etc. 2.5 cm thick can be placed in the cavity between the cladding and lining and the roofing and the ceiling. It is desirable to have air gaps on both sides of the insulation material so placed for better insulation.

Assembly and Erection of the Hut

Siting and Orientation

The hut should preferably be positioned with its long axis in an east-west direction or as close to it as possible to obtain maximum comfort inside the building.

Area required

The approximate size of the plot required for erection of a 4 bay hut is about 16m × 12.6 m leaving a clearance of 3 metres alround the hut. This area should be cleaned of all vegetation and top soil and levelled.

Working party

A party of two skilled men and four unskilled men can erect a standard hut (including lining and ceiling) of four bays in about 2 days on a prepared foundation.

Setting out

Since the hut is a prefabricated structure manufactured at a central depot, the setting out should be done accurately with a steel tape. The position of all holding down bolts should be located carefully by checking the diagonal measurements for each pair of bays and finally for the entire hut. It is preferable to set up profile boards with saw cuts to guide the string lines.

If water supply and sewage are to be provided, the necessary pipe line ducts must be formed at this Stage.

Setting the holding down bolts

Bolts may be set in, while concreting is in progress or boxes can be left in the concrete and bolts grouted in afterwards. The latter method permits slight adjustments and is therfore preferable.

Assembly and Erection of the Framework

A good layout of stores will save considerable time and labour. It is advisable to erect one end frame and one adjacent intermediate frame in the beginning and connect them with purlins before proceeding on with the erection of other frames. As the portal frames have little strength along the axis of the hut, until adjacent frames are erected and connected with purlins, a single frame should not be allowed to stand without any support.

The following tools and implements are of great use in erecting the hut.

Portable or movable temporary staging (2 m height) - Alternatively a 3 ton truck may be used for purpose of erection.	...	1 No.
Ladders not exceeding 3 m	...	2 Nos.
Hammer (i) ½ kg	...	2 Nos.
(ii) 2½ kg	...	1 No.
Hand saw	...	1 No.
Screw Driver 30 cm	...	1 No.
Coir rope 1 9 cm × 8 m long	...	2 Nos.
Steel tape, 15 m long	...	1 No.
Steel tape 2 m long	...	1 No.
Putty knife	...	1 No.
Thread ball (250 gm,)	...	1 No.
Spanners (i) D.E. 19 mm × 22.2 mm	...	2 Nos.
(ii) D E. 9.5 mm × 12.7 mm	...	2 Nos.

The frames are assembled on a level patch of ground, preferably at the site for the hut. Two men are usually required to assemble the frame. The procedure for assembly is as under:—

Intermediate frame

(a) Place the lattice members in position with the end plates touching each other.

(b) Insert bolts and nuts at all joints viz., the ridge and the eaves and tighten after checking the alignment and distance.

End frame

The end frames are also first assembled as above and additional base members, door posts and horizontal rails are assembled as under :—

(a) Join three pieces of the base member (bottom tie) with fish plates and bolts and bolt it to the frame.

(b) Fix the two vertical door posts to the frame and the bottom tie by means of bolts and nuts.

(c) Place the four horizontal rails at appropriate position and fix to the frame and vertical posts by bolts and nuts.

Four men are usually required to raise up the frame from ground and bring it to position.

(a) In case the frame is to be put on ground with spikes, a steel bearing plate is bolted beneath the base of each frame in order to spread the loads transmitted, to the ground. It should be ensured that the bases of all frames are in correct alignment, that the ends of the hut are at true right angles to the sides and that all the bases are at the required level. The bases are not fully spiked down until the frame work is complete.

(b) When the frame is to be put up on permanent foundation, the frame is carefully brought to position and bolted to the foundation bolts.

The frame should be supported by ballies in areas subject to high winds till the adjacent frame is also erected and connected by purlins, to avoid distortion of the frame.

Cladding and Roofing

After the frame work has been erected, the following order of erection is followed — fixing of the cladding — fixing of louvre window and windows — fixing of roofing sheets and ridge piece.

Wall cladding

It is preferable to commence the cladding at the two ends. The end cladding should commence at the frame and proceed towards the door. The C.G.I. sheets are hung in position with the upper and lower hook clamps forced home over the outer face of the upper and lower purlins. It is desirable to start the cladding from one corner and proceed successively. Where a window comes, four feet cladding sheets are hung in position on the middle and lower purlins by forcing home the clamps. The surrounding ground is dressed to a slope to drain the water away from the hut. Where necessary, suitable plinth protection or drains are provided.

Doors and windows

The doors are fixed to the hinges already welded on the vertical posts. The louvre windows are fixed over the door by bolts and nuts to the vertical post and the top members of the frame. The windows are hung in position by clamp hooks and forced fully in between the top rail and the middle purlin so as to ensure a proper fit.

Roof covering

The fixing of the roofing sheets is started from one end. The 3 metre C.G.I. sheets are hooked over the purlins and must be forced fully home to engage fully on the supporting purlins. Clamps which may have opened out should be pressed to fit in properly. The ridge sheets are also then pressed in between the clamps provided on the top of the roofing sheets. The ridge sheets are provided with bolts and nuts at the junction of two ridge sheets and bolted to roofing sheets, in locations where wind velocities are high.

Lining and Ceiling

It is preferable to commence the lining from the bottom and finish it at the eaves. The lining material (hard board) is fixed on the inner face of the purlins by means of clamps in the same way as the cladding and roof.

Dismantling and Repacking the Hut

The dismantling of the hut shall be done in the order — Internal partitions and services, if any — Electric wiring, if any — Ceiling and lining — Insulation, if any — Timber flooring, if any — Roofing, — Cladding — windows and doors — Framework. The same number of workmen as required for erection of the hut are suitable for dismantling as well. Almost the same tools and implements as recommended for erection of the hut, are useful in dismantling. Any light oil can be applied to the bolt threads which have been in position for some time, to facilitate the removal of the nuts. It is preferable to have one or two extra sets of socket or box spanners. Bolts and nuts should be placed in a box as they are removed and the box should be clearly marked with the description.

Removal/Dismantling

The ceiling boards are removed first and handed down and stacked on a dry, level surface. Next the lining boards are removed and stacked properly.

In dismantling the roof, the ridge sheets are removed first and then roofing sheets of one side are removed. The other sheets are then removed and stacked properly. When sheets from one side have been removed, the sheets on the other side are removed and stacked.

The cladding sheets are removed by slightly pushing upwards and taking off. The doors and windows are also taken out along with the cladding.

For removal of the framework, the work is started from one end. The vertical posts and horizontal rails of the end frame are disconnected and stacked properly. Before the purlins of the end bay are removed the frame should be supported with guy ropes. The purlins

are removed and stacked properly. The nuts of the holding down bolts are removed and the frame is gradually lowered on the ground. The same procedure is repeated till all the frames are removed. As the frames are dismantled, they are stacked properly.

Packing

After removal, all identical components shall be stacked together. Before packing, all components shall have their identification numbers/marks clearly marked on them, as the identification numbers/marks are liable to fading or rubbing off, specially if the hut has been in position for a long time. The structural components are packed in bundles ; small components and bolts, nuts, etc. are packed in boxes and other articles are packed in crates.

Local Materials, fittings and Electrifications

The strength and stability of the hut framework do not depend in any way on the materials used for cladding. Therefore locally available materials such as thatch, reeds. matting, etc., can be made use of in roofing and cladding. Use of such materials may require slight modification in the spacing of purlins. For purely temporary purpose, tarpaulin or canvass may also be used.

Partitions can be readily provided by putting extra vertical posts and horizontal rails, on any intermediate frame, as are provided in the end frame. In case where concrete floor has been laid, and the partition required is also of a semi-permanent nature, brick wall or concrete block wall may be provided.

Where required, water-borne sanitation can be provided without any difficulty. Mild steel angle iron brackets may be fixed, with bolts and nuts, to the main frame and timber planks may be provided over them to serve as shelves.

The hut can be easily electrified.

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 eighth in the series.

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