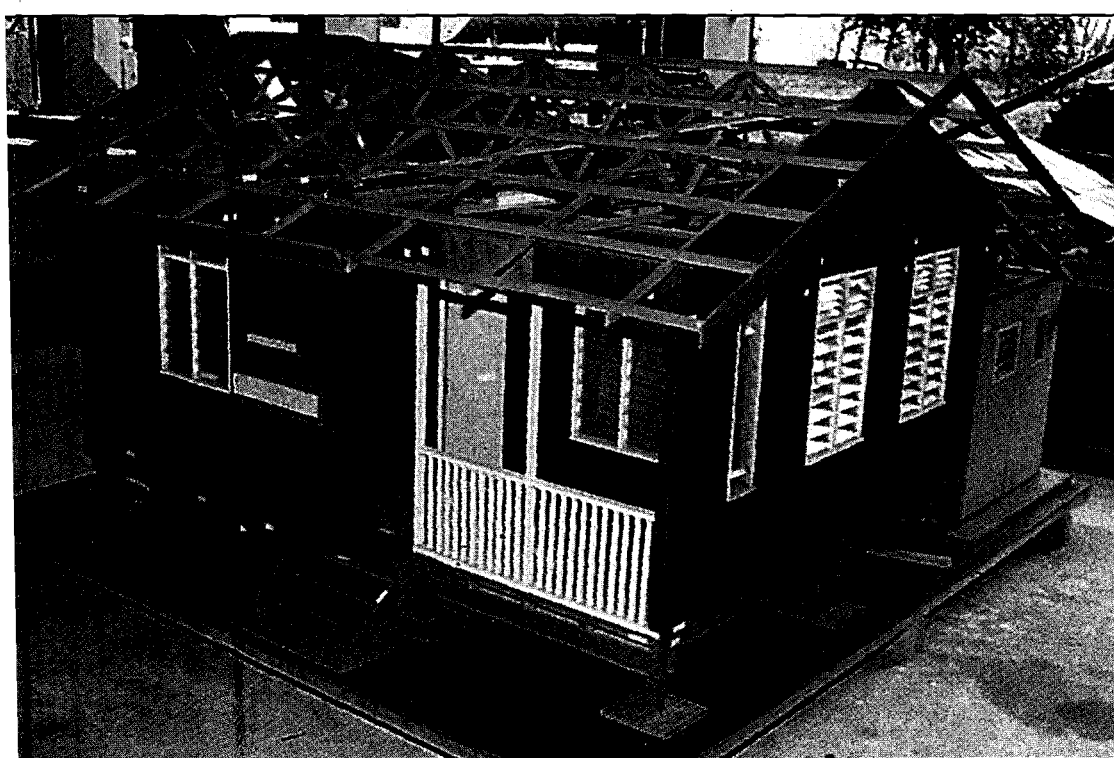


CONSTRUCTION MANUAL OF PREFABRICATED TIMBER HOUSE

by

Mohd Shukari Midon
Chu Yue Pun
Hilmi Md Tahir
Nor Azian Mohd Kasby



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Manual produced under the project
“Research on the Utilization of Tropical Timber in Construction”.
An International Tropical Timber Organization (ITTO) funded project
carried out at the Forest Research Institute Malaysia (FRIM).



Forest Research Institute Malaysia
(FRIM)



ITTO
International Tropical Timber
Organisation

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1996

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Construction manual of prefabricated timber house / by Mohd.

Shukari Midon ... [*et al.*].

(FRIM technical information handbook, ISSN 0127-9793; no. 5)

ISBN 983-9592-55-6

1. Wooden-frame houses – Design and construction – Handbooks, manuals, etc. 2. Prefabricated houses – Design and construction – Handbooks, manuals, etc. I. Mohd. Shukari Midon. II. Institut Penyelidikan Perhutanan Malaysia. III. Series.

721.0448

Editorial: Norani Ahmad & Nik Zanariah Nik Mahmood

Typesetter: Zuriati Ahmadin

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PREFACE

This manual is the end product of the FRIM/ITTO project on "Research on Utilization of Tropical Timber in Construction". The project which was carried out in FRIM was funded by ITTO together with some financial support from FRIM. The aim of the project was to come up with a manual to illustrate the construction of a prefabricated 'low-cost' timber house.

This manual is able to assist those who wish to build prefabricated timber houses either mass-produced in a factory or as single units. The type of house given in this manual is of the timber-framed type, based on the platform method. This manual attempts to show builders the good practice of producing houses so that these houses can perform in a manner as expected of a good timber house. The fundamental principles of timber-framed housing are also explained. These general principles are also applicable to other timber frame methods.

The house as described in this manual is only a typical factory made timber-framed house. Other arrangements of the house as regards to layout, height, size, etc. are possible and can be built using similar procedure and guidelines as given in this manual.

Beside describing the procedure in building the house, this manual also has a chapter on the maintenance of the house after it has been built and is being occupied. A brief specification of the timbers and the types of materials used in the construction of the house are also given.

ACKNOWLEDGEMENTS

The publication of this manual is made possible with the financial support and assistance from the International Tropical Timber Organization (ITTO) through its funding for the project "Research on the Utilization of Tropical Timber in Construction" which was carried out in the Forest Research Institute Malaysia (FRIM).

We wish to record our thanks to Dr. Salleh Mohd. Nor, the former Director General, and Dr. Abdul Razak Mohd. Ali, the present Director General of FRIM for their encouragement, and the supporting staff for their assistance throughout this project.

Chapter 1

INTRODUCTION

There are at present in Malaysia a number of factories making prefabricated timber houses using their own proprietary system of construction. The prefabricated house as proposed here is another method of construction where the parts of the house may be assembled in the factory or at the site in a do-it-yourself manner. Since there are very few guides available on the construction of timber houses, it is believed that a manual of this type illustrating such construction would be useful to builders of timber houses.

The aim of this manual is to recommend a system of construction not as a close proprietary system but as a general method for all who are interested in the use of timber.

The system of prefabrication proposed in this manual is the result of research carried out in FRIM on the structural strength of timber, timber joints, wall panels, roof trusses and the different components that made up the whole house. The system proposed here is the Modular Panel System.

The house can be built individually or mass-produced in a factory since they are of the prefabricated system. The step by step procedure in building the house as described herein is straight forward and easy to follow. There are many illustrations or sketches in this manual and this would further help a builder to comprehend what is described in the text. Not all the detailed dimensions of the various components are given in the text of this manual, but attempts are made to show the procedure and the sequence of construction. Detailed dimensions of the various components are given in the drawings of the house, in the Appendix.

Although the house is primarily designed for use in Malaysia, it would also be suitable for the building to be constructed in regions with similar climates, except in places which have very strong winds or hurricanes.

The arrangement of the house such as the partition of the rooms, hall, or other internal partitions can be altered to suit individual preferences without affecting the structural strength of the house as a whole, since these partitions are designed as non-load bearing walls.

Chapter 2

FABRICATION SYSTEM

There are a number of prefabrication systems in building a timber house. The following are some of them.

Pre-cut system

The pre-cut system is the oldest system of prefabrication. Pieces of timber are processed, cut to the required lengths, notched or drilled at the factory. The pieces are then marked and transported to the site for assembly. Transportation of the pre-cut timber is simple because they can be bundled into units and delivered to the building site. Compared to the conventional method of cutting timber in falling lengths at the site, this system is more accurate in its measurement and material wastage is minimised.

Modular panel system

Under the modular panel system, building components are constructed in the factory by two or three men without the use of cranes or other lifting devices. Wall panels are in uniform sizes using a module (M) as a unit of measurement. The normal unit 'M' is 1.22 m (4 ft.) in length to tally with the size of most cladding materials in Malaysia such as plywood, hardboard, chipboard and cement board. The modular panel system is the system adopted in this manual (see Figure 1).

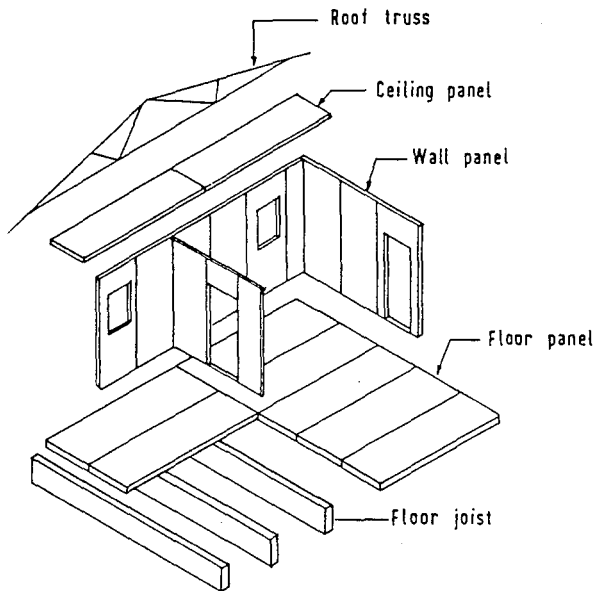


Figure 1. Modular panel system

Large size panel system

The large size panel system as shown in Figure 2, is suitable for use when constructing a large number of small houses at the same time. Large panels up to 10 to 12 m equalled to the length of adwelling can be assembled in the factory and delivered to the building site for erection. The use of large size panels reduces the problem of joining together the small prefabricated panels satisfactorily at the building site. However this advantage is offset by the increased in transport and handling costs and the necessity of using cranes in lifting the large panels.

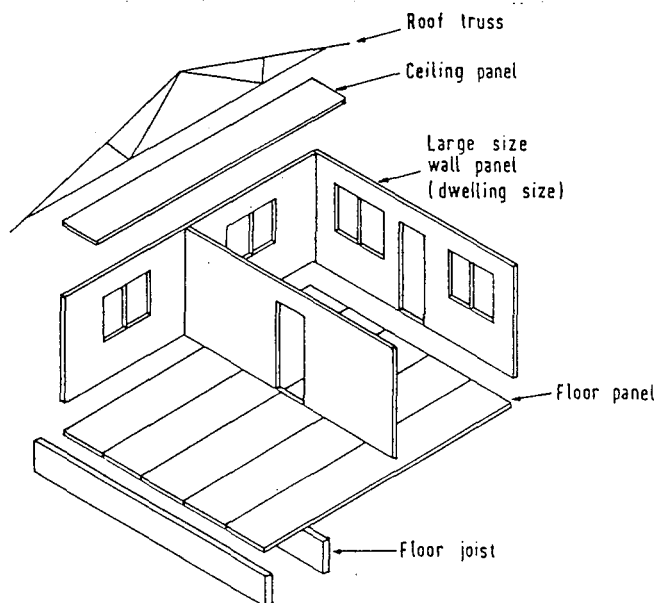


Figure 2. Large size panel system

Volume element system

In the volume element system of prefabricated housing, dwellings are completely finished at the factory. This system permits a home buyer to see exactly what his house will look like before it is built. This method of construction is very much faster than the other methods as far as site erection is concerned, but it requires the use of trailers for transportation and cranes for erection (see Figure 3).

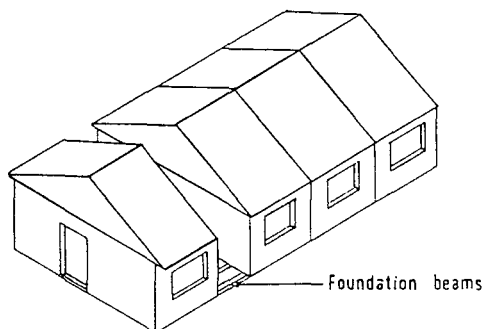


Figure 3. Volume element system

Chapter 3

DESIGN OF THE HOUSE

The traditional method of house construction in Malaysia is of the post and beam structural form in which beams spaced widely apart (between 2 and 4 m in domestic buildings) are supported on individual columns or posts to form a skeletal structure. The non-load bearing infill panels will form the wall and window units between the columns.

The house proposed in this manual is the timber-framed or wood-framed house and falls within the category of modular panel system as mentioned previously. The method of timber-framed house construction is traditional in North America, Scandinavia and some other parts of the world but is comparatively new in this country.

Basically there are two methods of building a timber-framed house, the balloon frame and the platform frame method. The balloon frame method has studs running the full height of the building and the intermediate floor joists are side-fixed to the studs and supported from them. The system is only suitable for either two or four storey buildings. In the more common platform frame method the shell is built one storey at a time using storey height wall panels to support the intermediate floors, which are then used as a construction platform to erect the next storey or the roof above. The platform frame method is used in this manual. These two framing methods are shown in Figures 4 and 5.

In timber-framed housing, partitions or wall panels are assembled by having the top and bottom horizontal plates spaced at a distance apart to suit the designed height of the building which in this case is 2.75 m (9 ft.) high. Vertical studs at generally 0.16 m centres are then nailed to the top and bottom plates. Where necessary noggings are added in to strengthen the edges of the intended sheathings. Sheets are then fixed to the framework either on one side only or on both sides. For simplicity all the framework is assembled with butt joints and fixed with nails. Figure 6 shows such a wall panel which is normally prefabricated at the factory. For ease of man-handling, the pre-assembled wall panels are made to a length not more than 3000 mm long. The wall panels are then erected over the prepared platform and the roof is put over it to complete the building.

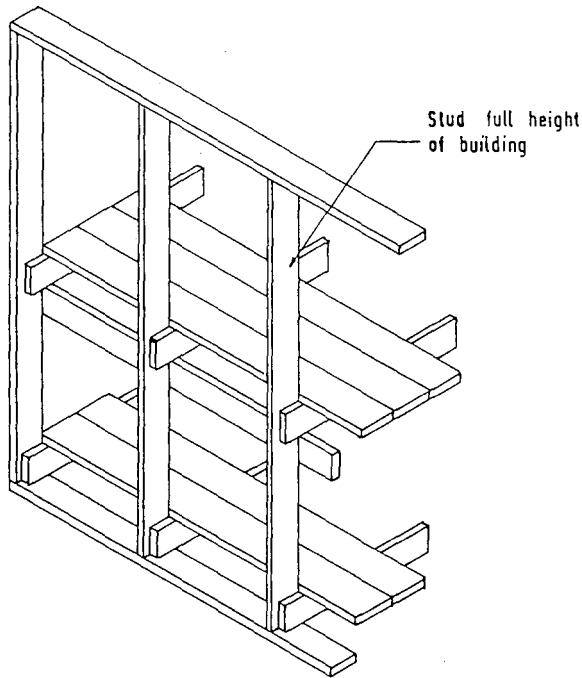


Figure 4. Balloon frame method

The main advantages of the timber-framed system of construction are:

- (1) Transportation of pre-assembled panels is simple;
- (2) Less labour is required on site, even when the panels are made up on site. If the panels are assembled at the factory, considerable saving in labour are possible;
- (3) The pre-assembled wall panels can be erected manually by two or three men without the use of cranes;
- (4) More speedy erection. It is possible to put up the whole timber-framed wall panels of a house within two to three days. Once the roof is covered, other works such as plumbing and electrical services can be started inside under assured dryness;
- (5) Houses can be finished at low cost to a high standard of thermal insulation,
- (6) Flexibility in architectural design, modification and extension is possible.

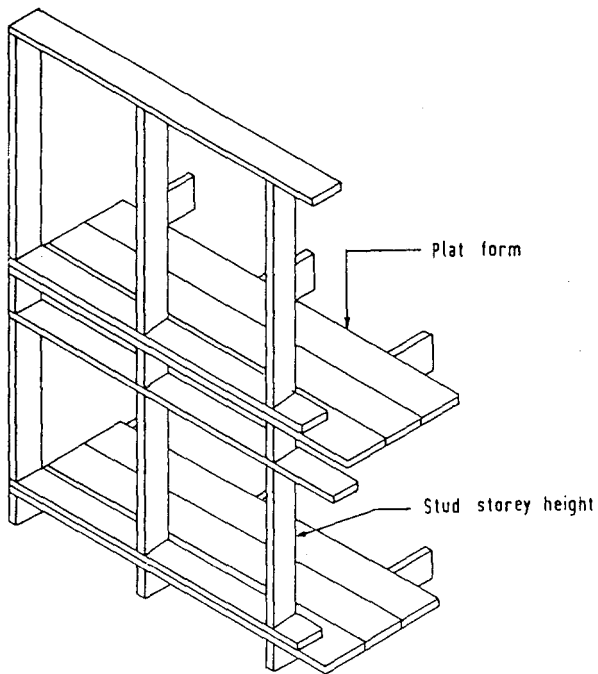


Figure 5. Platform frame method

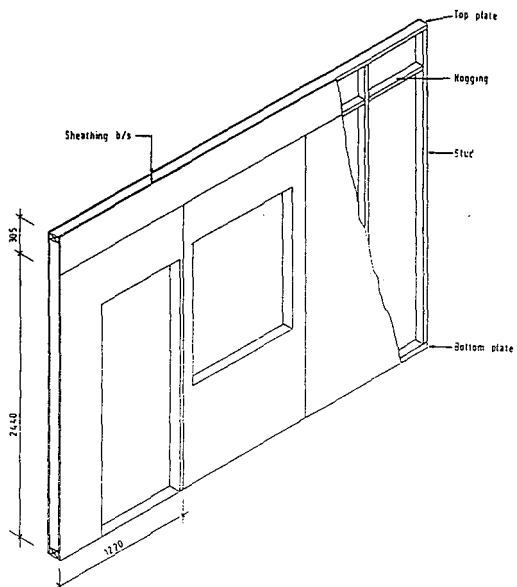


Figure 6. Typical prefab wall panel

Chapter 4

BASIC PRINCIPLES

The dimensioning of the house is based on a modular system which means the best use is made of materials, especially sheet materials and also the house can easily be extended at a later stage. Most sheet materials obtainable locally are of size 1220 x 2240 mm, therefore the planning of the house is based on the use of dimensions which are multiples of 610 mm. Hence a grid of 610 mm is used in the plan layout as well as positioning in fixing of the partitions, roofs, joists, etc. These and an alternative future extension are shown in Figure 7. In the modular panel system, architects can design a wide variety of houses with many different floor plans using prefabricated panels.

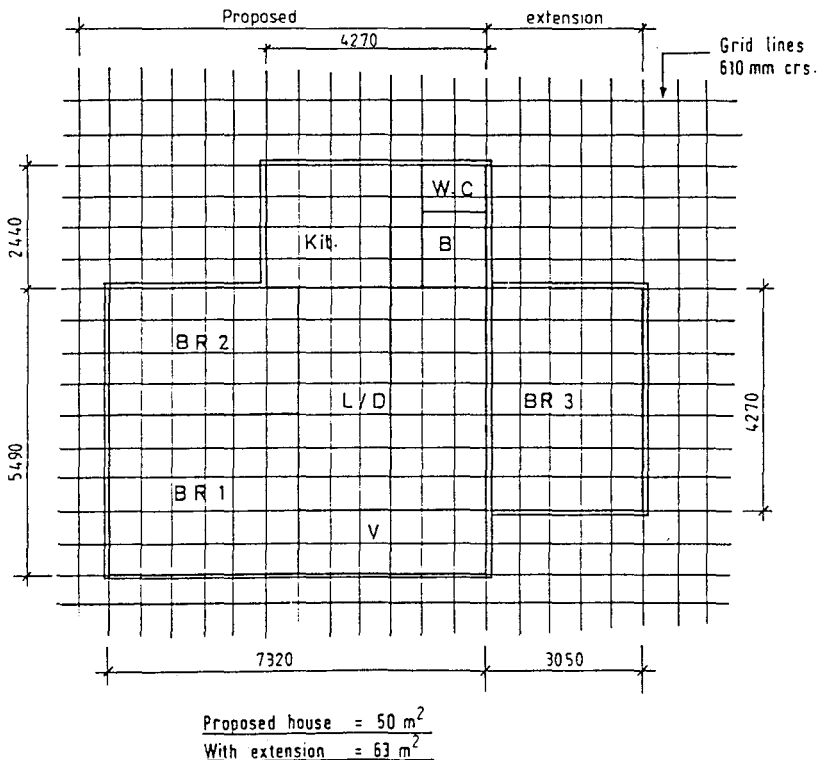


Figure 7. Plan of building on grid lines

Unlike the post and beam type of construction where the load is supported by the post and beam, the timber-framed house has the wall panels supporting the load which means the wall panels are made load bearing.

In the arrangement of different components of the house, it is desirable that roof trusses, studs in wall panels and floor joists are kept in line (see Figure 8) for efficient transferring of load from the roof to the ground via these members. In this proposed house, the spacing of the trussed rafter roofs is at 1220 mm centres while those of studs and floor joists are at 610 mm centres.

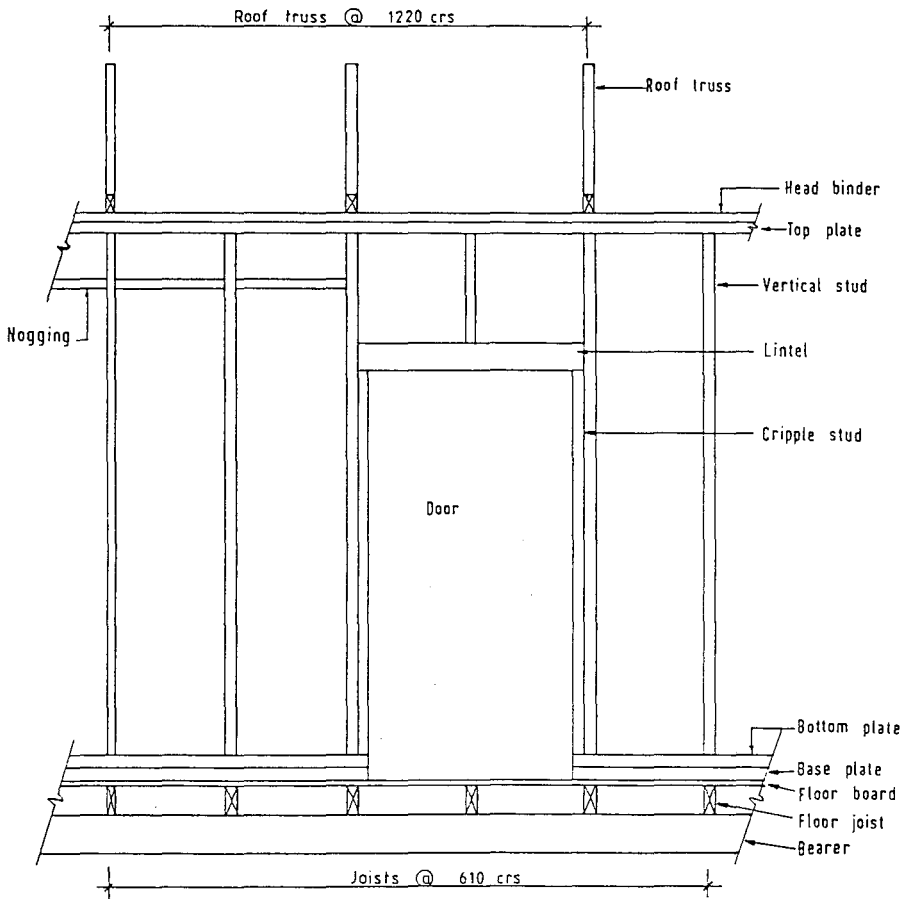


Figure 8. Vertical alignment of roof, stud and joist

Wall panels can be of load bearing or non-load bearing walls type. Load bearing walls are designed to support the floor and the roof above them. Non-load bearing walls do not support any load above them and they function as partitions. They are therefore made shorter than the load bearing walls in the same storey so that the roof or the floor joist above them does not rest on these walls as shown in Figure 9.

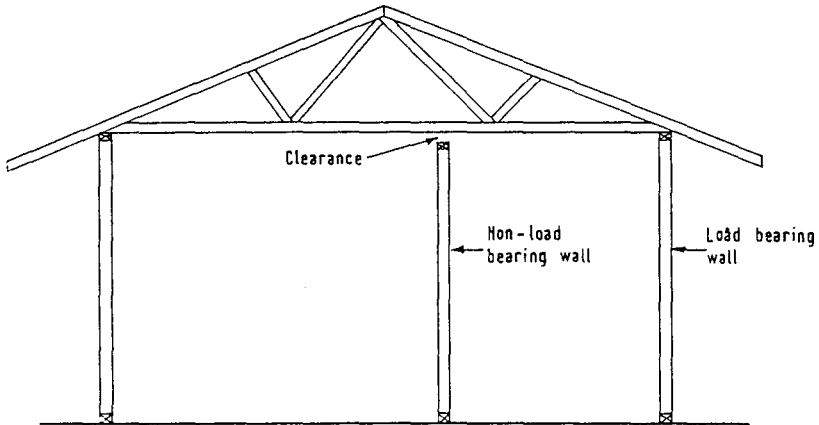


Figure 9. Clearance for non-load bearing wall

If there is an opening in the wall panels such as for door or window, a lintel is required to span the opening. The ends of lintels are supported on extra studs known as cripple studs which are fixed at each side of the door or window opening as in Figure 8. For small openings, lintels are not necessary; they can be fitted between studs and are simply framed up.

The following sizes and tolerances must be observed in making wall panels:

- (1) Depth of timber studs must be the same throughout, so that the width of the finished panel with sheathings is the same. For example, if the stud is specified as 47 by 97 mm then the latter dimension must be accurate or regularised.
- (2) A vertical gap of between 1 to 3 mm should be provided between plywood sheathings to allow for their expansion. The gap is then covered up with beading.
- (3) The finished length of each completed prefabricated panel is to be 1 to 3 mm less than the finished size as stated in drawing.

The house may be built as a separate detached unit or linked to each other by a separating wall as shown in Figure 10.

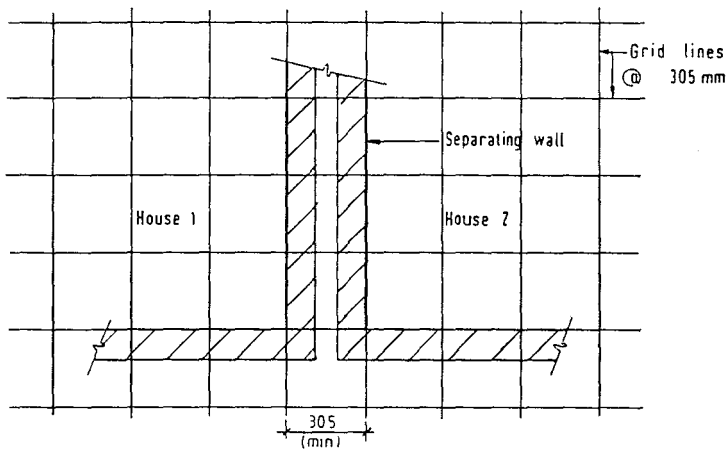


Figure 10. Plan of separating walls

Sequence of construction

The proposed house is shown in plan view in Figure 7 and in perspective view in Figure 11. The main building at frontal end is on a raised platform which is 700 mm above the ground and the kitchen at the back is on ground level. The total built-up area is 50 m² and the height of the building from floor to ceiling is a comfortable 2745 mm (9 ft.). The house can be enlarged in the future in a direction as shown in Figure 7.

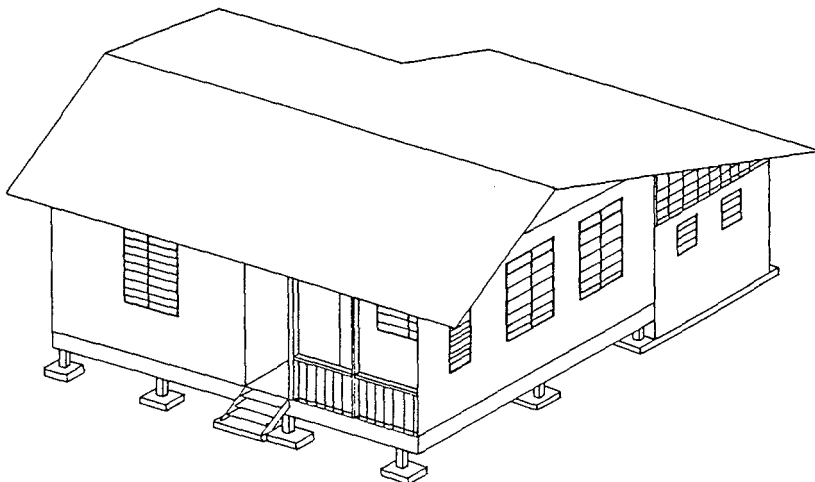


Figure 11. Perspective view of house

In the sequence of construction the ground is first prepared by laying concrete footings. Posts are erected over the footing. Bearers are attached across the posts with bolts. Floor joists with stiffening across pieces are laid over the bearers. Floor boards with tongue and groove are conceal-nailed to the joists and the platform is now ready for the next stage of construction.

Over the platform, pre-assembled wall panels are put up. During this time work can also start simultaneously in the kitchen which is on ground level and which is not connected to the platform at this stage. When the panels are erected over the platform as well as over the kitchen, head binders or wall plates will then bind the top of the panels together; and they also act as support for roof trusses. The panels are also fixed firmly together sideways with nailed iron plates or angles, which are then concealed with beading.

On top of the wall plates, prefabricated trussed rafter roofs are fixed. The rafters are braced diagonally and purlins are nailed over them. When roofing sheets have been laid, the dwelling is protected from rain and shine. Doors and windows can now be installed. All other subsidiary works such as plumbing, electrical wiring and sanitation can be commenced.

The house may now be painted and is ready for occupation.

Chapter 5

GENERAL REQUIREMENTS AND SPECIFICATION OF MATERIAL

General requirements

The general requirements for materials for the house are as follows:

Timber

Timber group:	Strength Group B as given in the Malaysian Standard Code of Practice M.S. 544 :1978 [SIRIM(2)].
Timber grades:	Standard structural grade in accordance with Part III, Section J MGR(3).
Timber size:	As given in drawing. Exposed surfaces shall be planed, unexposed surfaces sawn unless regularised, such as studs size of 47 x 97 mm where the dimension of 97 mm is fixed.
Moisture content:	At time of installation, M/C of floor boards shall not exceed 18% and M/C of other timber shall not exceed 22%.
Treatment:	Pressure impregnated with CCA to a dry salt retention of 5.6 kg m ⁻³ and the depth of penetration of CCA shall be at least 12 mm.

Plywood

Plywood should be purchased from a reputable mill. It should be either of the water boil proof (WBP) type or of the moisture resistant (MR) type in the respective position as stated in the plan.

Cement-bonded particleboard

Cement-bonded particleboard for kitchen use should be obtained from a reliable agent of the cemboard manufacturing factory. Fixing of cement-bonded particleboard shall be in accordance with manufacturer's instructions.

Others

All other materials should be obtained and used in a manner consistent with good construction practice.

Specification of materials

The specification and quantities of materials as given in Table 1 are only as a guide. The detailed dimensions can be obtained from the technical drawings, in Appendix 1.

Table 1. Specification and quantities of materials

Item No	Part	Material	Size (mm)	Remarks
(A) Platform				
A1	Post	Timber	120 x 120	Top or conc. footing
A2	Bearer	"	60 x 197	B/S of post
A3	Bearer splice	"	30 x 194	Lengthen splice
A4	Joist	"	47 x 145	Top of bearer
A5	Joist stiffener	"		
	(I)	"	50 x 50	At end of joist
A6	" " (II)	"	50 x 75	At mid joist
A7	Floor board	"	22 x 145	T & G
A8	Header joist	"	20 x 194	Close joist gap
A9	Base plate	"	47 x 112	Thicker panel
A10	Bolts & nuts	M.S.	12.7 dia.	Joint fastener
A11	U-strap	"	6 mm thick	To fix post
A12	Plate	"	6 mm thick	Bearer for post
A13	Round bar	"	12.7 dia.	Reinforcement
A14	Conc. footing	Concrete	1:2:4 mix	Footing for post
A15	Hardcore	Stone	25 mm size	For conc.
(B) Kitchen floor				
B1	Floor	Concrete	100 mm thick	Whole floor
B2	Curb	"	50 x 115	Thicker panel
			50 x 88	Thinner panel
B3	Hardcore	Stone	25 mm size	For conc.

(C) Wall panels

C1	Studs (I)	Timber	47 x 97	Thicker panel
C2	" (II)	"	47 x 72	Thinner "
C3	Lintel (I)	"	97 x 145	Thicker "
C4	" (II)	"	72 x 145	Thinner "
C5	Sheathing (I)	Plywood	9 mm WBP	Outside surface
C6	" (II)	"	6 mm MR	Inside "
C7	Sheathing (I)	Cemboard	10 mm	Kit. O/S
C8	" (II)	"	8 mm	Kit. I/S
C9	Beading (I)	Plywood	9 mm	In strips
C10	" (II)	Cemboard	8 mm	" "
C11	Pynda nail plate	Product	63 x 89	Connection, flat
C12	" angle "	"	44 x 44 x 93	" corner
C13	Plate w/holes	M.S.	80 x 80	Connection, Comb.
C14	Angle plate w/h	"	48 x 48 x 80	Con. Cem. corner
C15	Dowel	"	12.7 dia.	Embedded in curb

(D) Head binder

D1	Platform (I)	Timber	47 x 112	Bind thick panel
D2	" (II)	"	22 x 84	" thin "
D3	Kitchen (I)	"	47 x 115	Bind thick panel
D4	" (II)	"	22 x 88	" thin "

(E) Roofing

E1	Rafter, tie, web	Timber	35 x 72	Truss assembly
E2	Brace	"	22 x 97	Brace truss
E3	Nogging	"	38 x 50	For ceiling board
E4	Gusset plate	Plywood	9 mm WBP	B/S of truss joint
E5	Gable end	"	"	to close end
E6	Ceiling	"	4 mm MR	2' x 8' zigzag
E7	Purlin	Timber	35 x 72	Top of truss
E8	Fascia board	"	20 x 145	All round roof
E9	Roofing sheet	Fibre cem	1830 & 2440	2 sizes
E10	Ridge piece	"	Product	At peak

(F) Door and window

F1	Flush door (I)	Ply/timber	O/A 840 x 2100	Main entrance
F2	" " (II)	"	" 770 x 2100	Room / kitchen
F3	" " (III)	"	" 770 x 2100	Bath / WC
F4	Window (I)	Adj./fixed louv.	1055 x 1587	7 off, platform
F5	" (II)	"	414 x 1587	1 off, "
F6	Window only	Adj. louv.	1055 x 1213	1 off, "
F7	Fixed louv. (I)	Glass	403 x 610	1 off, "
F8	" " (II)	"	440 x 610	1 off, "
F9	" " (III)	"	700 x 610	1 off, "

(G) Water Tank

G1	Water tank	Product	750 x 1220 x 540 high	Top of bath
G2	Beam	Timber	4 / 47 x 97	Tank support
G3	Seating	Plydood	9 mm WBP	Top of beam

(H) Stairs (2 off)

H1	Stringer	Timber	60 x 219	Entrance & kit.
H2	Tread	"	47 x 250	2/3 treads
H3	Support strip	"	50 x 50	Attd. to string
H4	Angle iron	M.S.	63 x 63 x 200	Landing attach

(I) Railing

I1	Railing	Timber	47 x 97	Frame for mesh
I2	Balustrade	"	20 x 20	To rail and floor

(J) Wire mesh in Kitchen

J1	Framework	Timber	47 x 97	Frame for mesh
J2	Wire mesh	Product	50 x 50 crs.	Close opening

Chapter 6

DETAILS OF CONSTRUCTION

Site access

Before construction begins, access to the site must be looked into, especially if the house is to be built in a remote area. If necessary an access road suitable for vehicles has to be constructed to transport construction materials to the site.

Although most of the component parts of the building are pre-assembled at the factory, electric power and water supply are still required for many tasks during the building process. Electric supply may be obtained from the supply mains or obtained from a generator. Water may be obtained from the water mains, well, river or transported to the site.

At the plot, besides the area required for the proposed house, space for the storage of prefabricated components and other building materials must be allocated away from building sites.

Preparation of site

The site of the house must be prepared first before construction work begins. The soil is examined to see whether it is suitable for the building. Since the proposed house is constructed of timber and is therefore light, most normal soils would be suitable for its erection. If the place is known to be infested with termites, an anti-termite treatment is recommended for the soil before construction begins.

The site should be cleared of all unwanted vegetation. During the process of grading, roots and other cellulosic materials should be removed from the building lot. Care must be taken to obtain adequate drainage of the area and in particular of the building site. The frontal of the house may be built on level ground or on a gentle slope as this portion is of the raised platform type and hence the platform can be made level by adjusting the footing level or the length of the post (see Figure 12). The height of the floor must be at least 700 mm above the ground for effective ventilation. The site for the kitchen at the rear should be made level by cutting or filling earth with proper ramming to ensure the prepared surface is firm.

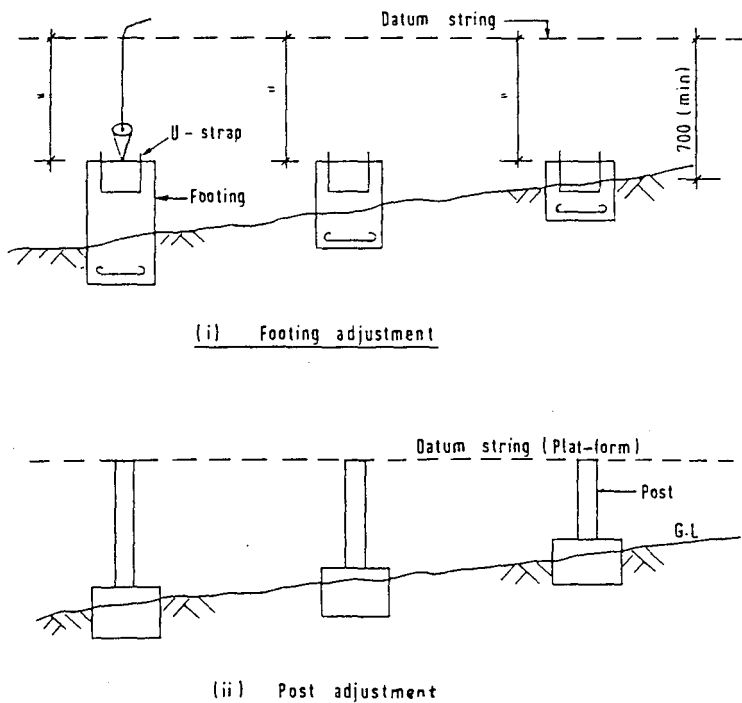


Figure 12. Platform on sloping ground

Setting out

When the site is prepared, the next step is to locate the house on the plot. The house should not be built too close to the boundary to allow rooms for one to move around the house with ease. Also if there is a house in the neighbouring plot, the empty space acts as firebreak. In Malaysia the minimum spacing is specified in the Uniform Building By-laws, 1984 or the latest edition. If the plot is large enough building is located near one end of the plot to give allowance for future extension (see Figure 13).

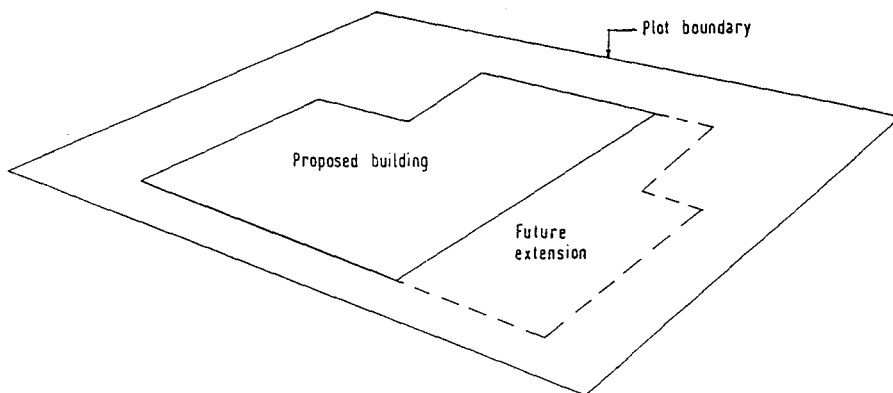


Figure 13. Position of building in plot

When setting out the position of the platform, first mark on the plot the approximate outline of the whole platform by driving in temporary pegs at the four corners of the house where the footings are to be built.

From the markings on the ground, set out the corners of the house by putting in batter boards. There are two batter boards at each corner, making it eight for the four corners. The batter boards consists of two vertical stakes 50 mm x 100 mm x approximately 1 m long driven into the ground. These stakes are fixed at a minimum distance of 1 m beyond the lines of corner foundation footings to avoid being disturbed during excavation (see Figure 14). A horizontal board of 25 x 150 mm is then nailed to the vertical stakes. The tops of all horizontal batter boards are made the same level. This can be achieved by checking with a surveyor's level or by using a transparent hose filled with water as shown in Figure 15. The highest corner of the house is chosen as the datum batter board where the levels of all other batter boards should follow.

When the batter boards are in position, strings are then stretched taut between the boards. To indicate the positions of the strings in the batter board, a nail is driven or a saw kerf is made on the board so that the string may be replaced if disturbed. Two adjoining sides of the building are first set using two steel tapes. To check the squareness of the two sides, a third tape is used to measure the diagonal. The lengths of the two sides are 7230 mm and 5400 mm. The length of the diagonal is therefore equal to:

$$\text{Diagonal} = \sqrt{(7230^2 + 5400^2)} = 9096$$

If the above length is too long, the squareness of the corners can also be achieved by using the common rule of "3-4-5" for a perfect 90° corner as shown in Figure 16. The sketch also shows the position of the first corner by

using a plumb bob and driving a nail into a stake underneath it. With the above procedure, three corners of the house are fixed. The fourth corner is established in a similar way. Check the diagonals again to make sure all corners are square.

Intermediate points of the footings are next marked using a steel tape and plumb bob. The measurements should always start from the corners and move along the string. The initial settings of the stakes may be corrected now if they are not accurate. The positions of all 12 footings are now set.

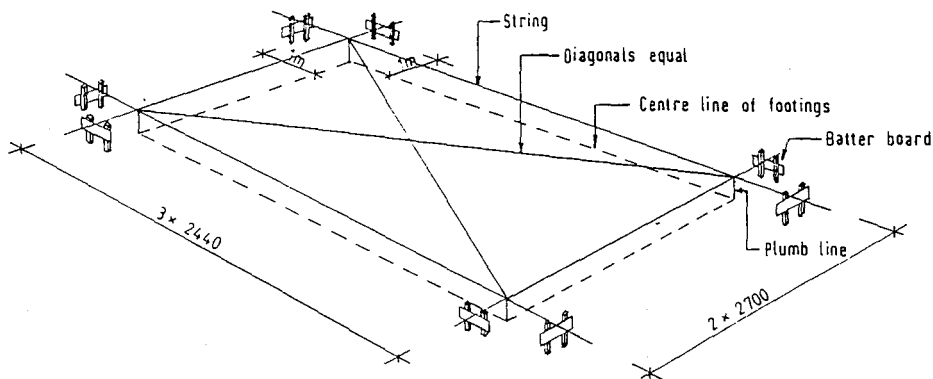


Figure 14 . Fixing outline of house

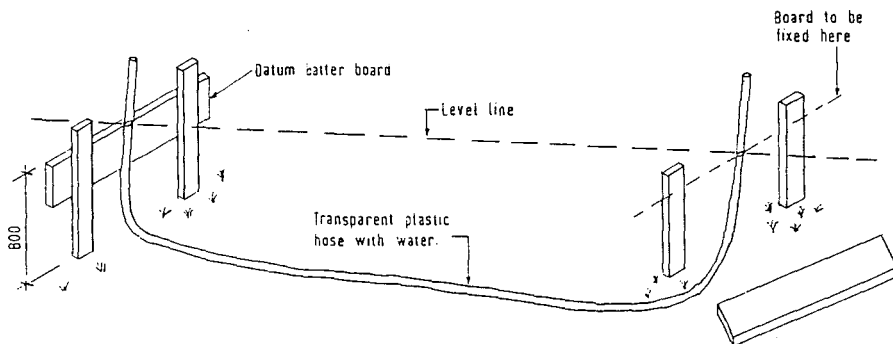


Figure 15. Leveling batter board

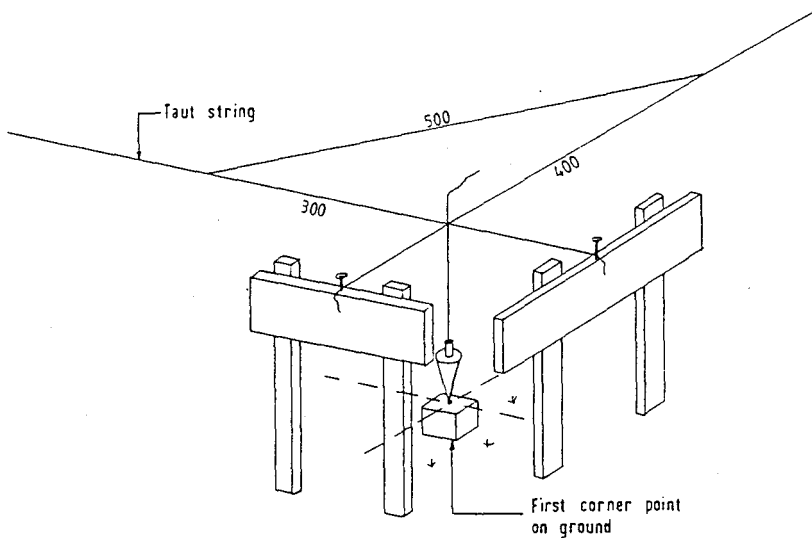


Figure 16. Fixing one corner

Footings

The strings can now be removed but the batter boards should be left in position undisturbed, for further alignment and levelling.

Excavate soil for the 12 footings at the positions marked on the ground. The size of each hole is 600 mm square and 400 mm deep. When the holes are ready, hardcore is placed into the holes and rammed properly up to 150 mm thick. A level of sand is put on top of the hardcore.

Construct framework to hold the concrete. The minimum depth of concrete footing is 300 mm but may be of greater depth depending on the contour of the land if it is decided that the top surfaces of all concrete footings are of the same level. Top of concrete footing should be a minimum of 50 mm above the ground level. The other alternative is to vary the lengths of the posts over the footings in which case the footing surfaces need not be of the same level. Before concrete is poured, reinforcement consisting of 12 mm diameter Mild Steel (MS) bars are placed near the bottom of each footing and MS U-strap for the posts are put at the top of the footing. The U-straps must be properly aligned and levelled by using strings between batter boards and plumb bobs as shown in Figure 12(i).

Concrete can now be mixed. The proportion of the mix is 1 part cement, 2 to 3 parts sand depending on its wetness and 4 parts stone. Mixing of concrete is preferably done using concrete mixer. If mixer is not available, mixing can be performed manually but it must be done thoroughly until the whole mix is uniform. The mixed concrete is then poured into the prepared framework and

is then rodded or vibrated to achieve a dense concrete making sure the fixed reinforcement is not being disturbed.

Platform

When the concrete footings are made, the next step is to fix the posts over the footings. First put in MS bearing plates 120 x 120 x 6 mm thick within the U-strap and then put in the posts, each measuring 120 x 120 x 499 mm high. Fix the bottom of each post to the U-strap with 2 bolts through holes previously drilled (Figure 17).

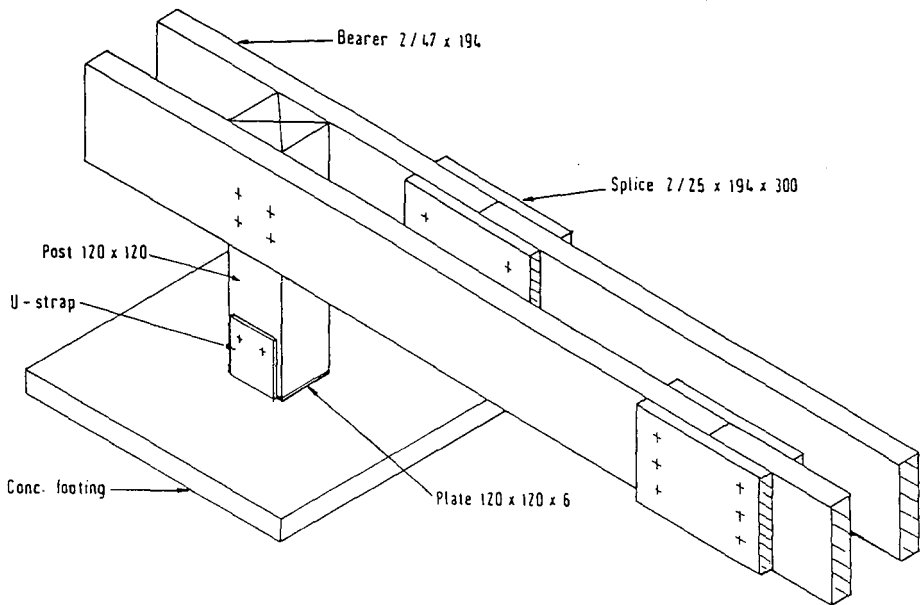


Figure 17. Joining details of post and bearer

Bearers can now be attached to the top of posts, one on each side with 4 bolts running through the 2 bearers and post. Washers are required for all bolt heads and nuts if they bear directly on the timber surface. The bearers are lengthened by splice joints at a place between the posts as shown in Figure 17. While fixing the bearers, care should be taken to ensure the posts are truly vertical, the top of all bearers are horizontal and of the same level.

Floor joists are next placed on top of the bearers. They are fixed to the bearers by slant nailing using 75 mm nails, one on each side of the joist as shown in Figure 18. To stiffen the joists and to prevent them from tilting, stiffening cross

pieces 50 x 50 mm are placed at each end and 50 x 75 mm at the centre. To accommodate the cross pieces, notches are cut at the top ends of the joists. Figure 19 shows the joists being fixed in position with the stiffening cross pieces embedded in the joists.

Floor boards in the form of strip flooring 30 x 145 mm with tongue and groove are next laid over the joists. Fit groove of one board to tongue of the matching board snugly and blind-nail through the tongue to the joist below as shown in Figure 20. A board or header joist 20 x 194 mm is fixed to the ends of the joist with its top level with the floor boards as shown in Figure 21. This board will conceal the empty spaces between the joists.

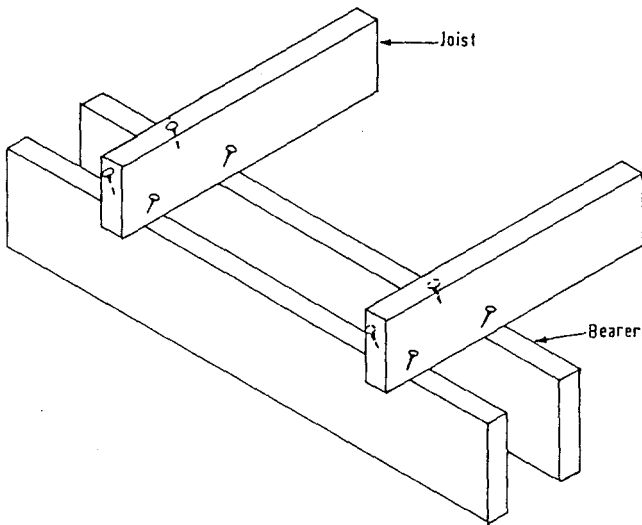


Figure 18. Slant nailing of joist to bearer

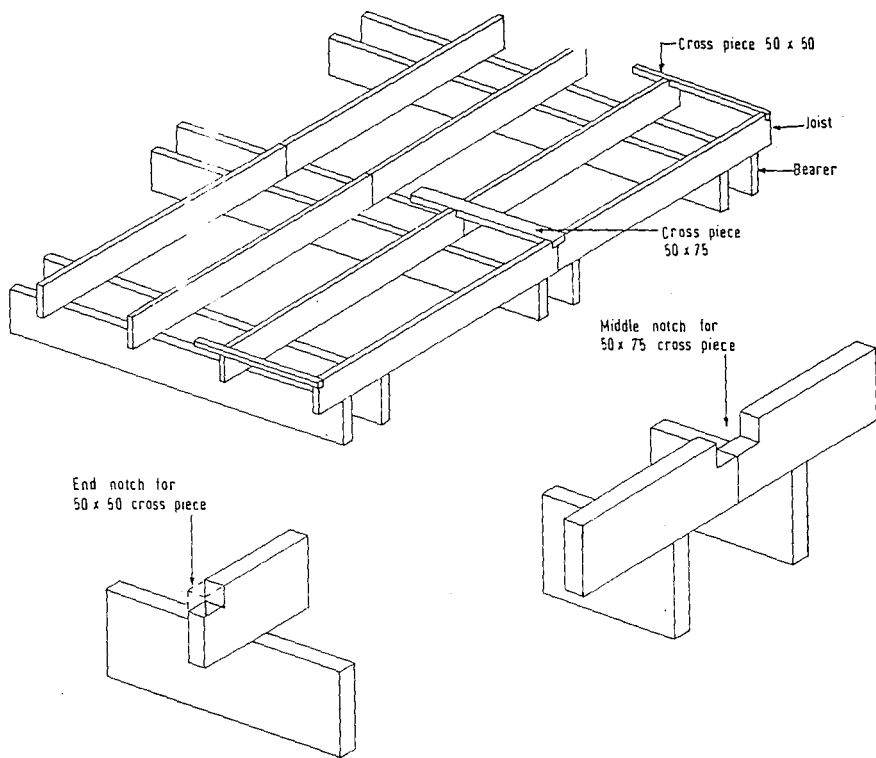


Figure 19. Attachment of cross piece to joist

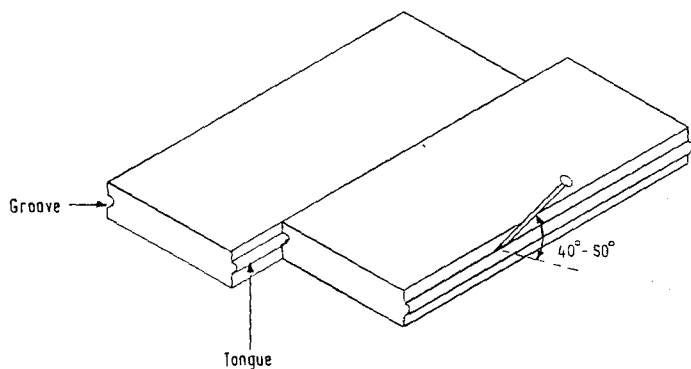


Figure 20. Concealed nailing of floor board

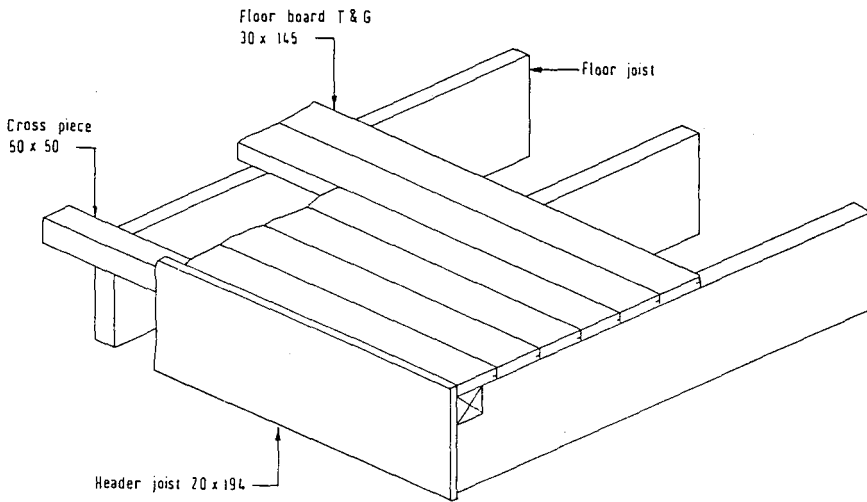


Figure 21. Floor boards on joist

The whole platform is now complete. At this stage the construction of the rear portion of the kitchen can be started either separately or simultaneously with the main building. The description of the kitchen's construction is given later.

Wall panels

Wall panels can now be erected over the platform. For speedy work panels are pre-assembled at the factory and transported to the site before the completion of the platform. The panels can of course be assembled at the site especially if only one individual house is built. Panels assembled at the factory are usually more accurate than those assembled at site.

If assembled at site, extensive labour can be saved by having all major pieces such as studs and sheathings pre-cut to the correct sizes in the factory before delivery. The assemblage of panels can be done on level surface such as a concrete slab or on makeshift trestles.

Base plates or sill plates, where wall panels are erected, can now be fixed over the platform. The sizes of the plates are 47 x 112 mm for the exterior walls and 47 x 84 mm for the interior walls to match the widths of wall panels. The position of these plates are as shown in Figure 22. After making sure that the positions and the squareness of the corners are correct, nail the plates to the floor boards using 76 mm nails at 300 mm centres in a zigzag manner.

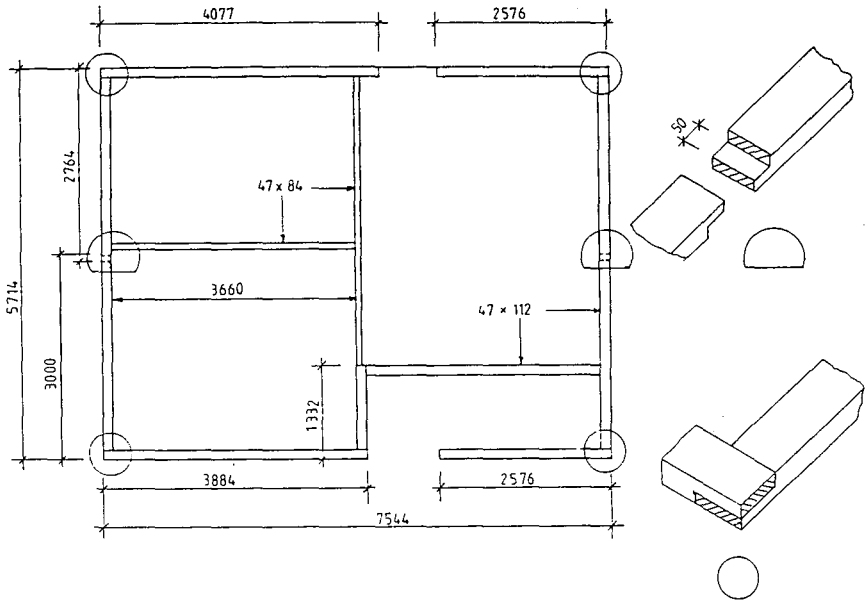


Figure 22. Base plates and the type of joints used

The pre-assembled wall panels can now be installed. The first panel to be installed is the corner one which is panel No. 1 in the drawing. Nail the bottom of the panel by skew-nailing to the base plate. To prevent it from tipping over and to maintain its upright position, it must be propped up by using temporary diagonal bracing as illustrated in Figure 23. These temporary bracing can only be removed when the panels are permanently fixed in position. Subsequent panels are similarly erected. There are altogether 21 panels over the whole platform and 6 panels over the kitchen. Figure 23 shows three panels had been put up over the platform area and are arbitrarily numbered 1, 5 and 6 as in drawing.

The panels over the platform are 2745 mm (9 ft.) high and the longest length is 2550 mm so that they can be man-handled without the use of cranes. It is suggested that to ease lifting the panels which are sheathed both sides, four handles are temporarily fixed at about 1000 mm high near the ends of each complete panel. The handles are solely used for the purpose of lifting the panels during construction and can be removed as soon as the panels are in position.

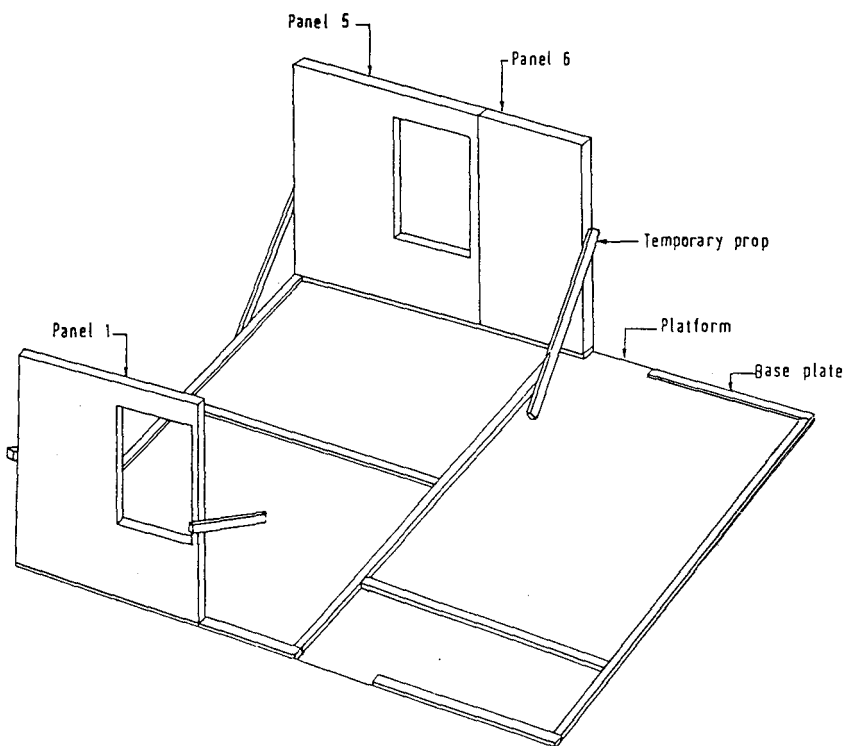


Figure 23. Erection of panels

Wall plates or head binders are now fixed over the top of the wall panels. Wall plate sizes of 47 x 112 mm are fixed over the thicker exterior walls while the 22 x 84 mm pieces are fixed over the thinner interior walls. As mentioned previously the thinner plates, 22 mm as against 47 mm, are used so that the roof trusses do not rest on them because these interior walls are not designed as load bearing walls. The fixing of wall plates to panels is done by nailing 76 mm nails at 300 mm centres in a zigzag manner as was done in nailing the base plates to the floor boards.

For attaching the panels to base plates, use Pryda knuckle nail plates 2N10 (89 mm wide x 63 mm depth with 2 rows of 10 punched-out nails) or similar type. These plates are fixed at 610 mm centres on the exterior side of the panels while the interior side is fixed with 76 mm nails skew-nailed to the base plates. These metal plates and nails are then covered with plywood skirting 9 mm thick x 100 mm wide. For side attachment of the panels to each other, use 3 pieces of the same type as that used for bottom attachment, i.e. Pryda 2N10 or similar, spaced out evenly. As for corner connection between two walls at right angles, use 3 pieces Pryda angle plates 3NA (44 mm wide x 44 x 95 mm depth) or similar

type, fixed to the interior angle. All these plates should be covered with plywood beading. Figure 24 shows the connection details.

When the wall panels with head binders over them are erected, roof trusses can be put over them. Prior to this, the kitchen walls should be erected first because the extended roof trusses of the main building rest on the rear kitchen wall.

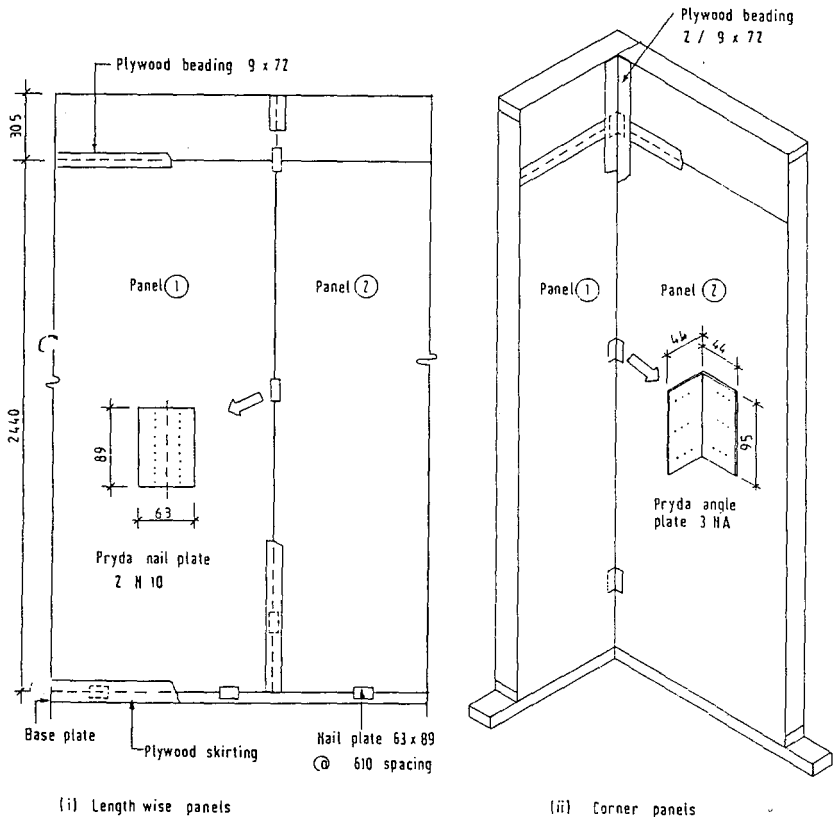


Figure 24. Connection of panel

Kitchen

Prepare the area for the kitchen which measures approximately 3.1 m x 5.1 m behind the main building. Excavate the ground to the required level. Put in hardcore and ram properly up to 100 mm thick. Blind the top area with sand and wet the top liberally with water before pouring concrete. The mixture of the concrete is 1:2:4 and the thickness is 100 mm. Concrete strip footings

measuring 150 mm wide x 50 mm thick are additionally provided below the concrete floor where the wall panels are situated.

On top of the floor, concrete curbs are used as base for the walls instead of timber sole plates as used in the platform area, reason being the wet nature of the kitchen. The curbs are 50 mm thick and 115 mm wide for the thicker walls and 50 mm x 84 mm for the thinner walls and their positions are as shown in Figure 25. Bolts 12 mm x 100 are vertically embedded in the concrete curbs for the purpose of holding the wall panels in position. 38 mm section of the bolt head side is inserted in the concrete and the remaining length with threads is exposed. The spacing of the bolts is about two bolts per panel (see Figure 26).

The wall panels in the kitchen are sheathed both sides with cement-bonded particleboard, 10 mm thick on the outside and 8 mm on the inside. In pre-assembling, only one side of the panel is first covered (10 mm side). Elongated holes are drilled in the bottom rail of the panel which should match the bolts embedded in the concrete curb. The panel is then put over the concrete curb through the bolts and tightened with a nut and washer. The other side of the panel is then covered with 8 mm cement-bonded particleboard in situ. For ease of fixing the 8 mm cement-bonded particleboard to the stud, it is suggested that holes for nails are first predrilled on the cemboard before nailing.

Wall plates are placed on top of the wall panels. Side and corner attachments between panels are done by nailing "Pryda plates" or equivalent types in a manner similar to the attachments done for the plywood panels as described previously.

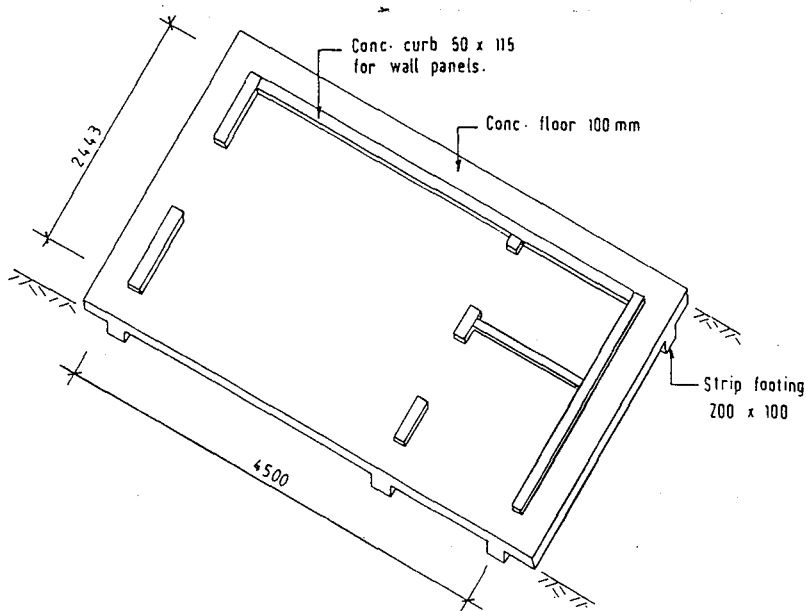


Figure 25. Kitchen floor

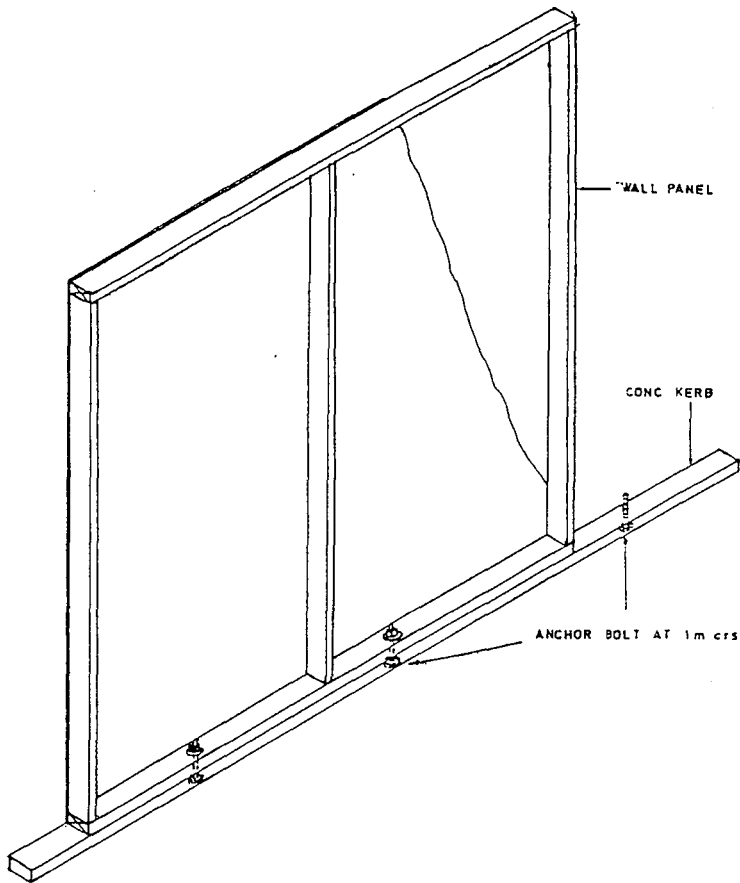


Figure 26. Anchoring of wall panel to concrete kerb

Roof truss

As in wall panels, trussed rafter roofs should preferably be pre-assembled at the factory and transported to the site when they are required. The trusses can either be assembled using nailed plywood gusset plates as shown in the plan or using proprietary brand punched metal plates. If metal plates are used, the trusses will have to be fabricated by the factory supplying such plates. In this case the sizes of the plates required for each joint are calculated by the licensed factory while the sizes of truss timber members remained the same as in the drawing.

The first truss is erected at one end. When it is in the correct position, nail the truss to the wall plate. The end truss is then temporarily braced to the ground at two places using 50 x 100 mm timber as shown in Figure 27. This

bracing, although temporary must be firm because all other trusses are to be fastened to this end truss. The second truss can now be erected. The truss is initially put upside down with the two ends resting on opposite sides of the wall plates and the peak of the truss pointing downwards as can be seen in Figure 27 above. The truss is then tilted up vertically using a long pole with a "Y" end as shown in Figure 28. When it is in the correct position nail bottom of truss to wall plate and brace temporarily to first truss. The rest of the trusses can be erected in a similar way. Figure 29 shows the attachment of trusses to wall plates by skew nailing 4/100 mm nails for each attachment, two on each side of the truss.

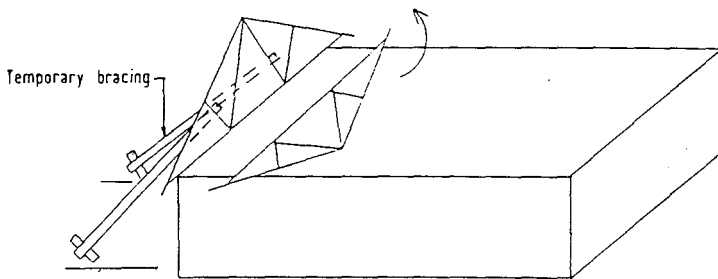


Figure 27. Erection of first truss

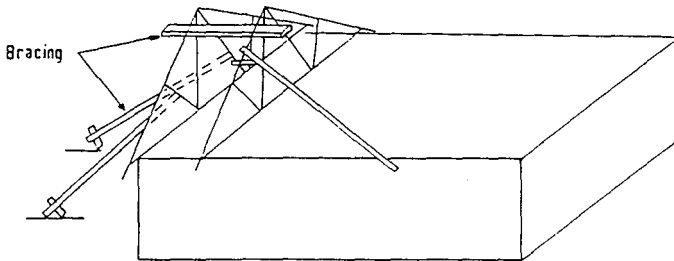


Figure 28. Erection of second truss

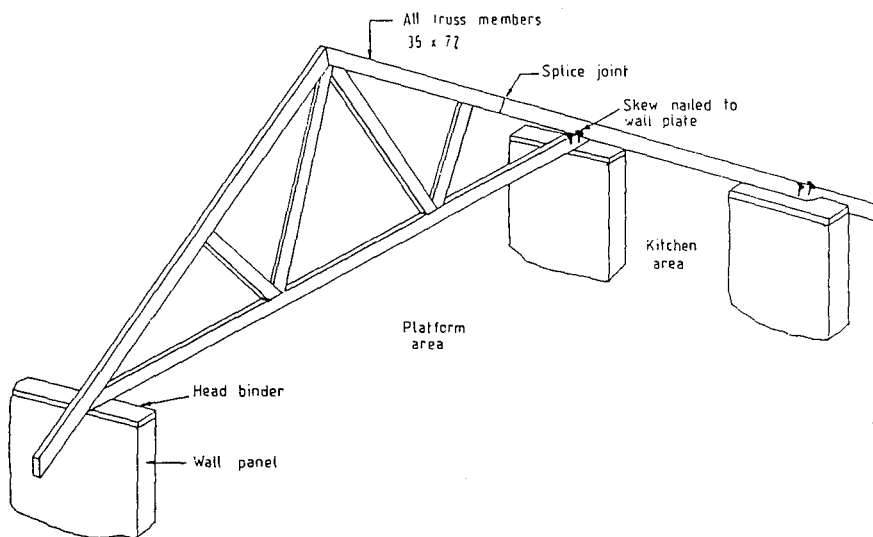


Figure 29. Attachment of trussed rafter to wall plates

The two gable ends of the trusses on the platform area are closed by fixing 6 mm plywood sheets to the required sizes. Ventilation inside the roof is through holes drilled in the plywood sheets of these two gable ends.

At the kitchen end, four of the trusses are provided with extended rafters to cover the kitchen roof. These extended portions of the rafters rest on the wall plate of the kitchen panels. Two additional beams the same size as the rafters, i.e. 35 x 72 mm are provided between each pair of trusses to strengthen the kitchen roof.

Four workers can manually erect the trusses in position. One worker sits on each wall to nail the trusses to the wall plates, another works at the centre of the truss to fix the top of the truss and another for general works including lifting of the trusses into position. If a crane is used work will be faster.

In order to prevent swaying caused by wind force, permanent bracing in accordance with the drawing is provided. Horizontal bracings are fixed at right angles to the trusses. Diagonal bracings are placed at an angle of 45° to the trusses starting from the top portion of the gable end truss to the bottom portion of the fourth truss as shown in Figure 30. When all permanent bracings are in place, the temporary bracings may then be removed.

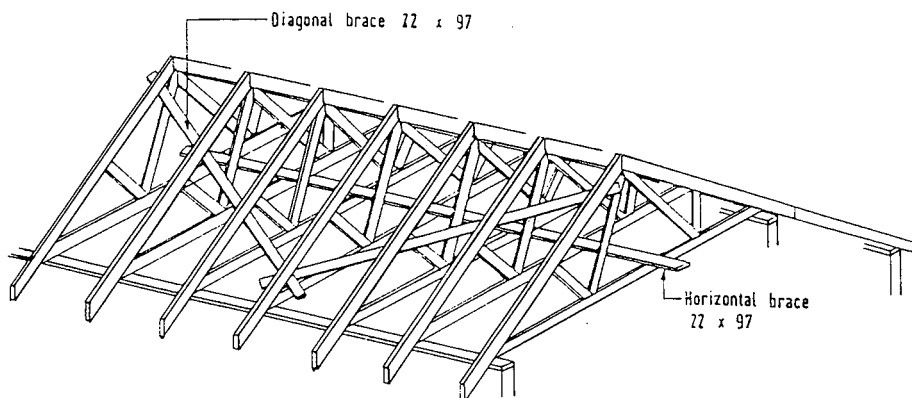


Figure 30. Bracing for trussed rafters

The next stage of construction is to place purlins on top of the trusses. Purlins are 35 x 72 mm in size and are skew-nailed to each rafter with two 76 mm nails, one on each side (see Figure 31). Fascia boards and barge boards are fixed to the ends of rafters and purlins.

Roofing sheets can now be laid over the purlins. The sheets are of corrugated asbestos-free fibre cement sheets. They are laid in accordance with the manufacturer's instructions. From this stage onwards, work can be carried out in the dry interior of the building irrespective of the weather conditions.

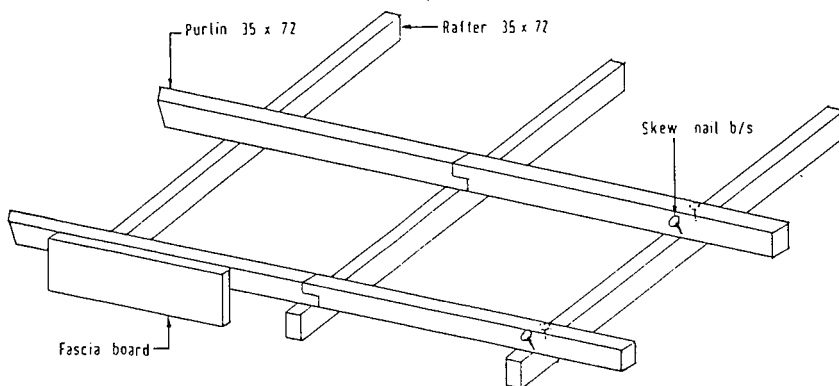


Figure 31. Fixing purlins

Doors and windows

Openings for doors, windows and fixed louvers are provided for when making wall panels. However, for the door openings, a full length bottom rail of the panel is initially retained so as to prevent the frames from being twisted during handling. When the panels are installed, this exposed portion of the bottom rail is cut out together with the base plate at this place as shown in Figure 32. Doors and windows are assembled in the factory and delivered to the site for installation.

The doors are of three sizes: 700 mm wide for WC and bath, 770 mm wide for the kitchen door and 840 mm wide for the main entrance door. The height for all doors is 2100 mm high, measured from floor level. It is important that the dimensions of the doors and windows match exactly the openings provided for on the wall panels after they have been installed in place. All doors should open inwards.

To make the doors, the framework is first assembled making sure the overall dimensions are correct and the corners are squared. Plywood sheets are then glued and nailed to the framework on both sides.

Frames for windows and louvres are made at site in the openings provided for in the wall panels. Adjustable louver aluminium frames with 8 leaves are then fixed to the wooden window frame. Glazing in the form of glass sheets cut to size are slid into the slots of the adjustable louver. Glass sheets are also used as fixed glass louvres on top of adjustable louvres.

Railings and stairs

In making railings, use rails 47 x 97 mm and vertical balustrades 20 x 20 mm in size. The top of the rail is constructed at 1000 mm above the floor.

In making staircase, the spacings for rise and run of the stairs are 170 and 230 mm respectively. The treads are 47 x 250 mm resting both ends on ledgers 50 x 50 x 180 mm which are fixed to the stringers 60 x 219 mm. The stringers are leaned against the floor joist at the top and fixed to the concrete landing with angle iron plates at the bottom as illustrated in Figure 33.

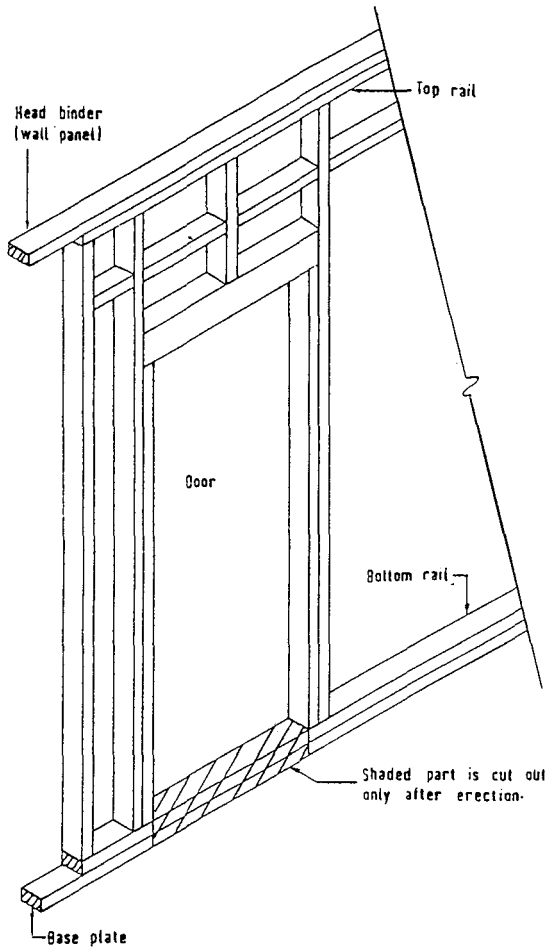


Figure 32. Frame for door opening

Ceiling

Before ceiling sheets are installed, noggings 38 x 50 mm at 610 mm centres are first fixed between the roof trusses as in Figure 34. Ceiling may be of plywood 6 mm or cement-bonded particleboard 6 mm thick. Ceiling is required only for the main building and not the kitchen. The ceiling sheets are nailed to the noggings and trussed rafters in a zigzag pattern.

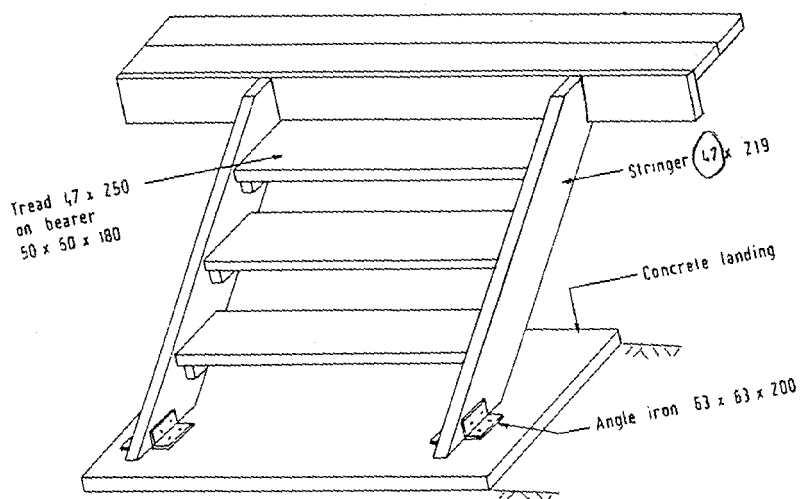


Figure 33. Staircase

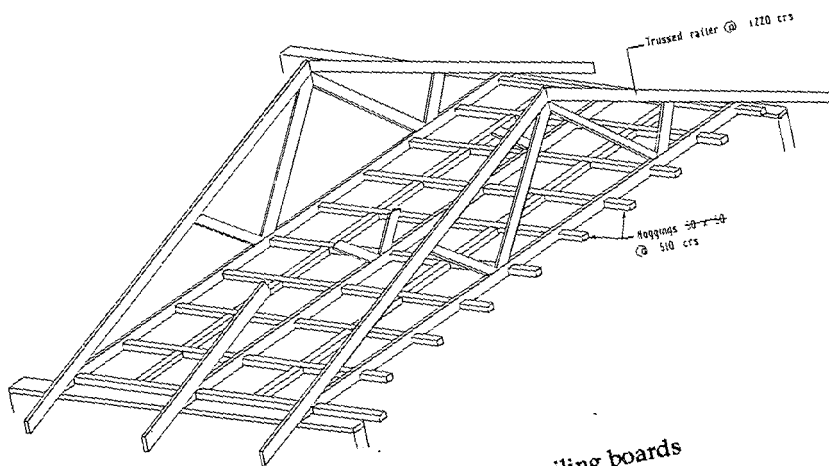


Figure 34. Noggings for ceiling boards

Services

Various services such as plumbing, electrical and sewerage works, can be installed in the building as soon as the roof is covered with roofing sheets. For general wiring, drilled holes in wall frames and floor joists are used. The holes measuring 25 mm diameter are drilled at the centre of the section. They should be located at least 300 mm away from the ends of studs, joists and other structural pieces, and from any other hole as shown in Figure 35.

Notches for piping and wiring can be made at the joists if the following conditions are followed:

- (1) All notches must be in top edge of joist,
- (2) The location of the notches from the support end should be between $1/10$ and $1/5$ of the joist span, and
- (3) Maximum depth of notch is equal to 21 mm for a 145 mm joist.

Instead of notches, holes can be drilled in joists for piping as shown in Figure 36.

All fixtures and fittings can be fixed to the framing timbers forming the panels. Extra noggings can be added to support heavy fixtures such as wash basins or boilers.

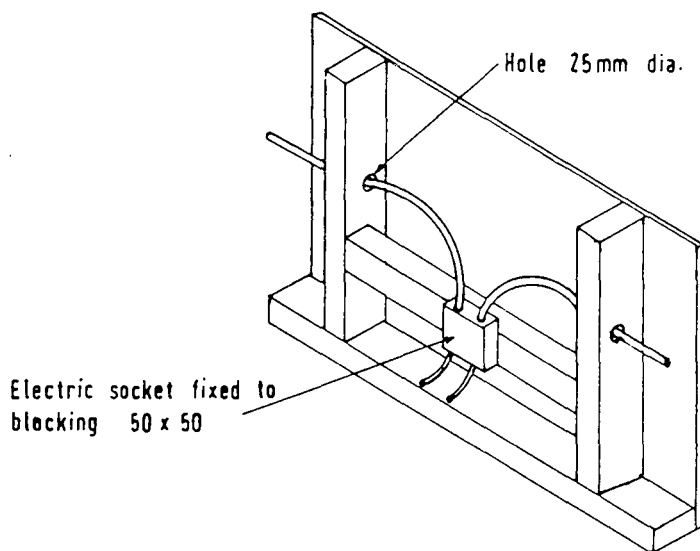


Figure 35. Internal wiring

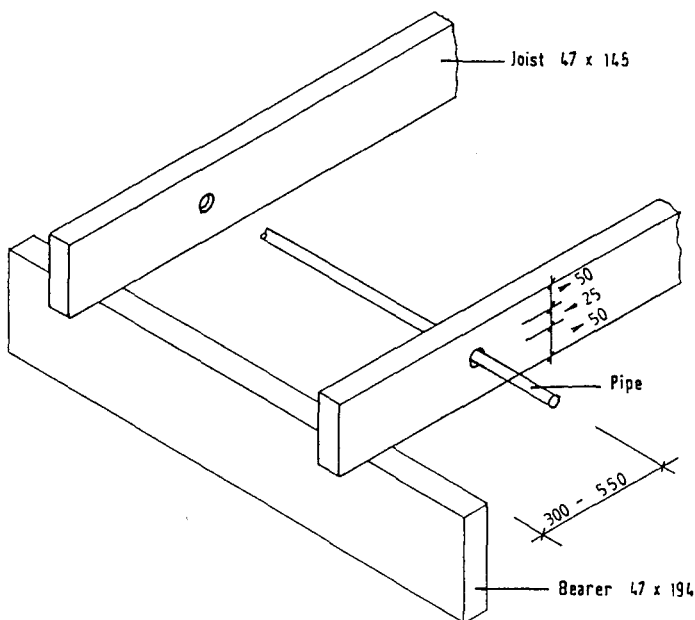


Figure 36. Drilled holes in joists

Finishing touches

Plywood skirtings of size 9 x 100 mm, for the main building can be fixed between the wall and the floor. Plywood beadings of 9 x 72 mm are used to cover all jointings between the plywood pieces.

Finally the whole building can be painted. The primary function of painting the wall is to protect the surface, for easy cleaning and to maintain appearance. Wood surfaces exposed to the weather without any finish, will quickly change; hence they need finishing both for appearance and protection.

For floors, the natural colour and grain of wood make them attractive and beautiful. The application of floor finishes should protect the surface from excessive wear and abrasion, and make it easier to clean.

The building now can be occupied.

Chapter 7

MAINTENANCE AND REPAIR

A house if properly designed and constructed with adequate attention given to details and to proper choice of materials used as outlined in this handbook, would require little maintenance. The following are some of the suggestions that may be followed to reduce the cost of maintenance. However, it must always be borne in mind that the two points to ponder are deterioration of timber house caused by termite attack which is mostly found in the tropics and decay caused by moisture and dampness.

Raised platform

- (1) Space beneath the platform should be well ventilated. Open spaces must not be blocked by obstacles, including grasses, shrubs and planting.
- (2) No water should be allowed to collect under the building. Hence the gradient of the soil should slope away from the house.
- (3) Make sure the top of all concrete surfaces such as concrete footings, stair landing and kitchen floor should be between 50 and 100 mm above the ground level as per original design.
- (4) Inspect regularly the surrounding area of the house for signs of termite activity. Break the earthen termite tunnel if found because subterranean termites can only survive if there is a connection between the soil and the building. If possible treat the soil with insecticidal solution to prevent termite infestation.

Exterior walls

- (1) No part of the building should be allowed to collect water as this increases the moisture content of the wood or plywood thereby encouraging the growth of fungi and causing wood decay or rot. Such damages are common on door and window frames.
- (2) Look for cracks or gaps in the exterior wall due to shrinkage or poor workmanship. Seal up the cracks by applying putty.
- (3) If non-corrosive nails were used in the construction of the building and were driven flush with the heads exposed rust spots may occur at the nailheads. The remedy for this is to set the nailhead below the surface and apply putty to cover up the head.

- (4) If the painting or finishes of the wall surfaces show signs of deterioration, apply fresh coats of paint.

Interior

- (1) If there are cracks in the interior walls, fill the cracks with putty and paint over as in exterior walls.
- (2) Do not allow moisture to remain long on the surface of any timber or plywood especially in the kitchen area.
- (3) The sheathings of wall panels may be accidentally damaged resulting in holes or cracks in the sheets. If the holes are small they may be filled up with putty and sanded smooth. Larger holes may require cutting a section around the damaged portion and replacing it with a new section.
- (4) Gaps may form between the floor boards due to shrinkage of the boards because they were originally laid with very high moisture content. One remedial action is to fit matching strips of timber between the flooring strips and glue them in place. In severe cases it may be necessary to replace sections of the floor.

Roof

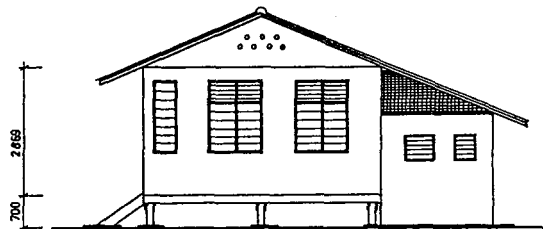
- (1) Stains in the ceiling boards will indicate that the roof is leaking. Check position of leaks and repair the roof.
- (2) Make sure air circulation is maintained in the enclosed roofing area by seeing that ventilation openings at the two gable ends are provided and not blocked.

References

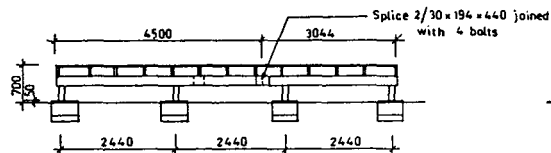
- Uniform Building By-Law 1984*. Printed by MDC Sdn. Bhd.
- Code of Practice for the Structural Use of Timber*. Malaysian Standard. M.S. 544: 1978. Standard and Industrial Research Institute Malaysia (SIRIM).
- The Malaysian Grading Rules for Sawn Hardwood Timber, (MGR)*. The Malaysian Timber Industry Board, 1984.



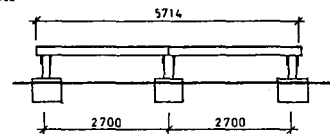
FRONT ELEVATION



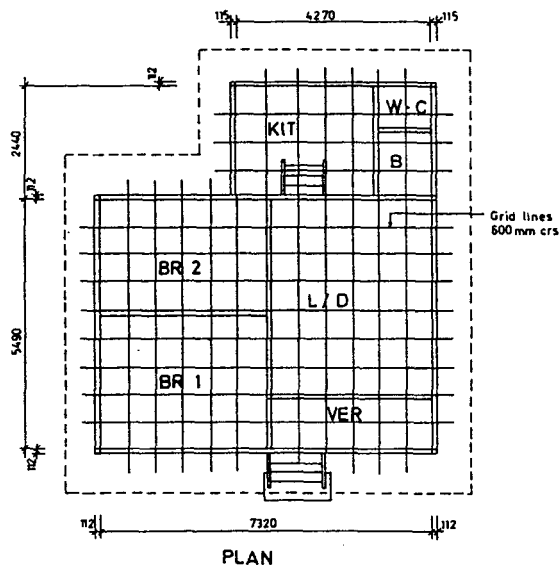
SIDE ELEVATION



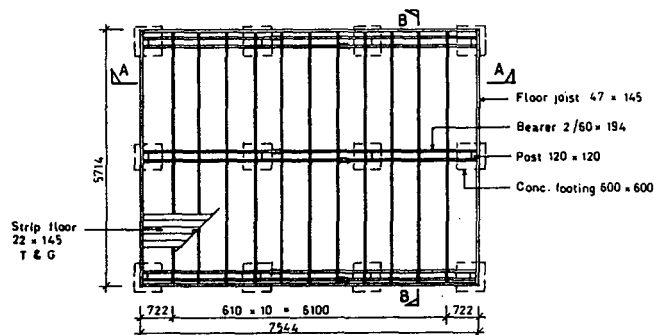
SECTION A - A



SECTION B - B

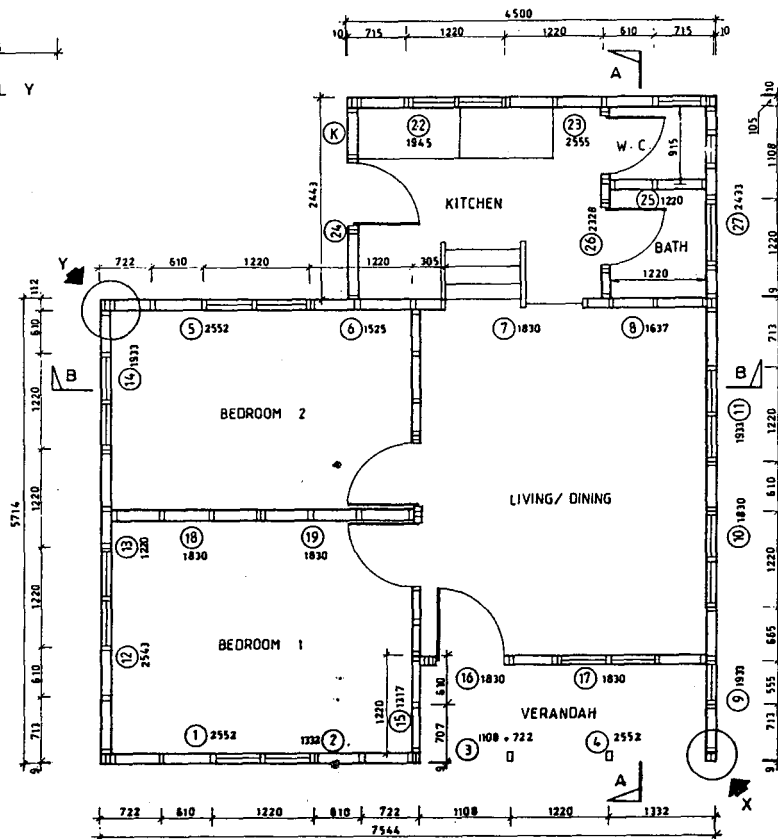


PLAN

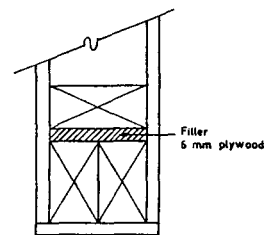


FLOOR JOIST LAYOUT

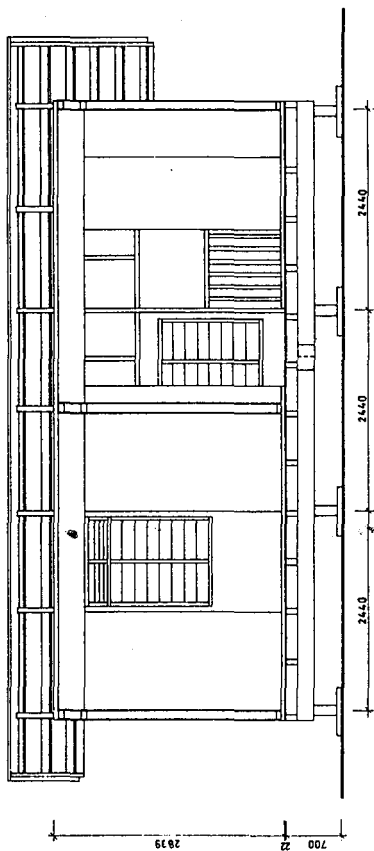
- Floor joist 47×145
- Bearer $2/60 \times 194$
- Post 120×120
- Conc. footing 600×600



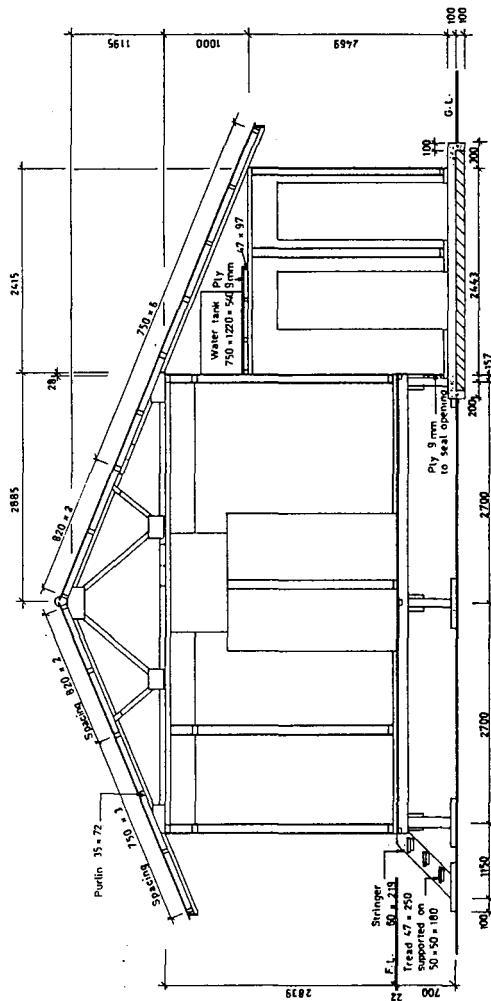
PANEL LAYOUT PLAN



DETAIL X

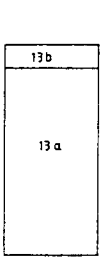
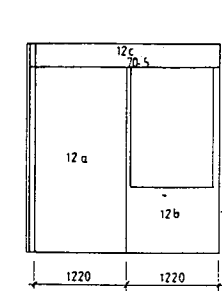
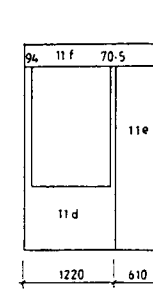
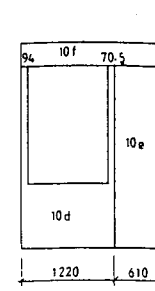
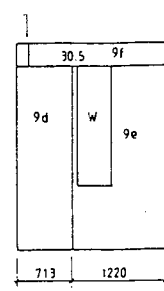
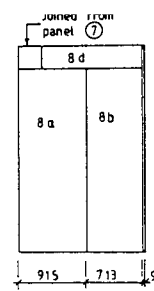
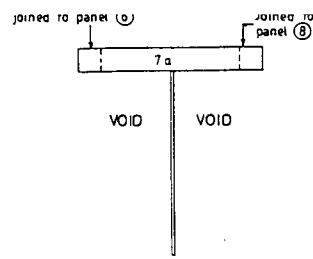


SECTION B - B

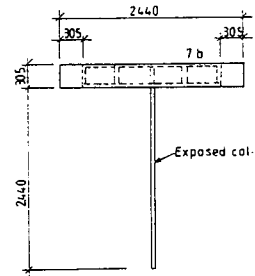


SECTION A - A
(Ref. Org. 2 of 9)

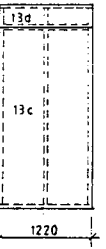
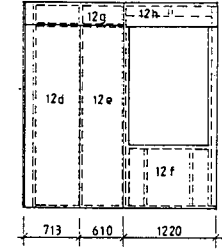
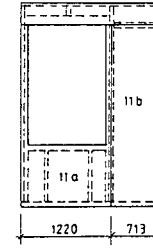
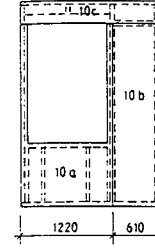
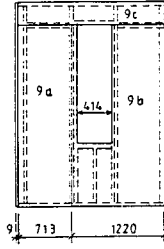
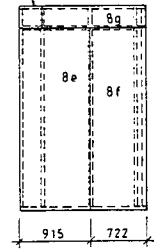
Elevation
6mm plywood



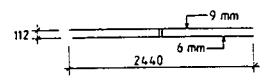
Elevation
9mm plywood



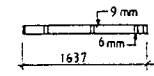
This portion to be
joined by panel 7



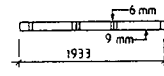
Plan view



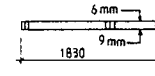
Panel 7



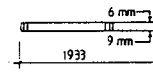
Panel 8



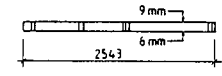
Panel 9



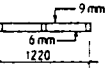
Panel 10



Panel 11

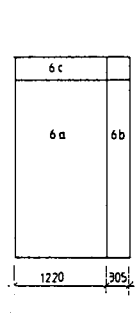
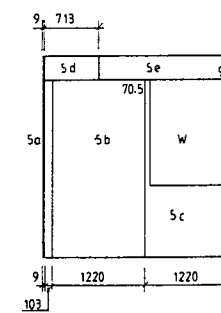
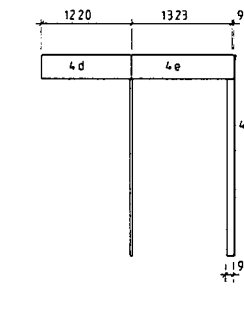
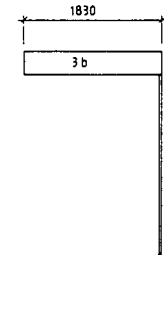
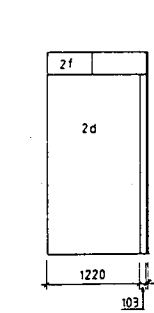
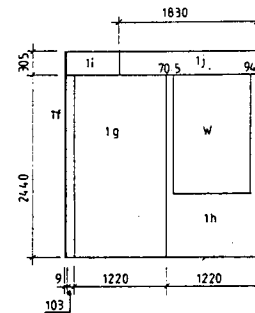


Panel 12

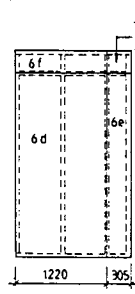
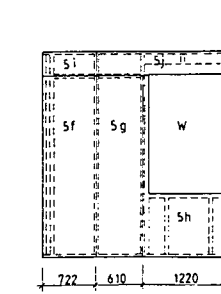
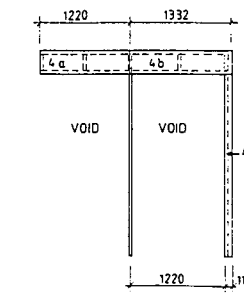
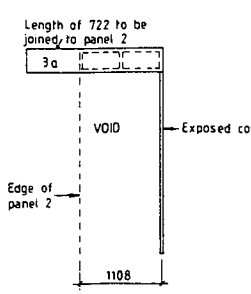
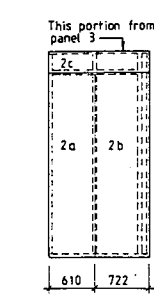
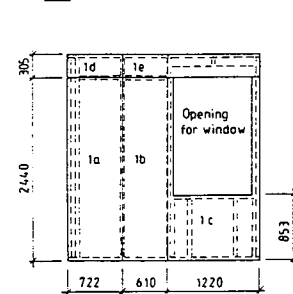


Panel 13

Elevation
6mm plywood

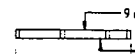
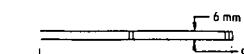
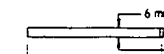
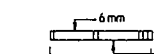
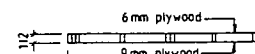


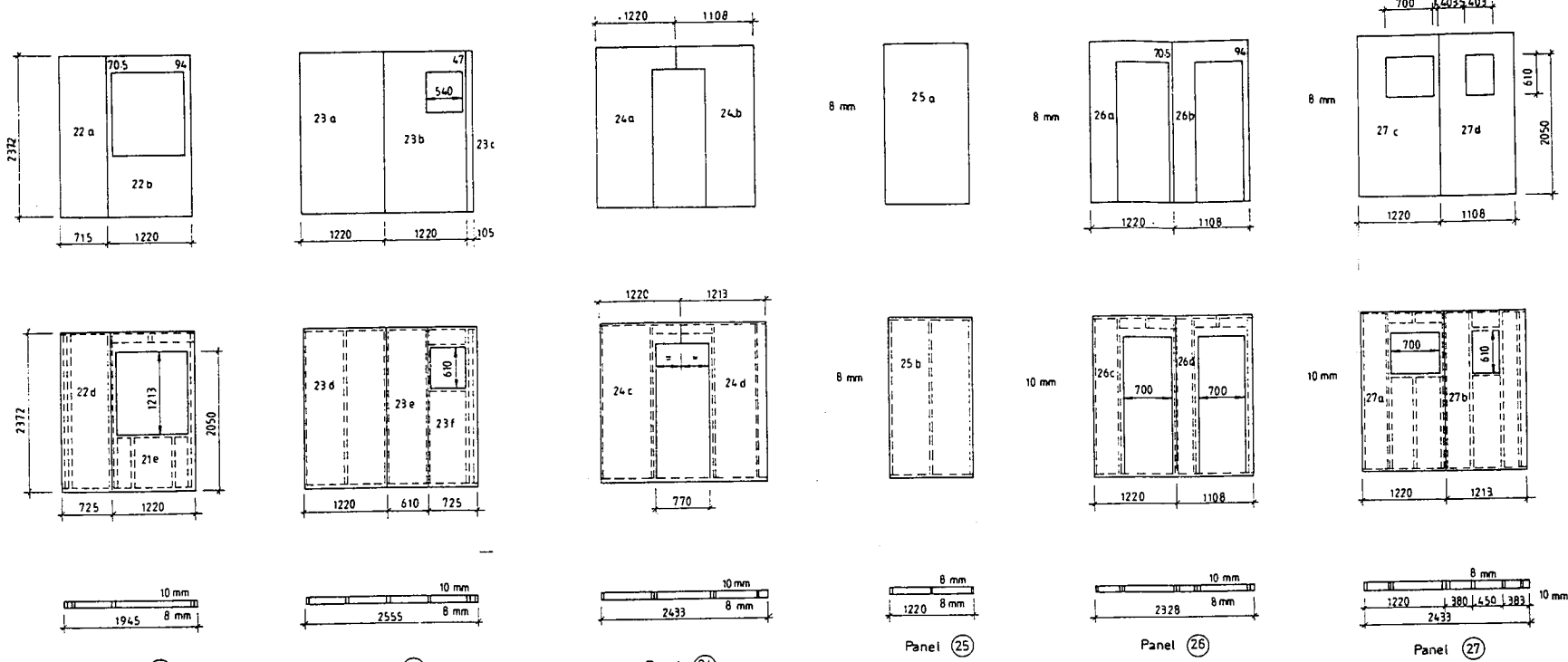
Elevation
9mm plywood



This portion to be
joined from panel 7

Plan view

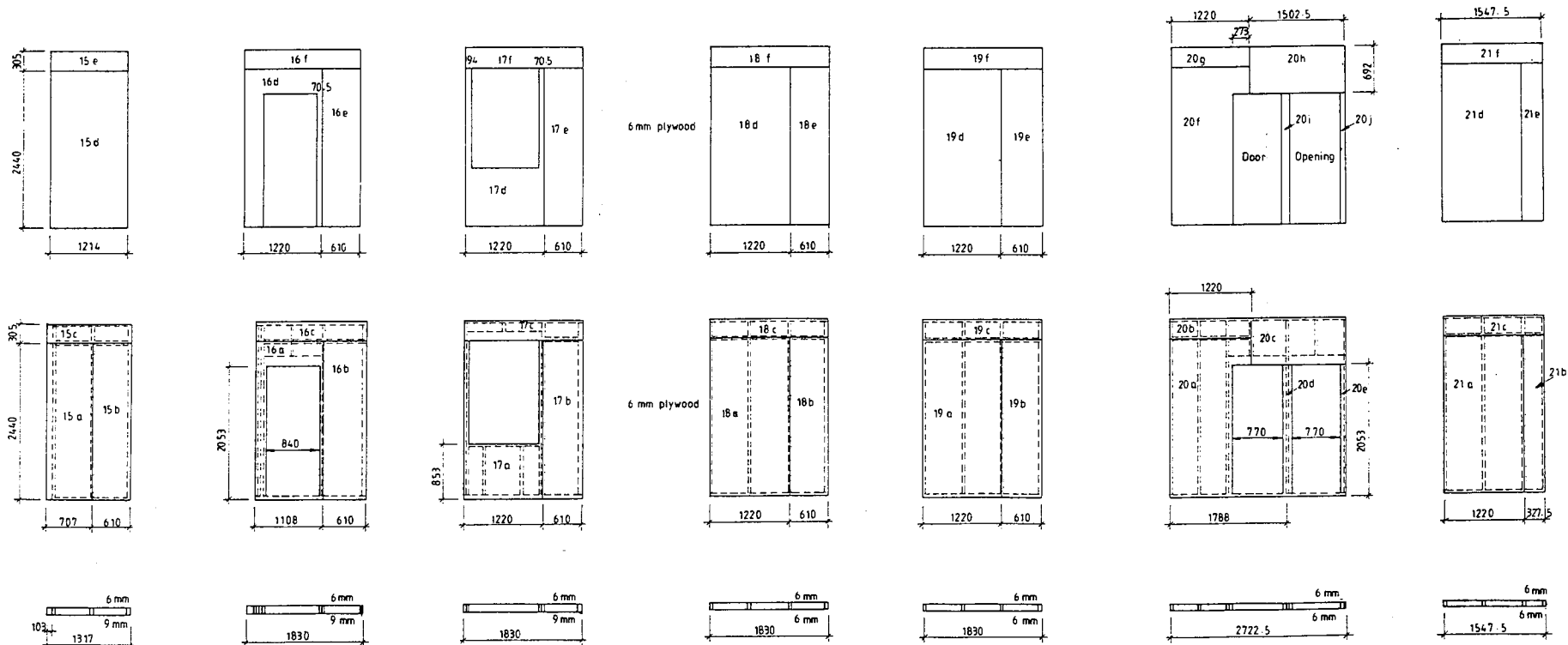




Summary of wall panels

Panels	Studs	Sheathing *	
		External	Internal
1 - 17	47 x 97	Ply. 9 mm	Ply. 6 mm
18 - 21	47 x 72	Ply. 6 mm	Ply. 6 mm
22 - 24, 26 - 27	47 x 97	Cem. 10 mm	Cem. 8 mm
25	47 x 72	Cem. 8 mm	Cem. 8 mm

* 9 mm plywood to be of WBP type
6 mm plywood to be of MR type
Tolerance of sheathing size ± 4 mm to allow expansion gap between sheathings





Stiffener
50 x 50.

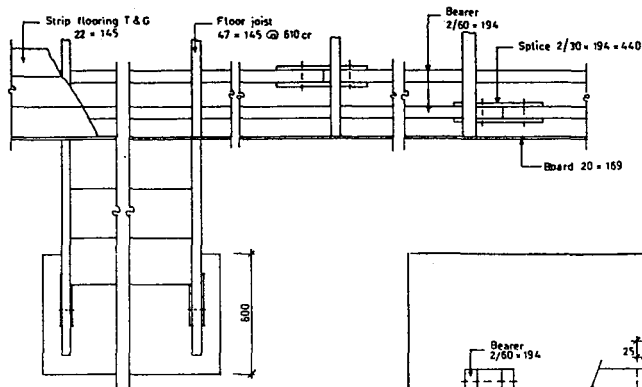
Joist 47 x 145
with notches
for stiffener.

Bearer
2/80 x 194

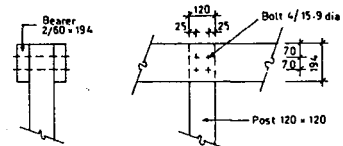
722

610

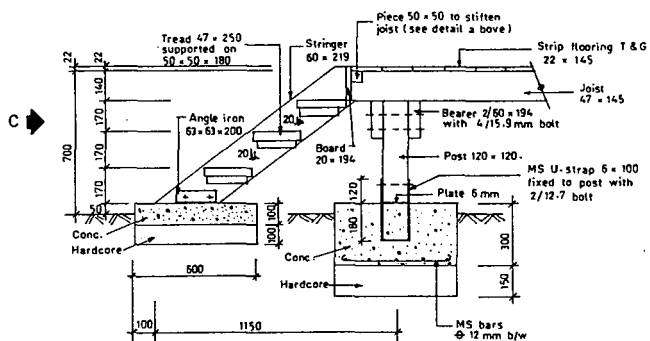
VIEW E



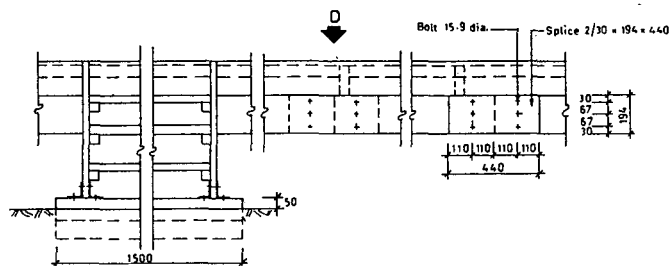
VIEW D



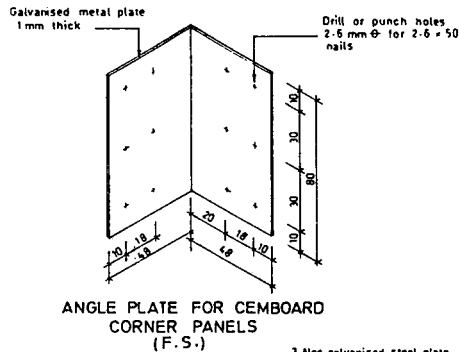
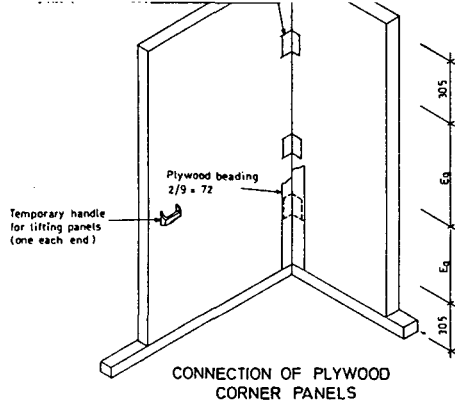
DETAIL OF POST & BEARER



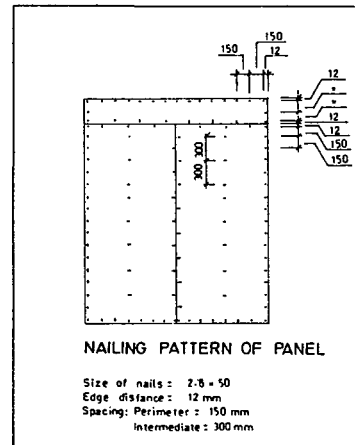
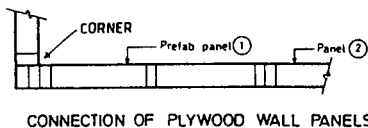
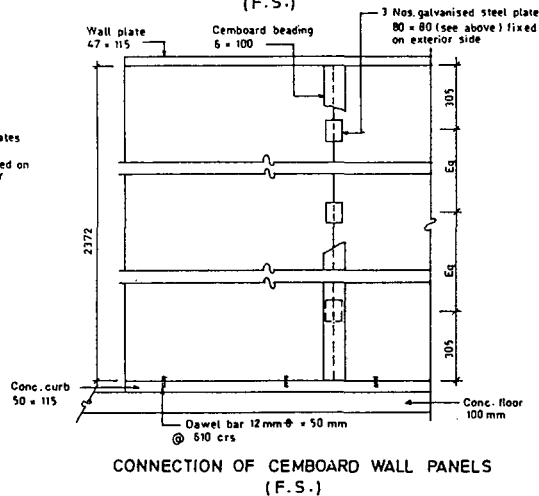
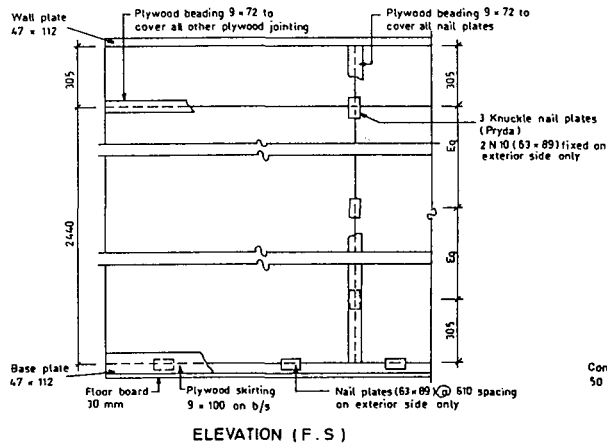
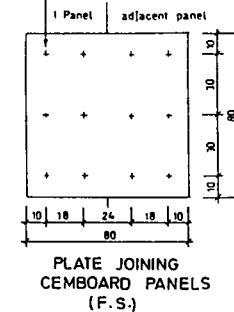
POST & ENTRANCE STAIRS



VIEW C



For joining 1 panel to an other and covered with cemboard beading 8mm thick x 100 mm wide



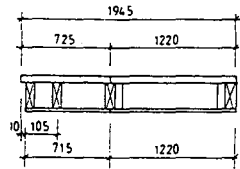
Drg. No.
101/94/8 of 9

Scale.
1 : 20

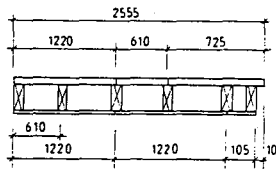
Panels (1) to (21) : Plywood sheathing 9 mm & 6 mm thick

Panels (22) to (27) : Cemboard sheathing 10 mm & 8 mm thick

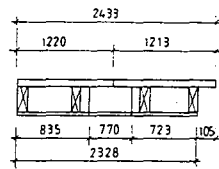
Studs 47 x 97 and 47 x 72



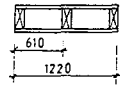
Panel (22)



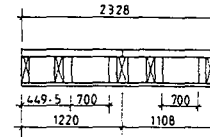
Panel (23)



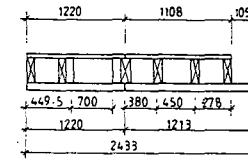
Panel (24)



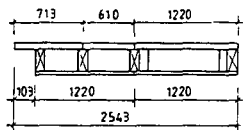
Panel (25)



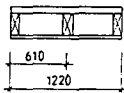
Panel (26)



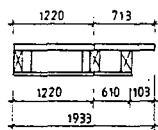
Panel (27)



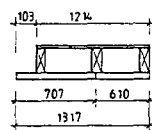
Panel (12)



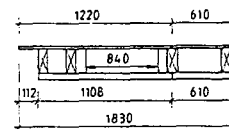
Panel (13)



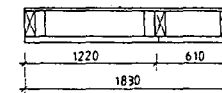
Panel (14)



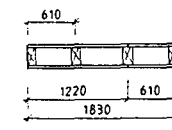
Panel (15)



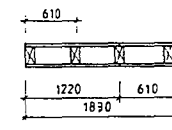
Panel (16)



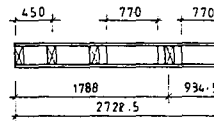
Panel (17)



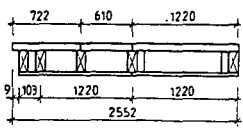
Panel (18)



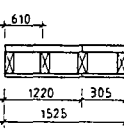
Panel (19)



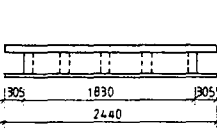
Panel (20)



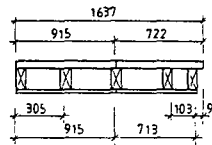
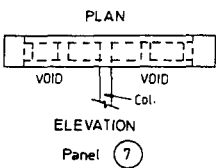
Panel (5)



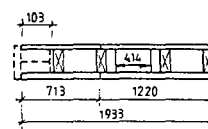
Panel (6)



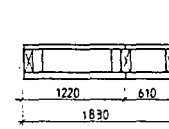
Panel (7)



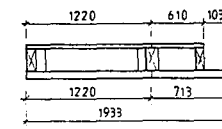
Panel (8)



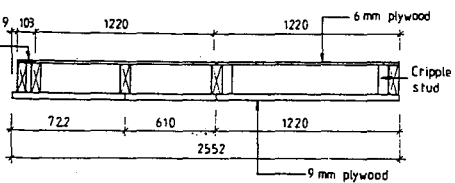
Panel (9)



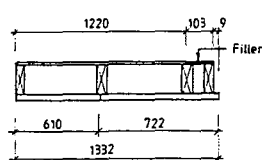
Panel (10)



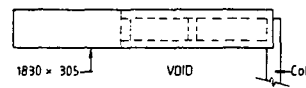
Panel (11)



Panel (1)



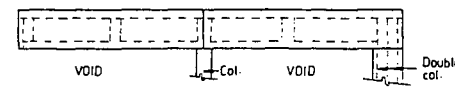
Panel (2)



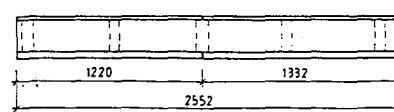
Panel (3)



Panel (3)



Panel (4)



Panel (4)

ISBN 983-9592-55-6

