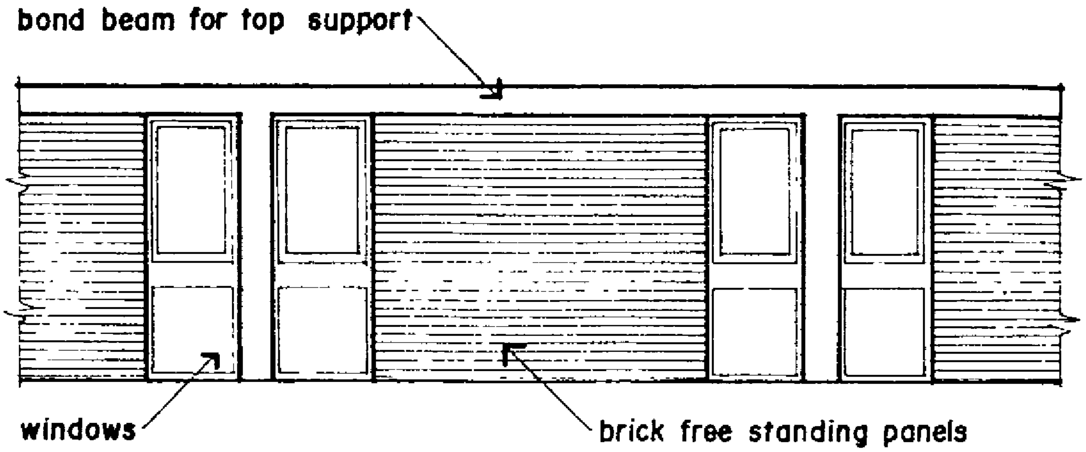
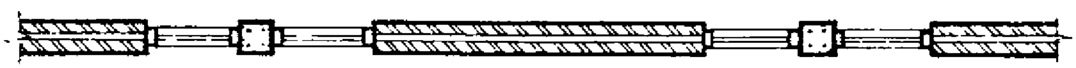
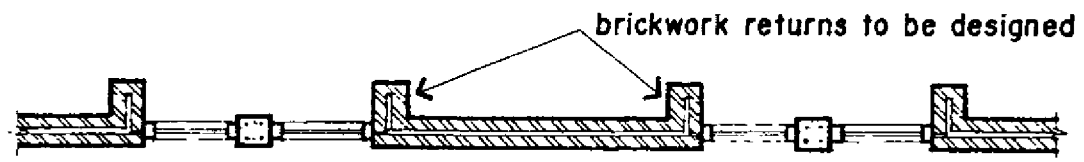


ELEVATION

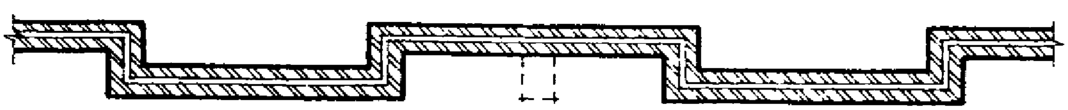


PLAN – Not Recommended

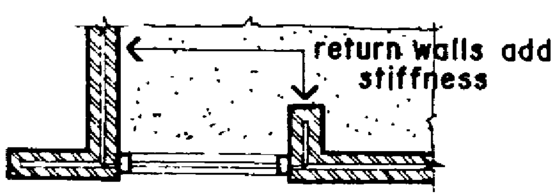


PLAN – Recommended

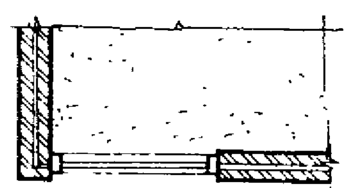
Stagger walls without openings or use attached piers.



PLAN – Recommended



Recommended
PLAN AT CORNERS



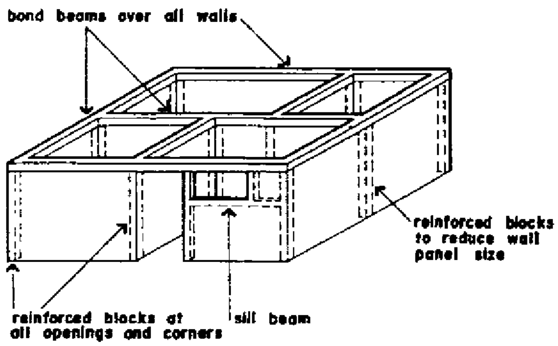
Not Recommended

BRICK WALL STIFFENING

9.4.4 *Concrete Masonry Walls*

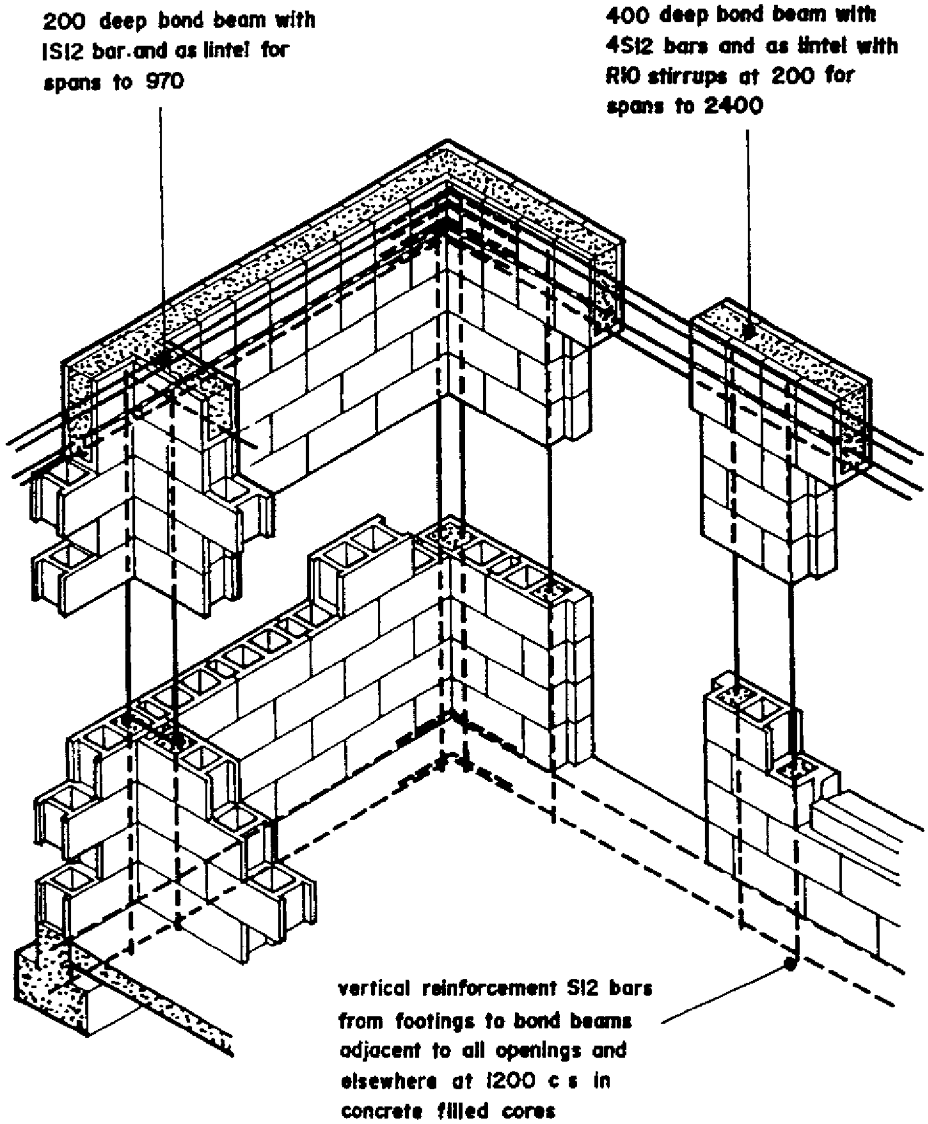
It is essential that hollow concrete masonry walls are reinforced and with adequate reinforcing to resist the wind forces imposed.

The following sketches illustrate the key elements of reinforcing, bonding and tie bar or anchor placement

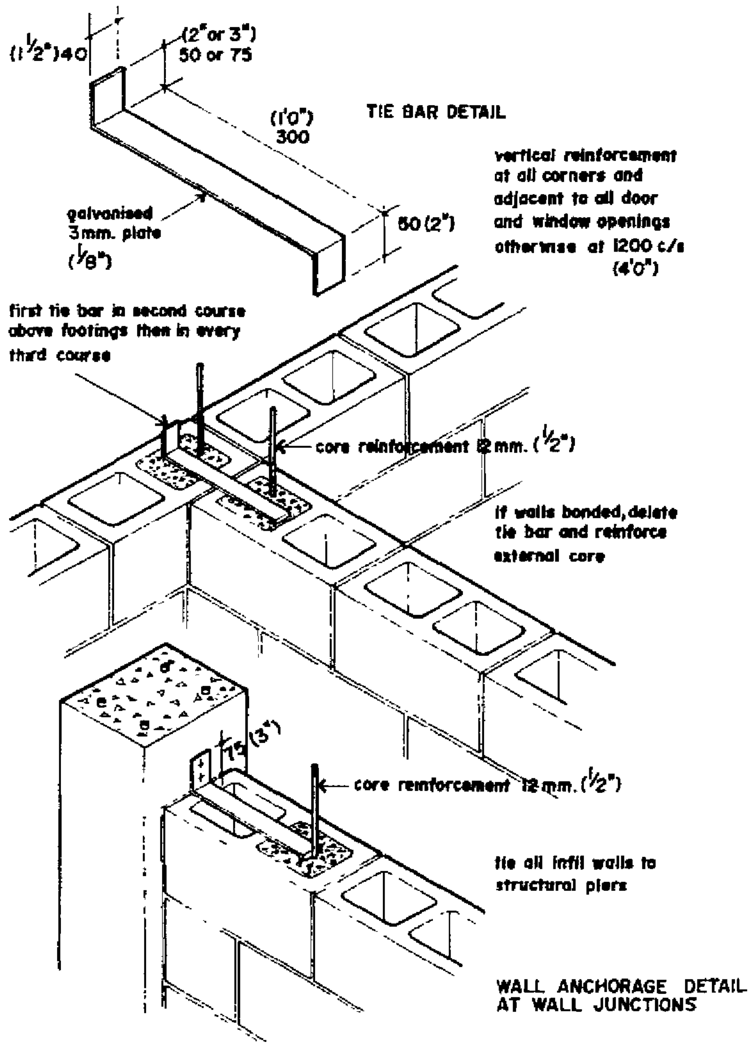


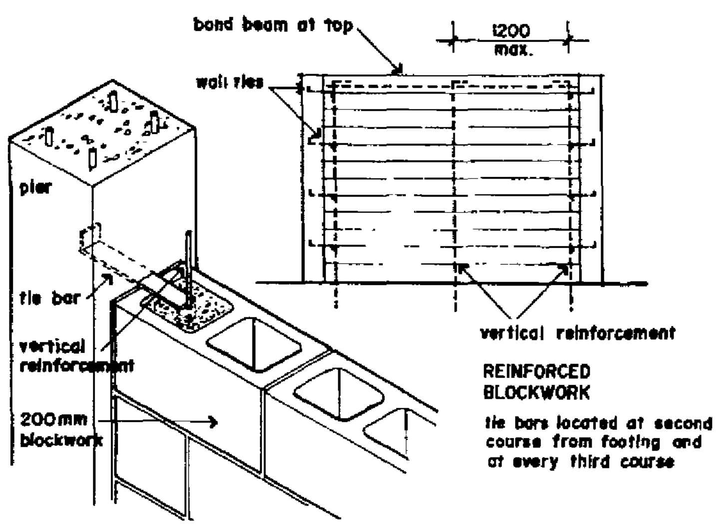
HOUSE STRENGTHENED USING BOND BEAM REINFORCED BLOCKS, SILL BEAMS, HORIZONTAL REINFORCED WALLS

NOTE: for reinforced walls the importance of horizontal reinforcing is of special significance, i.e. 6mm dia., 9mm dia. or special fabric, built into corners, ensure correct anchorage and lap



REINFORCED CONCRETE MASONRY


(1½")40
(2" or 3")
50 or 75
(1'0")
300
TIE BAR DETAIL
galvanised
3mm. plate
(⅛")
50 (2")
vertical reinforcement
at all corners and
adjacent to all door
and window openings
otherwise at 1200 c/s
(4'0")
first tie bar in second course
above footings then in every
third course
core reinforcement 12mm. (½")
if walls bonded, delete
tie bar and reinforce
external core
75 (3")
core reinforcement 12mm. (½")
tie all infill walls to
structural piers
WALL ANCHORAGE DETAIL
AT WALL JUNCTIONS

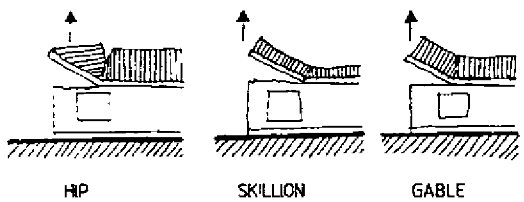

bond beam at top
1200
max.
wall ties
pier
tie bar
vertical
reinforcement
200mm
blockwork
vertical reinforcement
REINFORCED
BLOCKWORK
tie bars located at second
course from footing and
at every third course

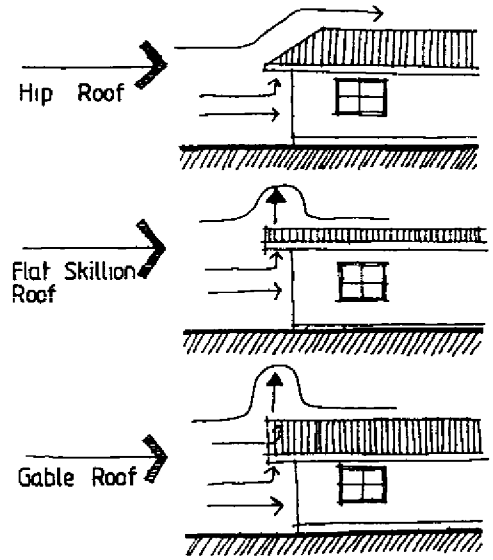
9.5 ROOF FRAMING & CONNECTIONS

9.5.1 Roof Shapes

In theory, the wind action and wind pressures vary, depending on roof shape and direction of wind.

Note! A badly fixed hip roof will blow away a few minutes after a badly fixed gable roof or a little later again after a badly fixed flat roof.





9.5.2 Averaging The Forces

We can even out the wind pressures on the roof by changing the spacing of the battens or purlins to create even cladding pressures over the roof.

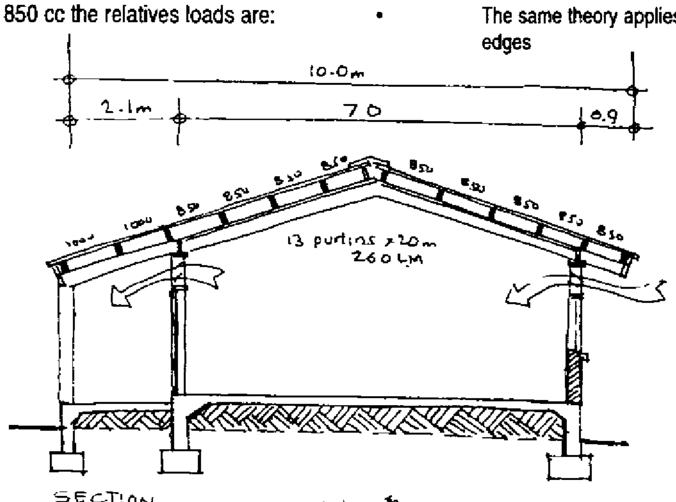
For example, we know that within 15% of the edges of the roof cladding forces are 2.7q, whilst in the general areas of the roof the forces at 1.9q.

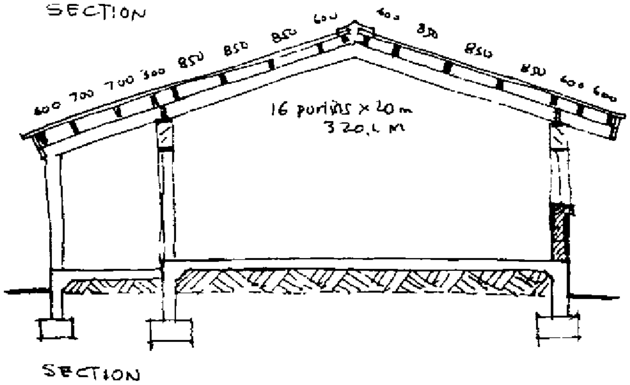
If batten or purlins are spaced at the edges at 600 cc and in general areas of 850 cc the relatives loads are:

Edge	0.6 m x 2.7q	= 1 62q
General	0.85 m x 1.9q	= 1.62q

Margins are near enough to allow all connections to be designed similarly instead of having different designs at different parts of the roof.

- If the roof is steep then similar tactics should be used near the ridge.
- The same theory applies at wall corners and edges





9.5.3 Roof Framing — Connection Details

It is important to detail the requirements for each of the roof frame connections.

It is also important that the work is inspected to ensure compliance with the details.

It should be remembered that a chain is only as strong as it's weakest link and in roof framing the chain of integrity calls for:

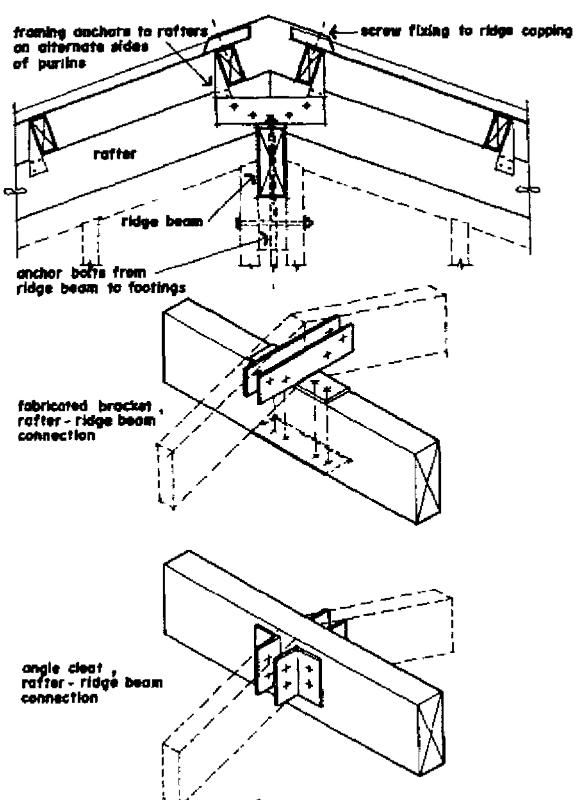
1. Fix roof sheeting to battens or purlins.
2. Fix battens to purlins or rafters.
3. Fix purlins to rafters or bearers.
4. Fix rafters or beams to wall top plates.
5. Fix top plates through to foundations

It is equally important that each of the connections is capable of transferring the loads placed on the joint concerned.

The following sketches show typical details used in cyclone areas.

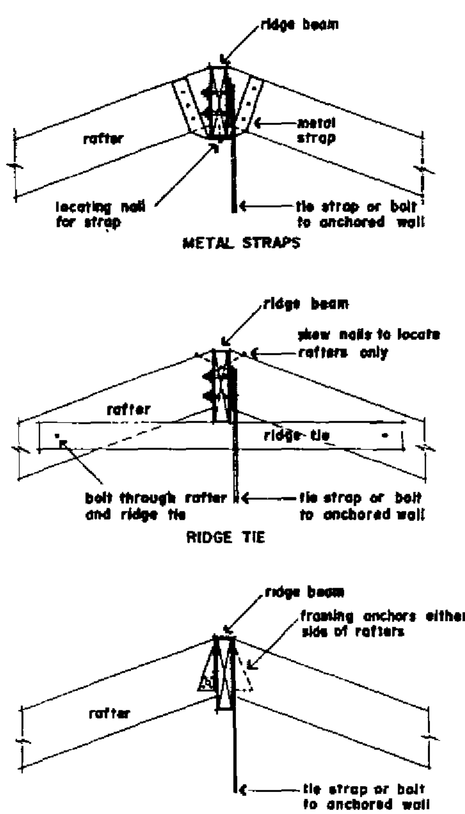
Existing roofs can be made good if framing is in position and lacking only good connections.

Where fixings are inadequate, remove the roof, eaves or ceiling sheeting to gain access to enable the upgrading to be properly done.

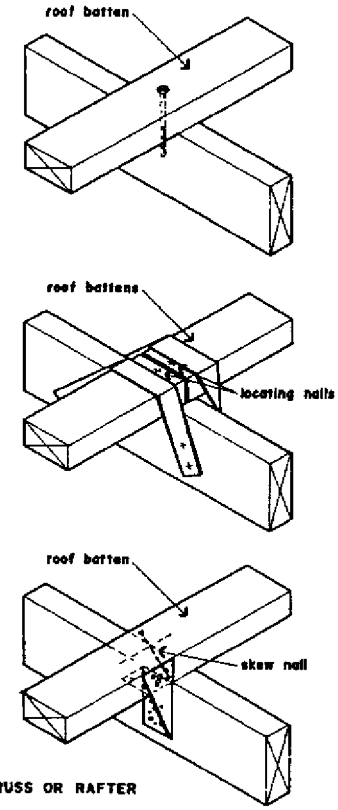


ROOF DETAILS
PURLINS ON ROOF BEAMS

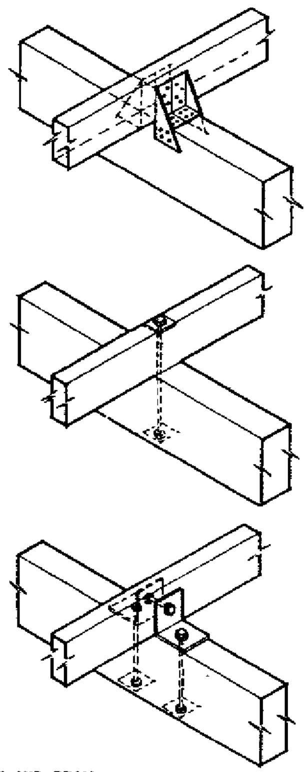
RAFTER-RIDGE BEAM
CONNECTION DETAIL



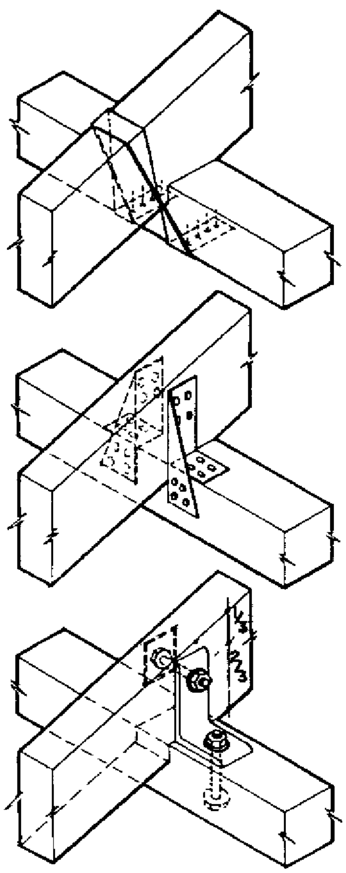
RAFTERS TO RIDGE BOARD
FIXING DETAILS



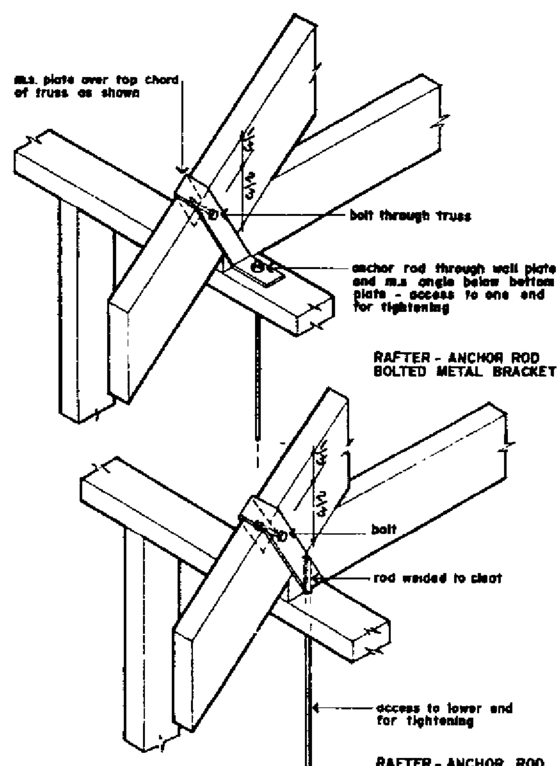
BATTEN FIXING TO TRUSS OR RAFTER
AT 900 SPACING



ROOF DETAILS
GRADED PURLINS ON POST AND BEAM



RAFTER - TOP PLATE
FIXING DETAIL

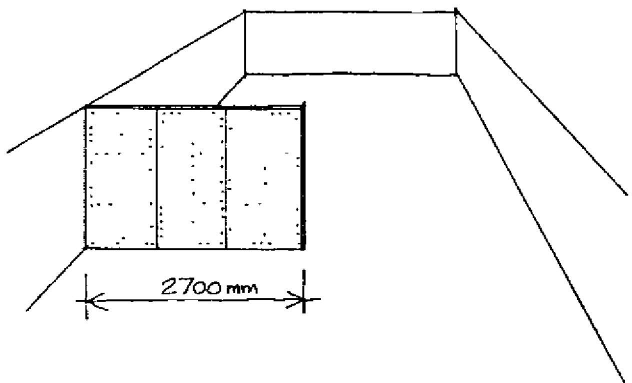


RAFTER TO TIE-ROD CONNECTIONS

9.6 BRACING & DIAPHRAGMS

9.6.1 Bracing Walls

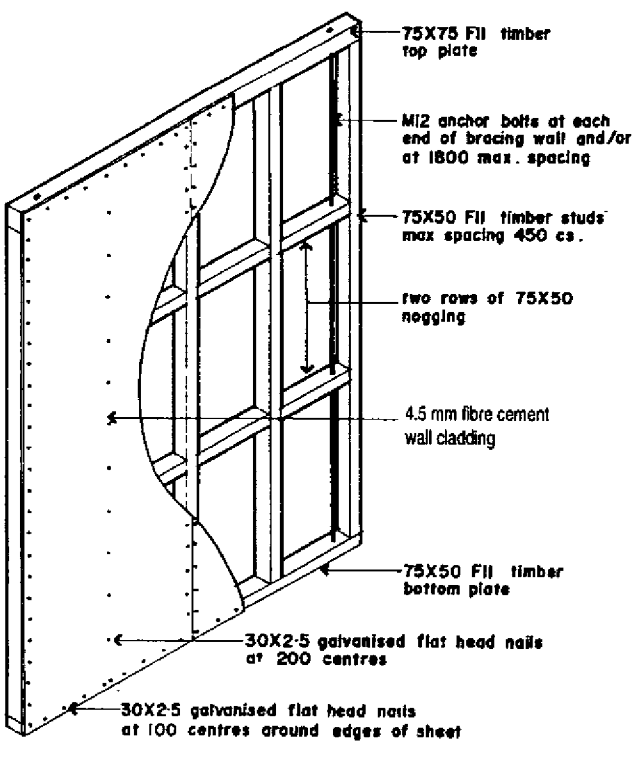
The need for support of external walls by cross walls can be resolved by the installation of bracing walls, the examples are for timber walls. Brick walls can equal or exceed these transfer forces.



SKETCH OF BRACING WALL

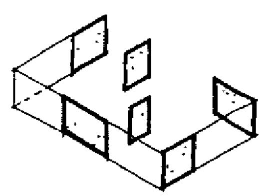
BRACING PANELS – TIMBER STUDS CLADDED WITH PLYWOOD, HARDBOARD, CEMENT FIBRE

RESISTANCE = 2.7 x 4.0 kN/m
= 10.8 kN APPROX.

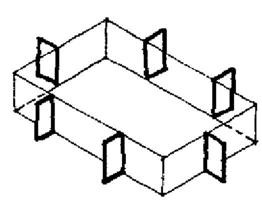


BRACING WALL DETAIL
THIS WALL CAN RESIST FORCES OF 4 kN / LINEAL METRE

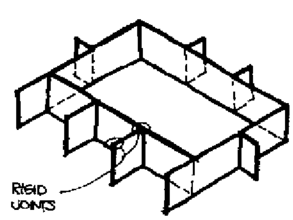
BRACING



BRACING WALLS IN FRAME BUILDING

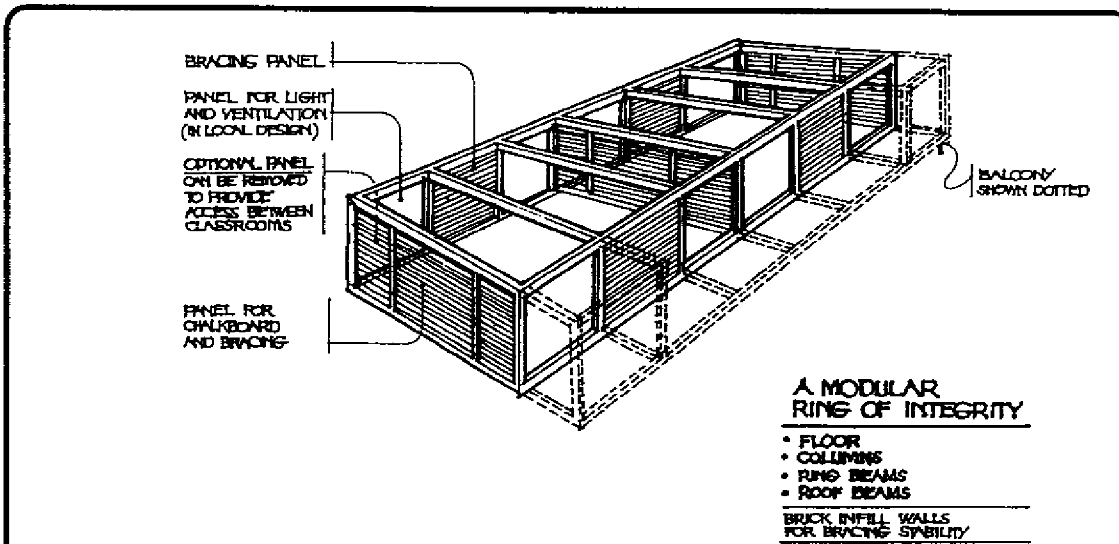


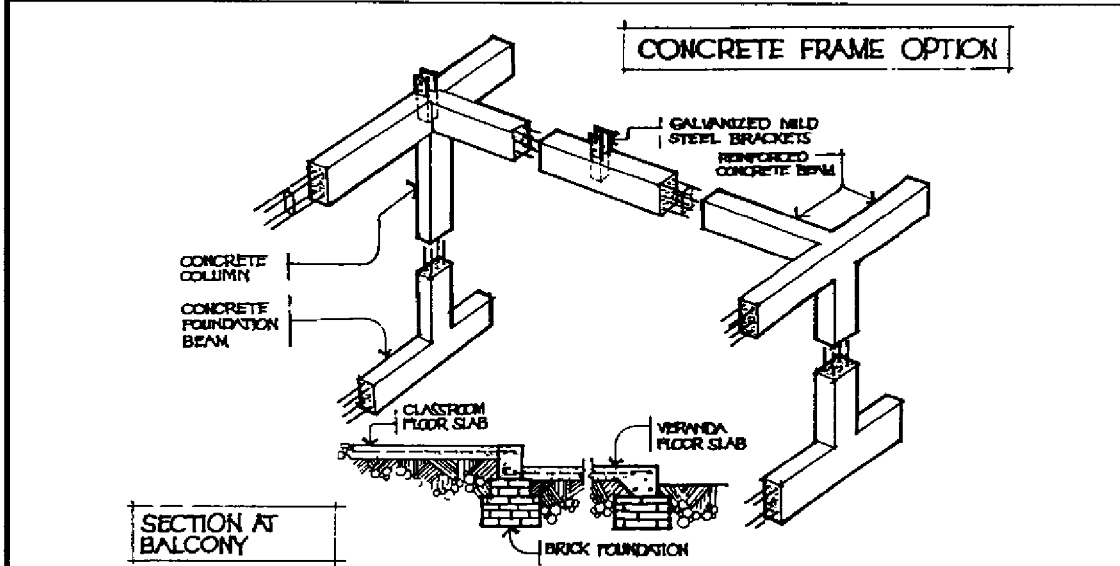
BRACING SYSTEMS

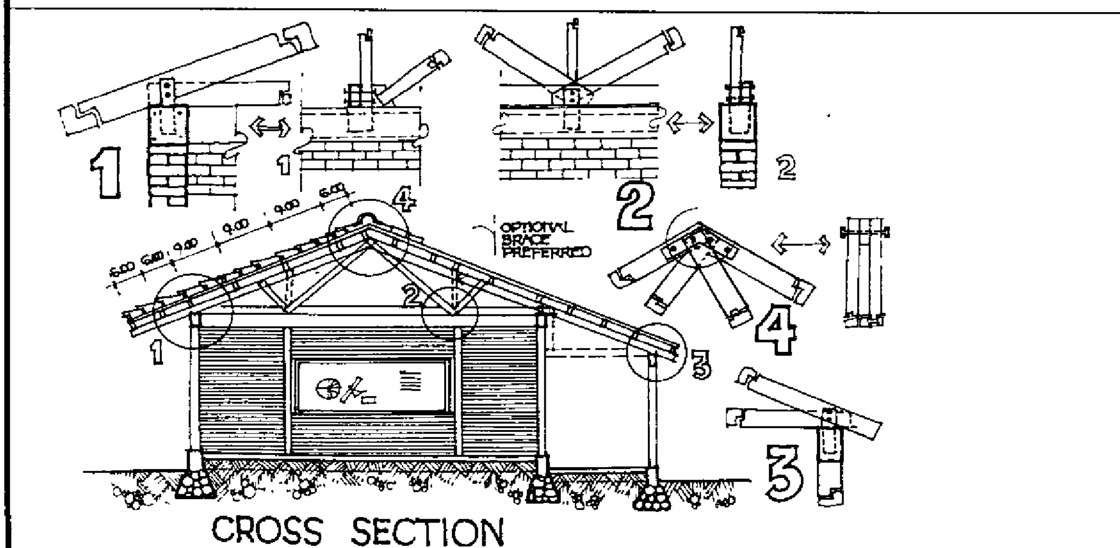


9.6.2 Modular Wall Construction

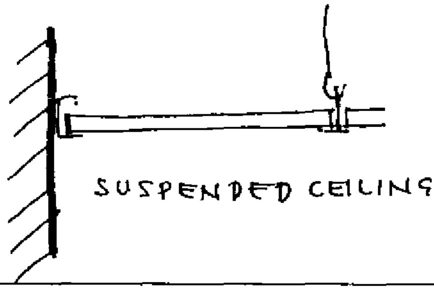
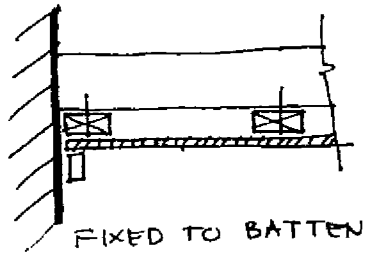
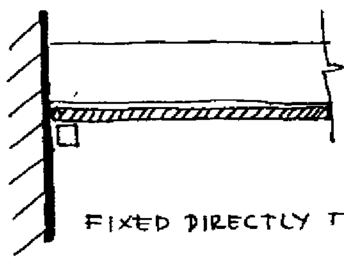
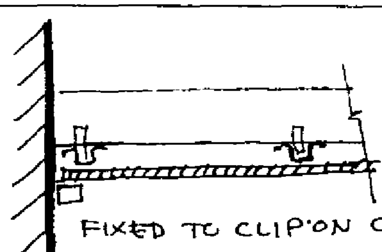
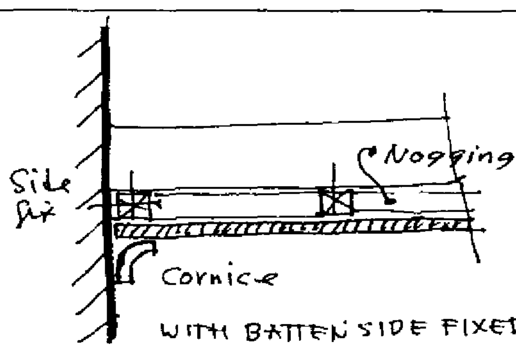
A suggested solution with concrete framed walls, brick infill and concrete and steel beams.







CEILING SHEETING AS DIAPHRAGMS

	Strength per m² kN/m²	Strength 10.0m length kN/m²
 SUSPENDED CEILING	ZERO	0
 FIXED TO BATTENS	0.5–1.7	5–17
 FIXED DIRECTLY TO JOISTS	0.7–1.5	7–15
 FIXED TO CLIP'ON CHANNELS WITH CHANNEL BATTEN SCREWED	0.1–0.2 0.6–1.0	1–2 6–10
 WITH BATTEN SIDE FIXED AND NOGGING TO JOINTS WITH CORNICE GLUED	1.8–2.9	18–29

9.6.3 Ceiling Diaphragms

We are mostly familiar with the solidity and stiffness of the concrete floors and brick walls in our buildings.

However, we tend to accept much lighter constructions in our ceilings and roofs with thin metal or fibre cement or tile roof cladding and ceilings are either omitted or are of the suspended drop-in panel type or of other light materials

University tests of the Cyclone Testing Station in Townsville, Australia, have revitalised interest in the contribution that properly constructed ceilings can make to the integrity of the building by providing in the ceiling plane, significant resistance to the forces tending to bend the external walls.

Most ceilings, erected without consideration of the fact that the construction and it's fixings are so important, can expect the ceiling to have an equivalent design strength of from zero to 0.8 kN/m.

With the better fixing methods, the design load can be increased up to 1.5 to 2.9 kN/m with better placement of sheet and more nails, holding the ceiling sheets to the ceiling framework. It justifies the cost of the re-introduction of ceiling joists and their supports in the developed countries

Some examples are as follows.

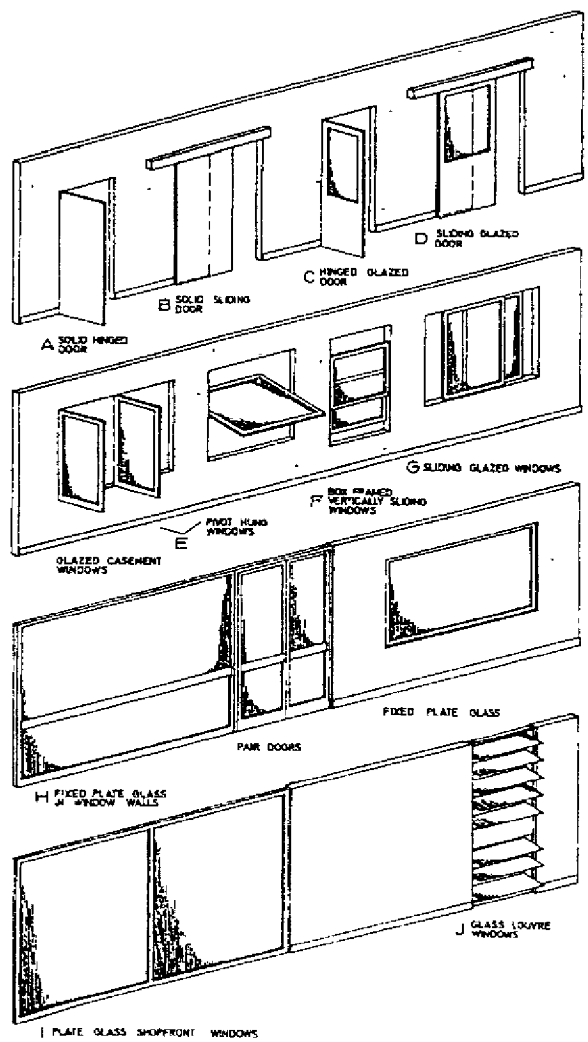
1. Plasterboard on clip on metal furring channels with fixings at 300 cc to perimeter and field.
2. Ditto but with furring channels screwed to joist, a big improvement.
3. Ditto but with pine timber battens.
4. Fibre cement sheeting fixed directly to ceiling joists.
5. Ditto but fixed to battens
6. Ditto fixed, but with edge batten also fixed to wall to add to strength.
7. Hardboard sheeting with perimeter fixings at 100 cc, field fixings at 300 cc fixed to battens with cross nogging between battens at end joints

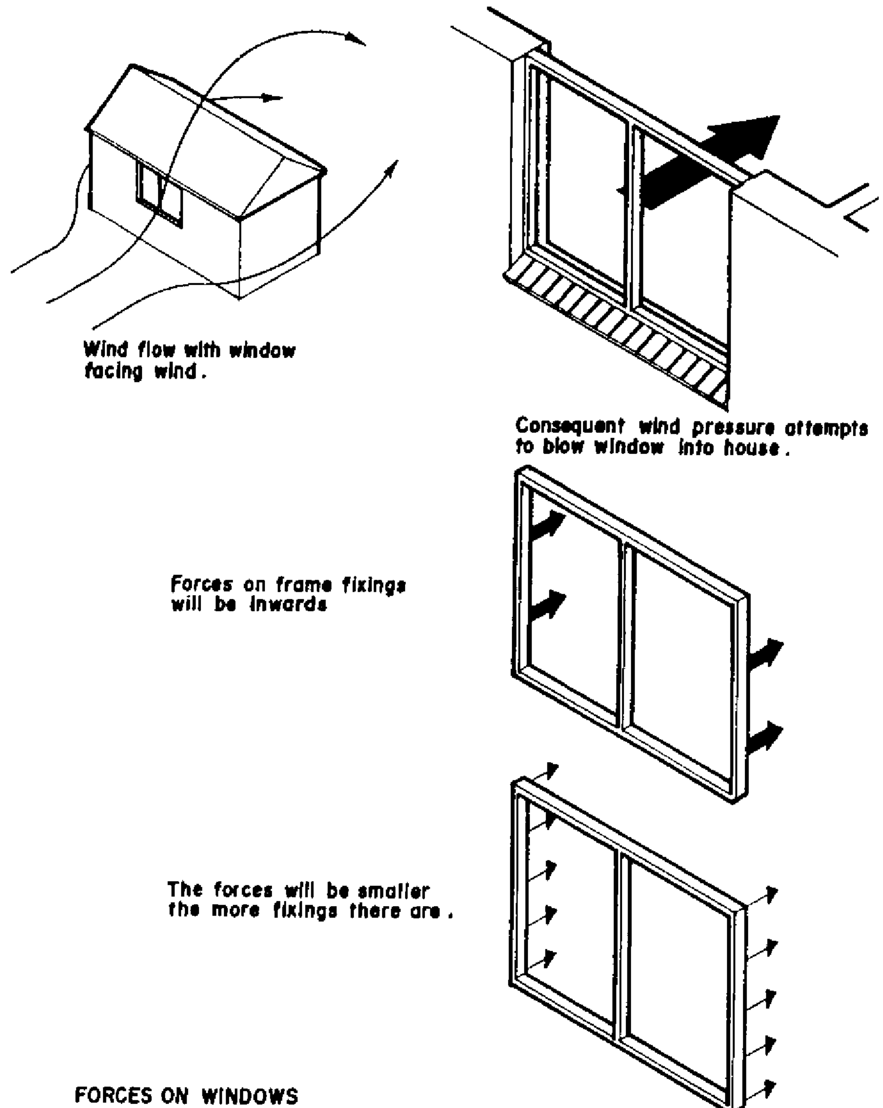
9.7 DOORS & WINDOWS

The installation of doors and window openings requires attention to the following:

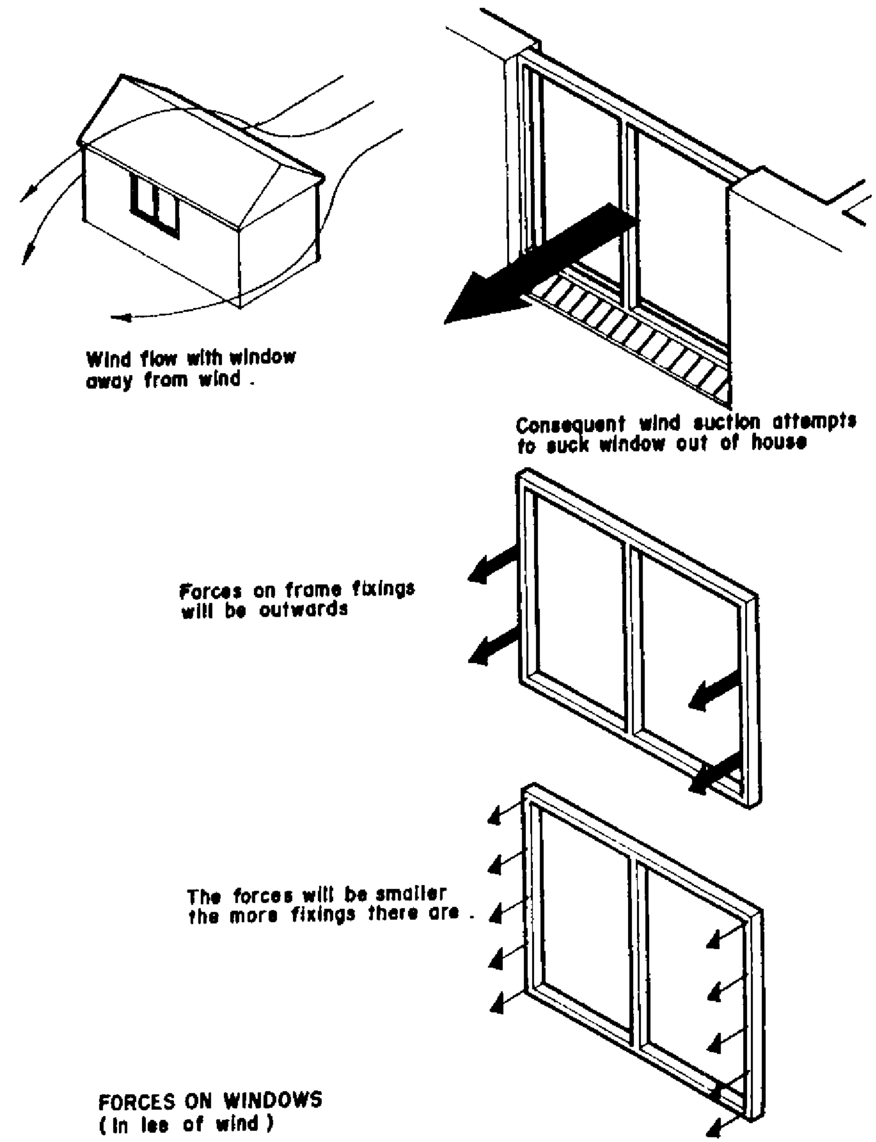
- Design of glass, frame and fixing by experienced personnel.
- Thickness and size of glass.
- Fixing of frame to wall, including size and spacing of fixings.
- Adequate supervision

The illustrations show a range of doors and windows, together with diagrams of wind pressures and suction forces.





FORCES ON WINDOWS
(Facing wind)



FORCES ON WINDOWS
(In lee of wind)

10 CASE STUDIES – REHABILITATION

CONTENTS

10.1 OVERVIEW OF REHABILITATION CASE STUDIES

This section includes case studies on:

i. **Case Study 1** • A Joint Venture Reconstruction Programme in Tonga

Showing how small nations can initiate, absorb research results and implement state of the art technology.

ii **Case Study 2** • Restoration of Historic Buildings

Showing how a large historic Federation building can be upgraded and rehabilitated with minimal interference to the architectural fabric.

iii. **Case Study 3** • Rehabilitation of Damaged Motel Buildings

After loss of roof and some walls and loss of interiors and exposure to deterioration for some years the building was able to be saved and rehabilitated to a first class, cyclone secure position.

iv. **Case Study 4** • Upgrade of Holiday Units

A timber framed complex of holiday units which was sub-standard in structure was able to be upgraded to enable it to survive cyclone winds

v **Case Study 5** • Two Level School and Facilities

A two level timber classroom block with suspect structural capacity was made secure with minimal cost and survives 24 years later. A toilet block shows how to ventilate the walls to reduce the effects of wind forces and models good quality tie-down techniques.

10.1.1 Case Study 1

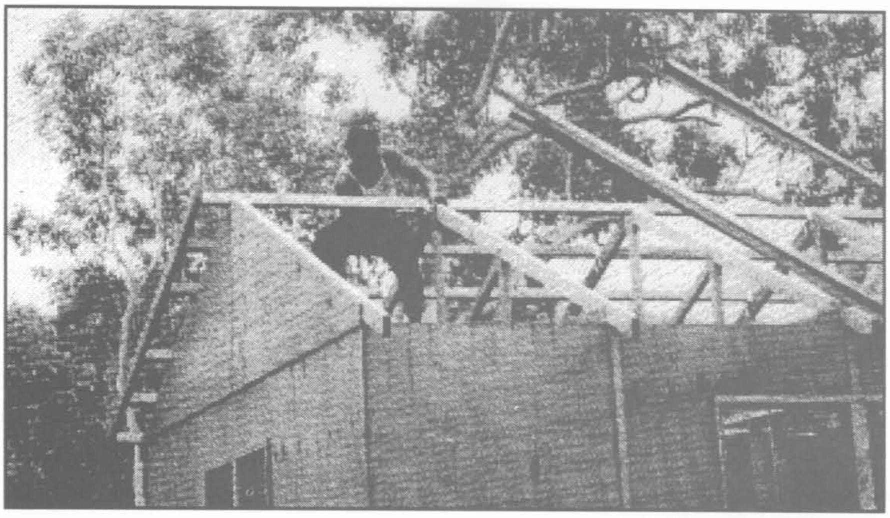
- *Joint Venture Community Reconstruction – Tonga*

It could be said that Tonga led the world in 1982–84 with investigation, identification, research, full scale testing, adoption of recommendations and implementation of new design techniques for cyclones.

During March 1982 cyclone "Isaac" (43 m/s) hit the islands of the kingdom of Tonga causing much damage. The Government was committed to a reconstruction programme of 2,000 houses in a two year period

After the cyclone and damage assessment review, the Government identified some weakness in the designs for the new houses and it was decided to make available a house for full scale testing (refer Eaton & Reardon 1985).

- A unique joint venture developed.
- The Tongan Government provided the house.
- The Commission of the European Community financed the cost of the house materials
- The New Zealand Government funded the cost of a travel for a Tongan official to visit Australia to erect the house at the test site at James Cook University of North Queensland, Townsville, Australia, to Tongan standards.
- The Australian Government funded part of the testing in conjunction with the Cyclone Structural Testing Station (CSTS) at the University.
- The British High Commission to Tonga provided the liaison.
- The British Building Research Establishment (BRE) acted jointly with the Testing Station in regards to recommendations and testing.



After the full scale testing, simple but effective solutions with roof batten location and more secure fixing methods were identified that would enable the house to be modified to resist maximum cyclone winds of over 60 m/s.

These recommendations were quickly adopted by the Government and implemented in the houses already under construction in Tonga.

The houses contained 2.4 x 1.2 ply sheeted wall panels, pre-cut and assembled in a factory, together with the pre-fabricated roof trusses, creating a mini-industry for a training and assembly program, and providing employment.

The whole project of initiation, testing and action in implementing the results into the 2,000 homes was completed in the existing housing development programme of a little over two years.

It was a fine example which created employment, initiated quality controlled mass production of wall and roof panels and trusses also used in school construction; the whole of which educated the construction industry which lifted its level of expertise.