MASONS, CARPENTERS & TECHNICIANS

TRAINING MANUAL ON EARTHQUAKE, CYCLONE, FLOOD AND TSUNAMI SAFE CONSTRUCTION IN FIJI

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&

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CONTENTS

INTRODUCTION

Natural Hazards such as Earthquake, Cyclone, Flood and Tsunami are normal occurrences in our region and Fiji in particular. The government has to meet bulk of the cost of damages caused by such hazards. During the period 1985 to 2004 Cyclone and Flash Flood damage was estimated to cost US$306,387,228.00 as detailed below :-

Hazard (Cyclones)	Year	Cost
TC Eric & Nigel	1985	39,712,636.00
TC Raj	1986	14,000,000.00
TC Rae & TC Sina	1990	36,300,000.00
TC Joni	1992	1,600,000.00
TC Kina	1993	100,000,000.00
TC Gavin	1995	18,300,000.00
TC June	1997	60,000,000.00
TC Dani	1999	2,000,000.00
TC Paula	2001	800,000.00
TC Ami	2003	22,089,200.00
Hazard (Flash Flood)	2004	11,585,392.00
	Total	**306,387,228.00**

Source : National Disaster Management Office

The high cost of rehabilitation work required after the occurrence of a hazard can be reduced if some proactive work are undertaken to ensure that new structures are properly built and maintained so as to ensure that they serve their purpose and existing structures are upgraded to a minimum standard. The introduction of the National Building Code is therefore very important in this regard and steps must be taken to speed up its introduction. Similarly, some mechanism within the city, town, settlements or villages should also be established and introduced so as to ensure that existing structures are structurally safe, not only for the occupants but for their neighbors and the general public as well.

The introduction of this Manual is expected to assist technicians, masons and carpenters to improve existing buildings and contribute to the construction and maintenance of safe and sound houses, especially schools for our children.

ACKNOWLEDGEMENTS

The Manual has been compiled with contributions from the following people and organisations:-

- Mr. Usieli Kamikamica, Ian Macallan & Co. (Fiji) Ltd.
- Ms. Nanise Degevacu, Ian Macallan & Co. (Fiji) Ltd.
- Staff of National Disaster Management Office, Ministry of Regional Development.
- Schools Retrofitting Project Technical Committee
- Ms. Keleni Bola, Research Assistant

BACKGROUND

Building Retrofitting is the process of strengthening a building structure so that it can better withstand natural hazards such as Earthquake, Cyclone, Flood and Tsunami, etc. The four types hazards mentioned above are quite common in Fiji and will be discussed in this Manual.

The manual has been prepared under the UNCRD Programme on "Reducing Vulnerability of School Children to Earthquakes." Although the Manual focuses on Retrofitting of School Buildings, the same concept can also be applied to any other public or private building.

The Manual is aimed at assisting Technicians, Masons and Carpenters to gain better understanding of the common hazards that usually occur in Fiji and more importantly to be able to undertake the Retrofitting work required using the concept and procedures outlined in the Manual. It is also aligned to the "Home Building Manual: which was prepared by the Fiji Building Standard Committee that produced the Fiji National Building Code in 1990. The Home Building Manual is a guide which Home Owners can use within it's limitations to design and construct their own homes. Construction details in this Training Manual should be used as minimum standards of construction for retrofitting existing school buildings (one or two storey construction) as the construction of new ones.

Although the Manual targets Technicians, Masons and Carpenters, it is hoped that policy makers, administrators, school managers and principals will also realise the great risks involved in the use of unsafe school public buildings and take appropriate steps to allocate more resources for the improvement of those buildings.

2.0 EARTHQUAKES

2.1 Causes of Earthquakes

The earth's surface is made up of a number of Tectonic Plates. Fiji sits on the top of the conjunction between three major Tectonic Plates. As the earth cools, it contracts and the movement of the contraction is mainly along the edges of the plates. Since the plates are held together by friction, the continued shrinking causes forces to build up along the edges until they exceed the friction forces holding the plates together and they let go or break, thus releasing the energy causing the vibration of the earth or Earthquake.

Some smaller earthquakes can also be caused by local volcanic activities.

2.2 Earthquake Prone Areas

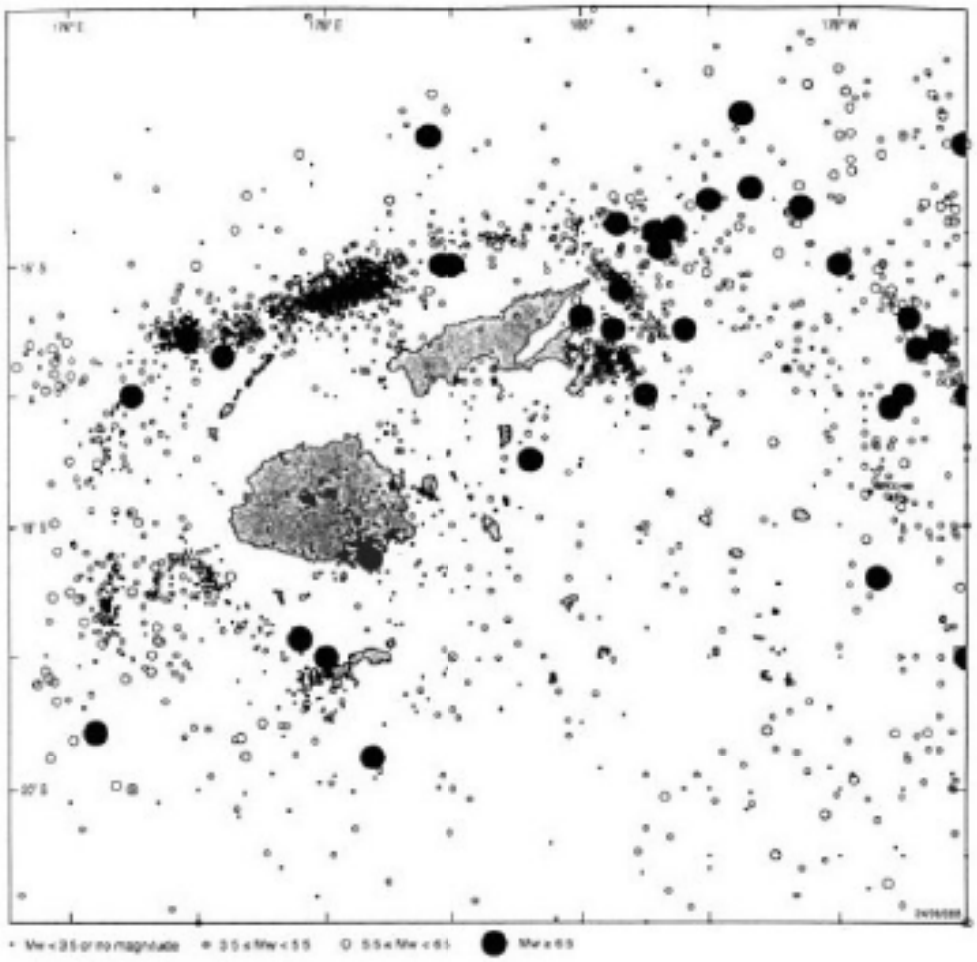
Earthquake prone areas can be identified from maps showing past occurrences of earthquakes.

In Fiji, one such map was produced from information provided in a paper that was prepared by Trevor Jones and is reproduced here as Fig. 1

It will be noted from the Earthquake map that a lot of earthquakes of different magnitudes have occurred in Fiji in past years. Concentration of such earthquakes can be found along the Yasawa Group, Northern side of Taveuni and North of Kadavu. It can therefore be said that these are the areas that will be more subjected to earthquakes than those with less concentration of activity. Proper care must therefore be taken when designing and building in those areas.

Figure 1.

Jones



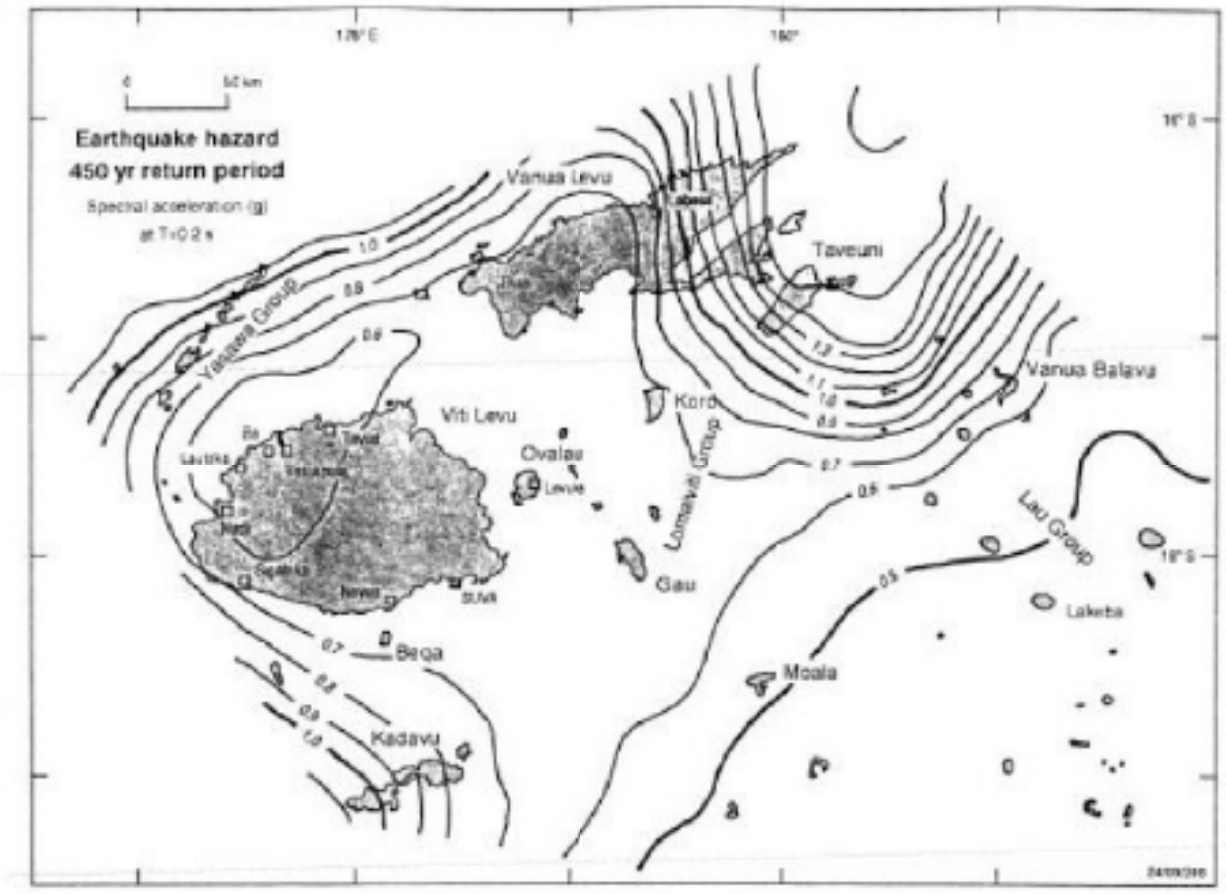
The occurrences of earthquakes in Fiji.

Preliminary Earthquake Risk Zoning Map

The Risk Zoning Map for Fiji (Fig 2) identifies three high risk zones : Yasawa Group, Northern Taveuni and Northern Kadavu.

Figure 2

Probabilistic earthquake hazard assessment for Fiji



The earthquake zone factor is used by Design Engineers to ensure that the designed structure will be able to withstand or minimize the effect of earthquake in a particular area.

Figure 3.

Zone Factors For A Return Period Of 450 Years	
Suva	0.68
Lautoka	0.54
Nadi	0.54
Labasa	0.81
Sigatoka	0.67
Levuka	0.68
Ba	0.55
Tavua	0.57
Navua	0.67
Rotuma	0.20

2.3 Damages Caused By Earthquakes

The vibrational energy transmitted through the earth causes strong shaking of the ground. The shaking of the ground can cause the following damages:-

- Collapse of structures which in turn may kill or injure occupants.

- Landslide or landslip is the movement of earth or surface down a slope due to heavy gravity. It can vary in size from a single boulder or a massive amount of materials in a debris avalanche.

- Vibration caused by earthquake may overturn equipment and furniture in a building causing damages and may also result in fire.

2.4 Structures At Risk

- Low strength masonry buildings
- Structures with heavy roof and little lateral support
- Reinforced concrete structures that are wrongly designed or poorly constructed
- Timber framed buildings better withstand earthquake if they are well built and the elements or members are well connected
- Buildings built on loose soils or sited on weak slopes are also at risk in an earthquake

2.5 Best Protection Against Earthquake

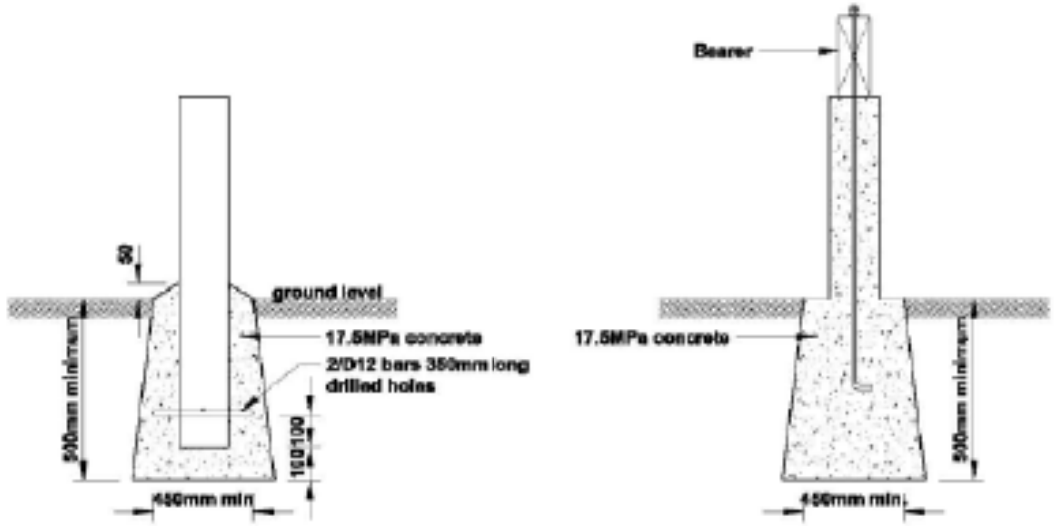
- Good and strong construction
- Proper siting of the building. Avoid siting the building on unstable sites

2.6 Earthquake (Seismic) Retrofitting for School Buildings

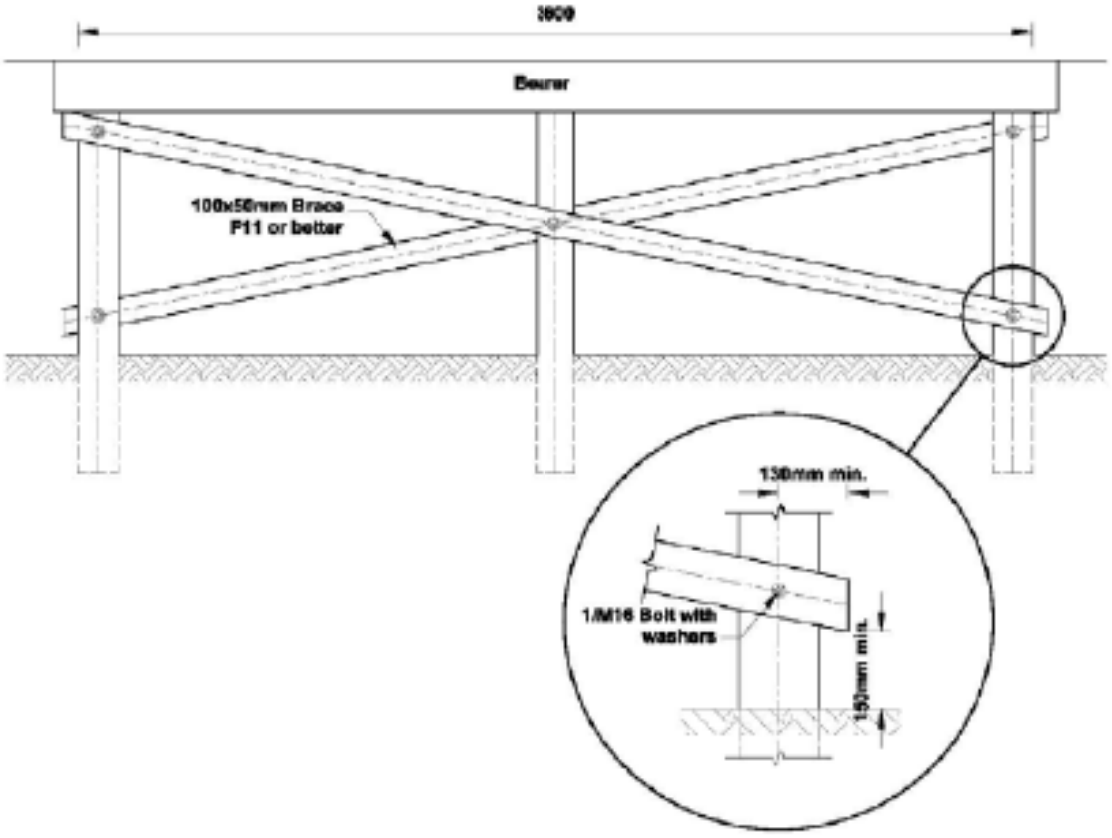
Earthquake retrofitting is the modification of existing school buildings to make them more resistant to earthquake or seismic activity, ground motion or soil failure.

Most school buildings in Fiji are of single or two storey construction and are made of timber, masonry or reinforced concrete. Retrofitting work discussed will focus on those types of buildings. The retrofitting work or method of construction used to counter the effect of earthquake and cyclone on school buildings of one or two storeys are similar. If they are properly carried out, the building should be able to better withstand the effect of both earthquake and cyclone.

ANCHOR PILES

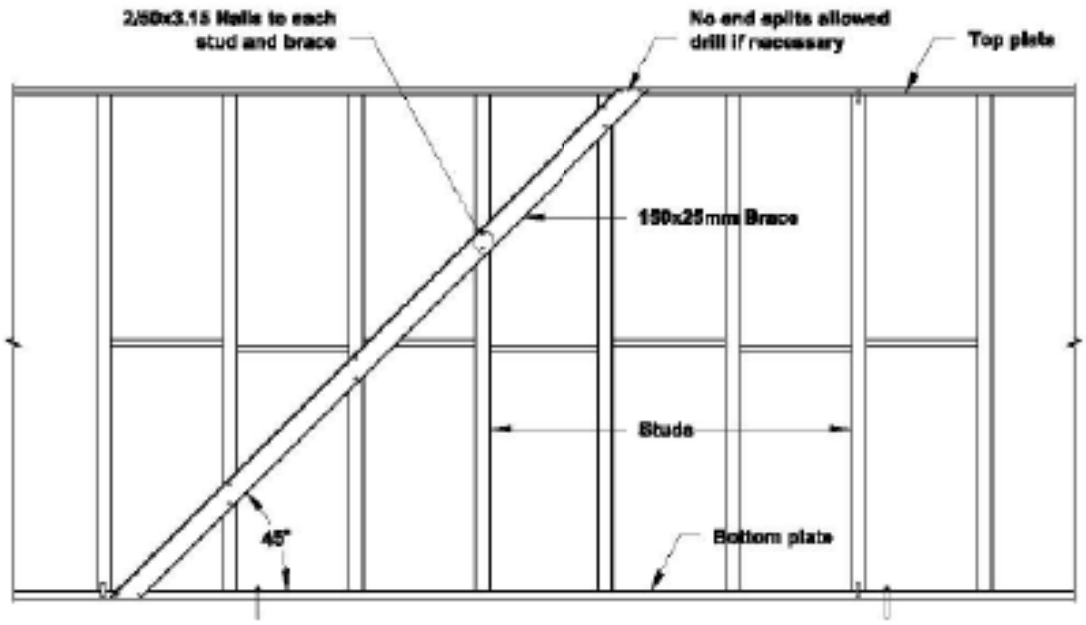


SUB-FLOOR BRACING TYPES

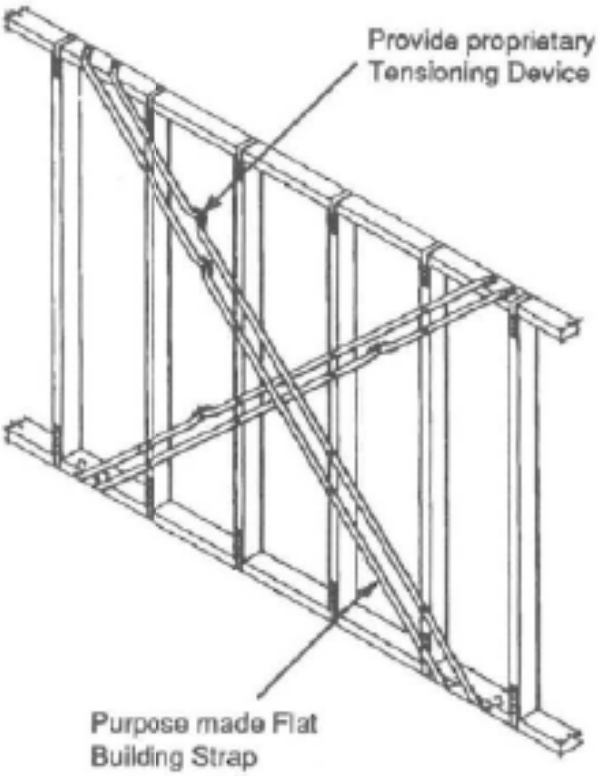


BRACING TYPES

1.TIMBER BRACE

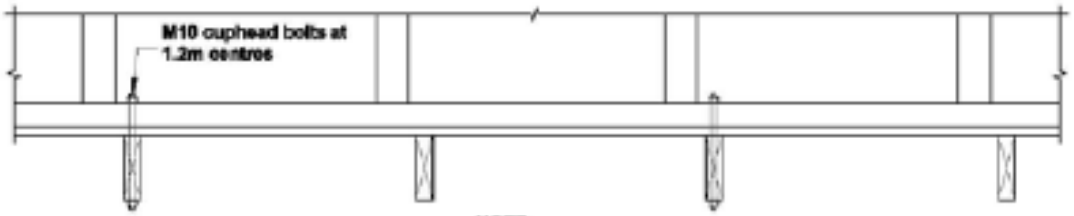


2. Metal braces



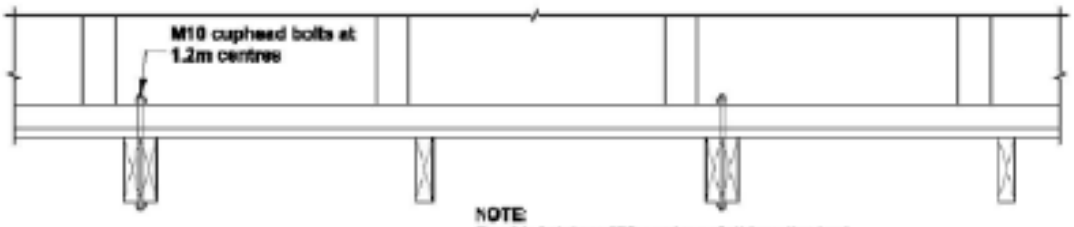
TIE DOWN: BOTTOM OF BRACING WALLS

1.



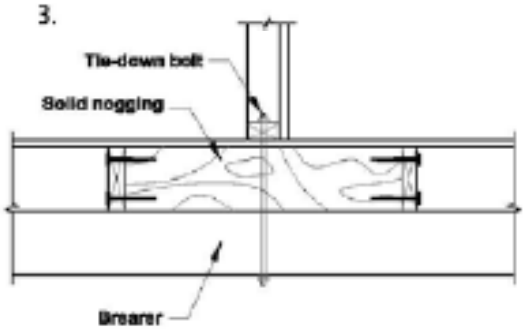
NOTE:
Minimum joist width is 45mm

2.



NOTE:
Double joist or 450mm long full length cleat nailed to joist with 6/75x3.15Ø nails

3.



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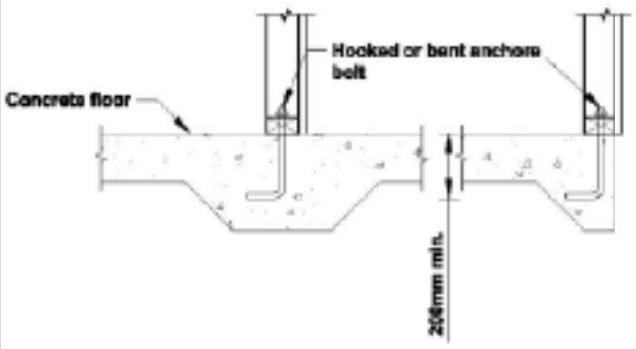
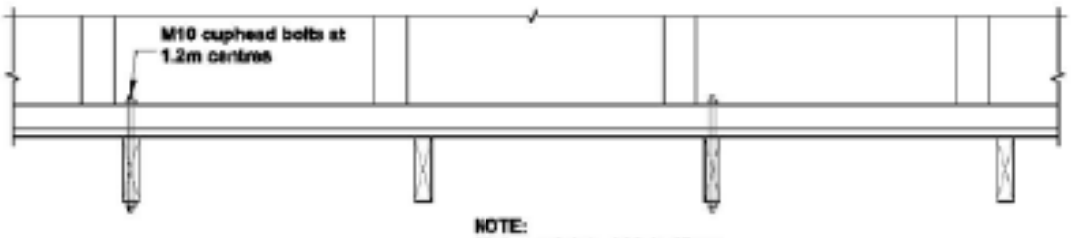


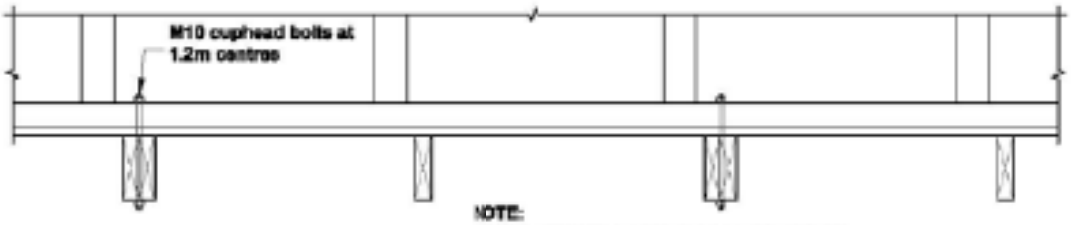
TIE DOWN: BOTTOM OF BRACING WALLS

1.



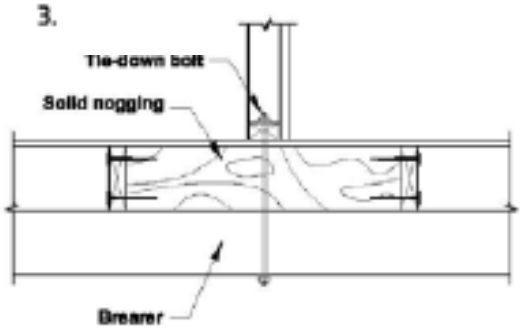
NOTE:
Minimum joist width is 45mm

2.

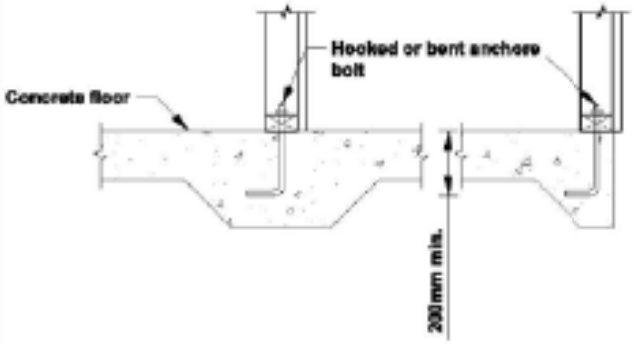


NOTE:
Double joist or 450mm long full length cleat
nailed to joist with 6/75x3.15G nails

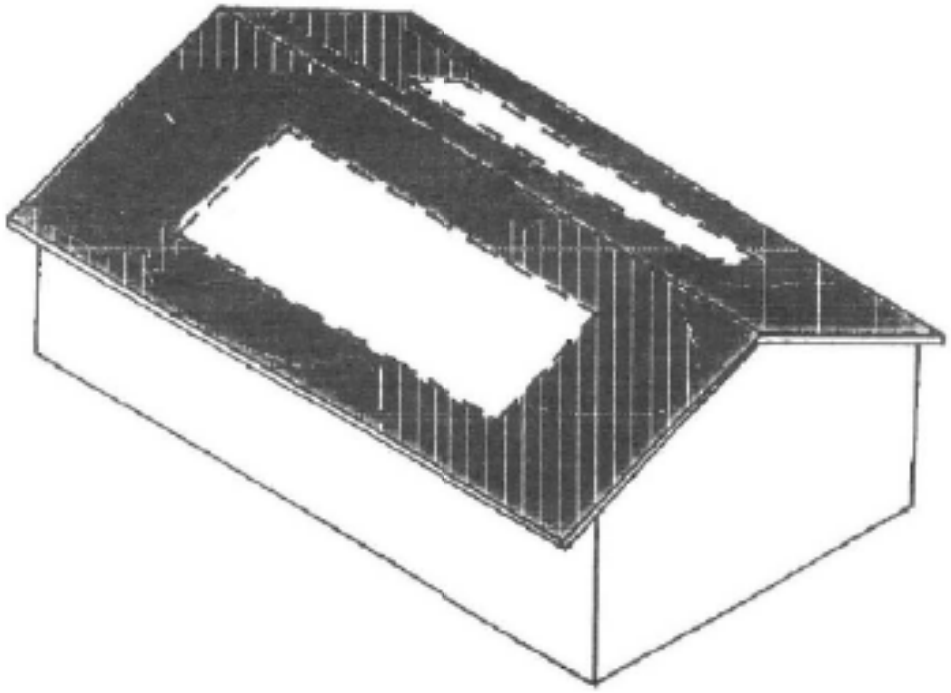
3.

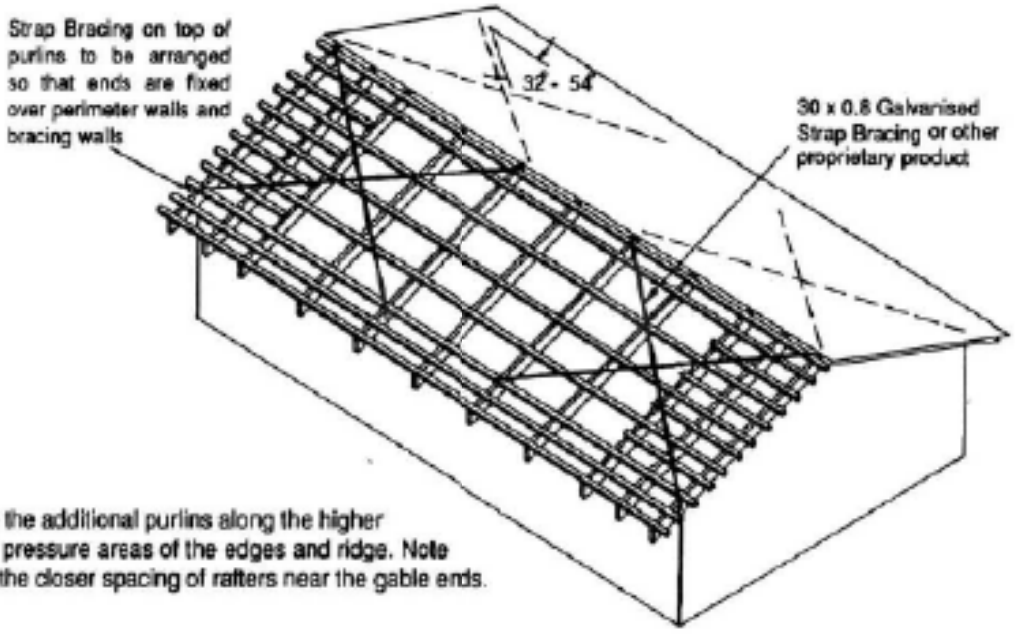


4.



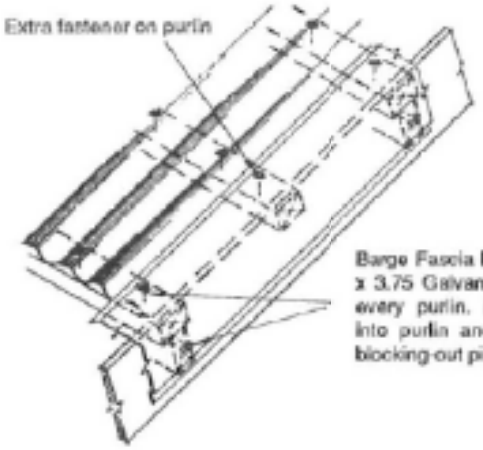
RAFTER ROOF FRAMING DETAILS



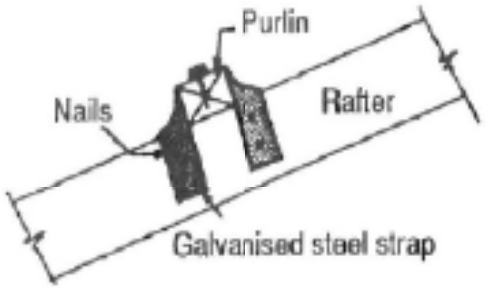


Note the additional purlins along the higher local pressure areas of the edges and ridge. Note also the closer spacing of rafters near the gable ends.

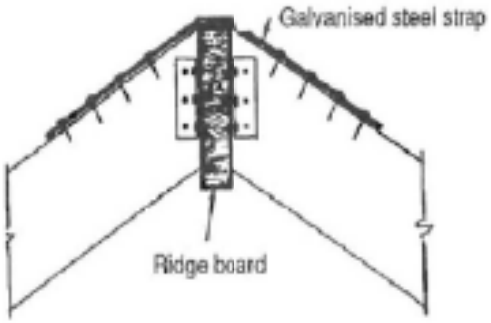
FIXING OF BARGE FLASHING AT GABLE END



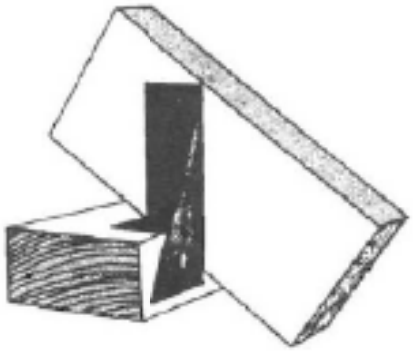
CONNECTION OF PURLINS



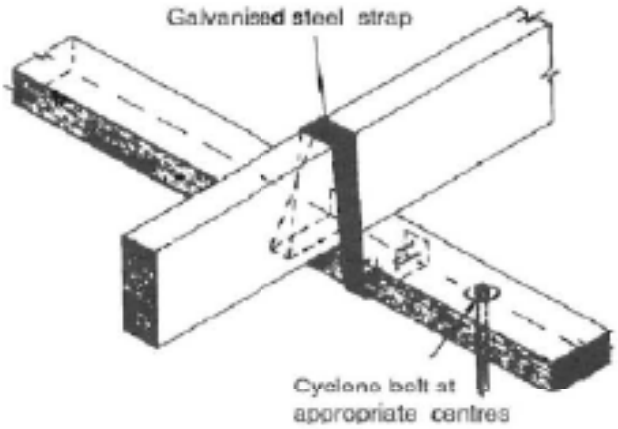
CONNECTION AT THE RIDGE JOINT



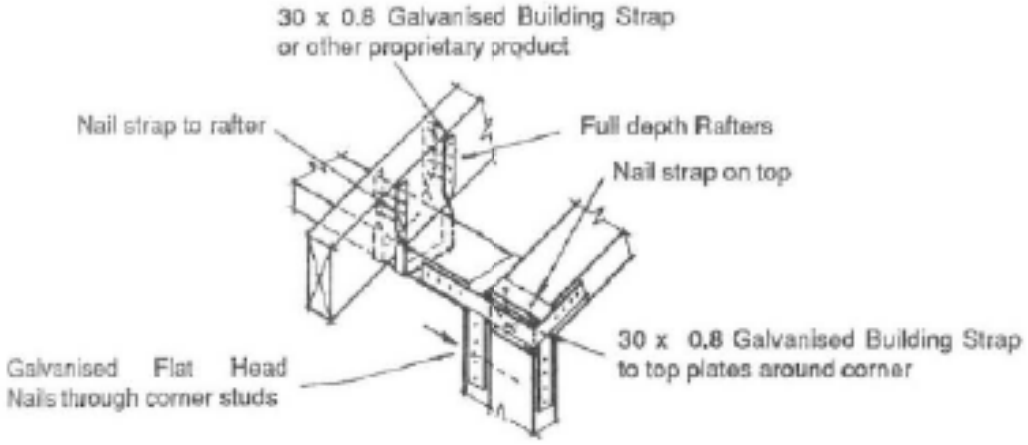
CONNECTION USED TO SECURE RAFTERS TO TOP PLATES



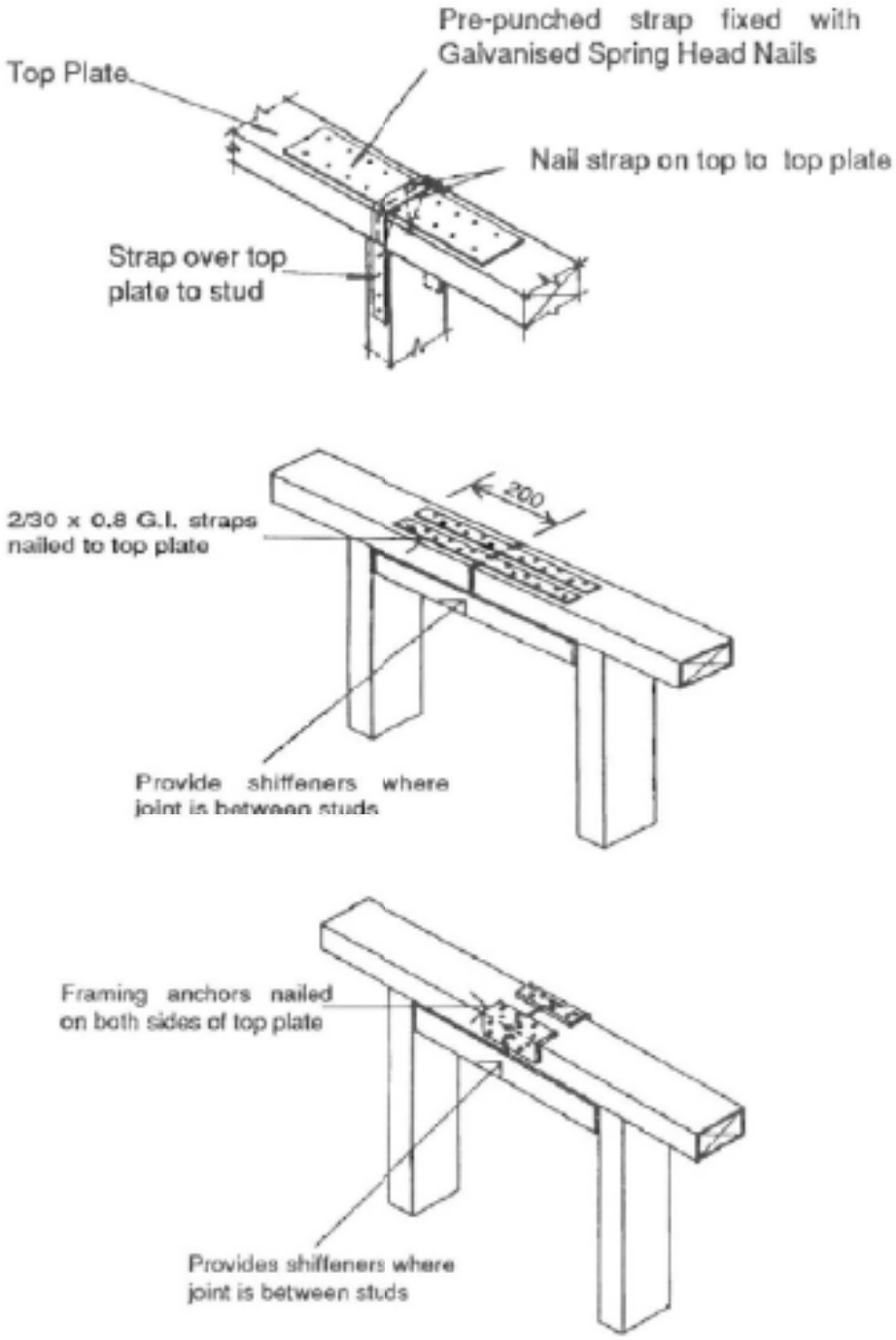
FIXING OF RAFTER TO TOP PLATE



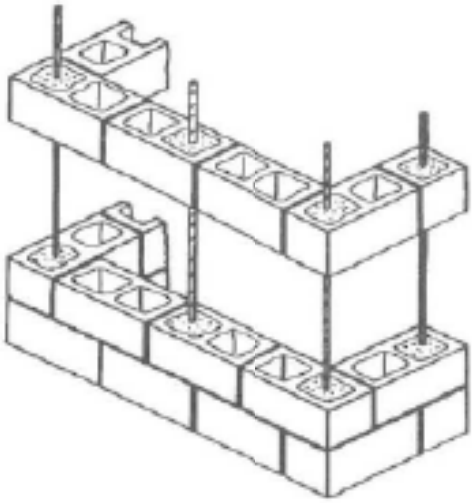
FIXING OF GABLE END WALLS TO SIDE WALLS AT TOP PLATE LEVEL



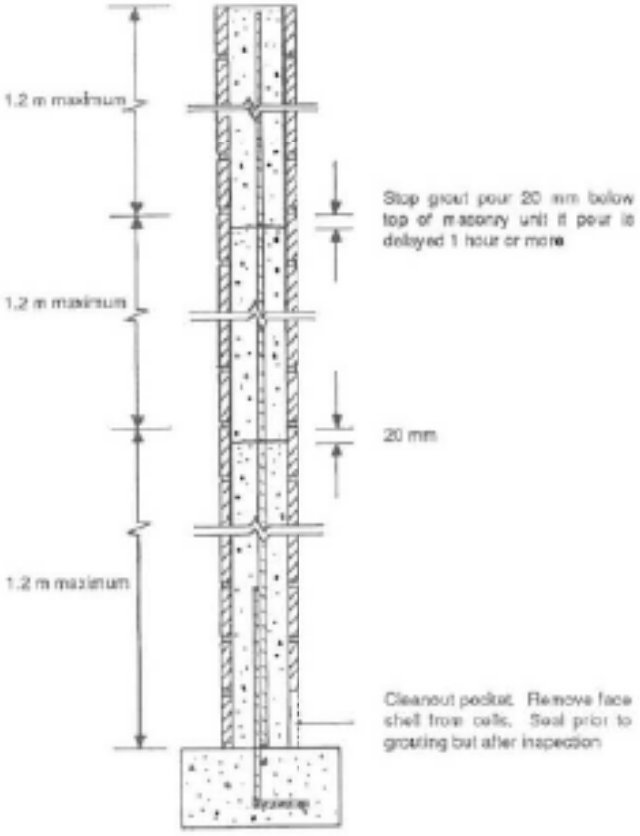
JOINTS IN TOP PLATES



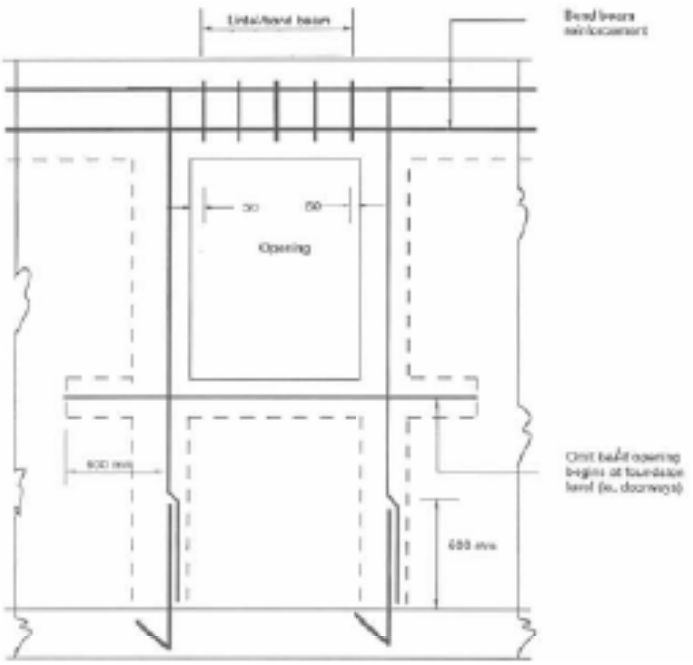
CORNER DETAILS FOR PARTIALLY GROUTED MASONARY WALL

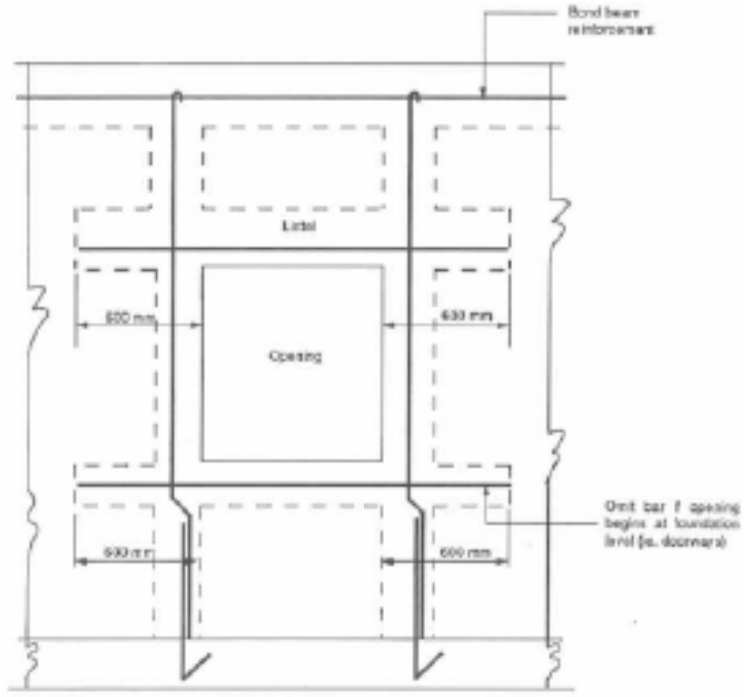


METHOD OF GROUTING BLOCK

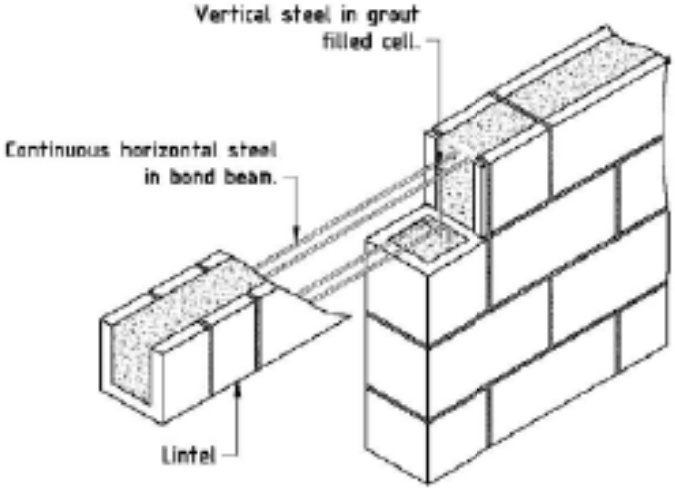


REINFORCEMENT DETAILS AROUND OPENINGS IN WALLS





LINTEL AND BOND BEAM DETAILS



3.0 School Building Maintenance Programme

A School Maintenance Programme is an organizational activity undertaken by the school management to prolong the life expectancy of school buildings, furniture and equipments. Regular maintenance of school buildings is particularly important in order to ensure that it provides proper learning environment and a safe shelter in the event of natural hazards such as earthquake, cyclone, etc.

The School Maintenance Programme should ensure that the school building can:-

- Function at it's designed level at all times
- Function during the normal life span of the building
- Resist the effect of extreme natural hazards such as earthquake, cyclone, flood and tsunami.

Three Main Building Maintenance Programme Components include:-

- Maintenance Management Team
- Inspection
- Maintenance Plan

3.1 Maintenance Management Team:

Major Roles include:-

3.1.1 Ensure that school buildings and other facilities are properly maintained at all times
3.1.2 Source maintenance funds
3.1.3 Prioritise maintenance work according to available funds

The team may include:-

i. School Management Committee Representatives
ii. School Principal
iii. Occupational Health and Safety (OHS) Committee Representative
iv. Building Maintenance Officers

3.2 Inspection

A preliminary inspection should be undertaken by the Building Maintenance Officers. The inspection can be based on the following check list which consists of the major components of the School Buildings and Facilities:-

- Structure
- Roofing
- Building Exterior
- Building Interior
- Plumbing
- Electrical
- Grounds
- Furniture and Equipment

Note: Any major structural defect identified during the inspection should be referred to a structural engineer for a professional opinion.

Major ideas to be inspected at the major building components mentioned above are listed in the Inspection Report Forms.

3.3 Maintenance Programme:

The maintenance programme is compiled by the Maintenance management Committee. It is based on the Maintenance Officers' Inspection Report of

the various Building Components and the maintenance funds available.

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING STRUCTURE				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Columns				
Beams				
Structural walls				
Ground floor				
Upper floor				
Roof structure				
Stairs				
General Remarks:				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING ROOFING				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Roof Covering				
Flashing				
Gutters				
Down-pipes				
Flat roof protection				

Other				
General Remarks:				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING EXTERIOR				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Exterior walls				
Exterior windows				
Exterior doors				
Corridor railings and posts				
Other				
General Remarks:				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING INTERIOR				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Floor Covering				
Interior walls				
Ceiling				
Interior doors				
Interior windows				
Window glazing				
Other				

General Remarks:

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING PLUMBING				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Water Supply				
Water Store				
Fixtures				
Waste collection				
Septic tank				
Other				
General Remarks:				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING ELECTRICAL SYSTEM				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Service entrance cable				
Main panel box				
Circuits and conductors				
Outlets and switches				
Interior lighting (lamps and bulbs)				
Exterior lighting				

Electrical equipments				
Other				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING GROUNDS				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Courtyard				
Sidewalks and walkways				
Parking lot and driveway				
Retaining walls				
Gardens				
Fencing				
Other				
General Remarks:				

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING ROOFING				
Name of school:			Date of Inspection:	
Building No.			Name of Inspector:	
Identify the specific item accordingly with a description. Leave blank if the item does not exist.	*Choose One*		*If unsatisfactory, describe the problem*	*Where is the unsatisfactory component located in the school building?*
	Satisfactory	*Not Satisfactory*		
Roof Covering				
Flashing				
Gutters				
Down-pipes				
Flat roof protection				

Other				
General Remarks:				

MAINTENANCE INSPECTION REPORT

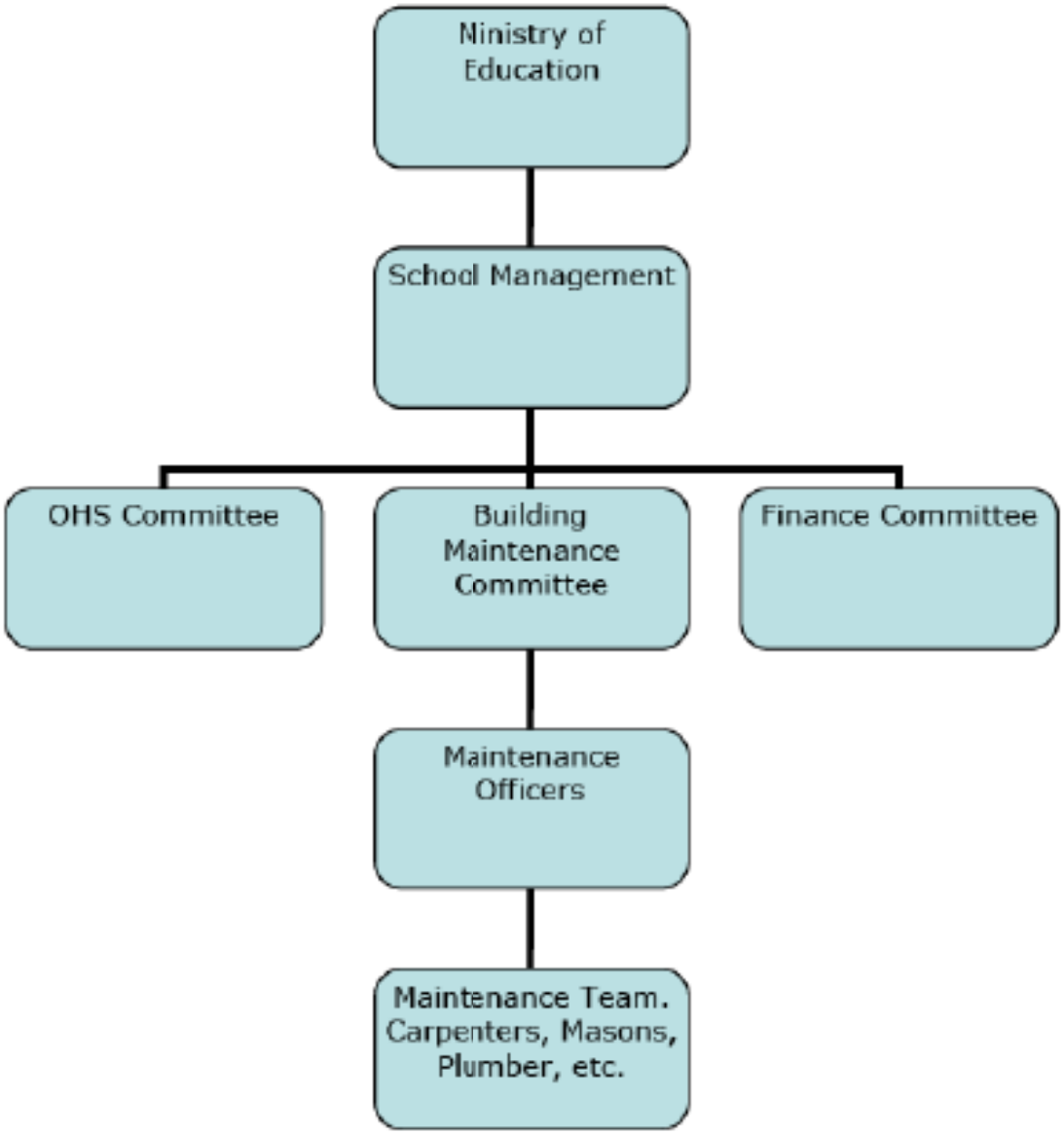
UNSATISFACTORY FURNITURE AND EQUIPMENT								
Name of school:				Date of Inspection:				
Building No.				Name of Inspectors:				
Location *Item*	Classroom	Lab	Workshop	Library	Gym	Office	Storeroom	Kitchen
Desk								
Chair								
Blackboard								
Board								
Cabinet								
File cabinet								
Table								
Audiovisual equipment								
Computer								
Typewriter								
Educational material								
Lab equipment								
Musical instruments								
Sports equipment								
Office equipment								
Office supplies								
Books								
General Remarks:								

MAINTENANCE INSPECTION REPORT

SCHOOL BUILDING MAINTENANCE PROGRAM			
List of problems according to priority			
Name of school:		Date of Inspection:	
Location:		Name of Inspector:	
#	ITEM	TIME FRAME	ESTIMATED COST
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

4.0 Institutional Arrangement

The way forward to Reducing Vulnerability of School Children to Natural Hazards will depend on putting in place an institutional arrangement that links up all the activities involved at Management and implementation level was shown in the following diagram:


Ministry of Education
School Management
OHS Committee
Building Maintenance Committee
Finance Committee
Maintenance Officers
Maintenance Team. Carpenters, Masons, Plumber, etc.