Disaster Resistant Building Technologies for Socialized Housing

Presented by: **Arch. Gertrudes C. Samson, MAHS**
Activity: **TAO-Pilipinas YP Workshop 2006**

Source:

From Emergency Shelter Towards Implementation of Disaster Resistant Technologies in the Philippines

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Short Introduction

Characteristics of these sample disaster resistant technologies:

• effective in resisting both typhoon/hurricane and earthquake at the same time, the synergy of the two.

• applicable and affordable for Philippine setting meaning could be easily integrated to the traditional local construction system therefore could encourage people's participation.

• would be helpful both for professional designers and lay people, or disaster victims who wants to build disaster resistant shelters, or interested to retrofit their houses.

Statement of the Problem

Realities in the Philippines and its vulnerability to Disaster

World Map [1]

Philippines lies in the southeast Asian continental landmass.
A location frequently visited by disasters.

Statement of the Problem

This is because Philippines "expect typhoon (tropical cyclone) and earthquake to befall every now and then" [6] due to its :

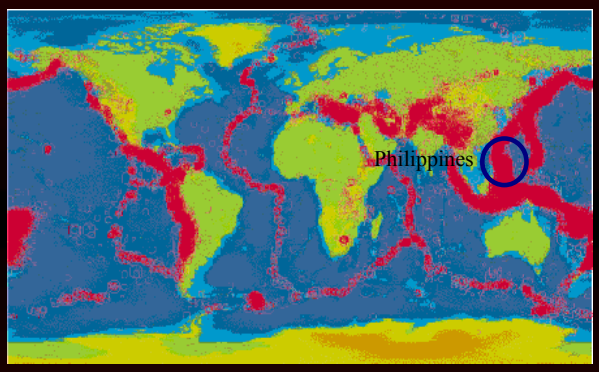
Typhoon belt setting...

Cyclone Zone as indicated by the hatched area. [7]

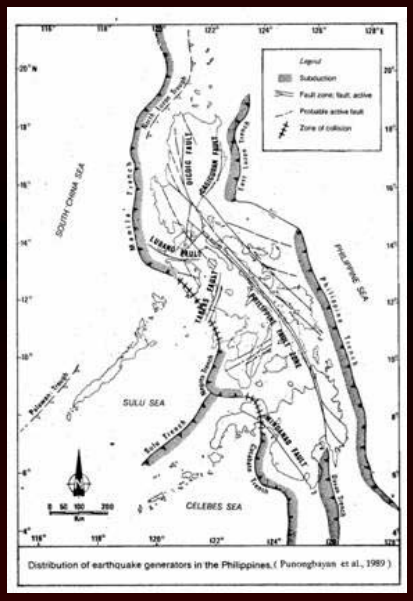
Phil. Typhoon Tracks 1955-1985 [8]

Statement of the Problem

Philippines also lies in earthquake belt of the world.



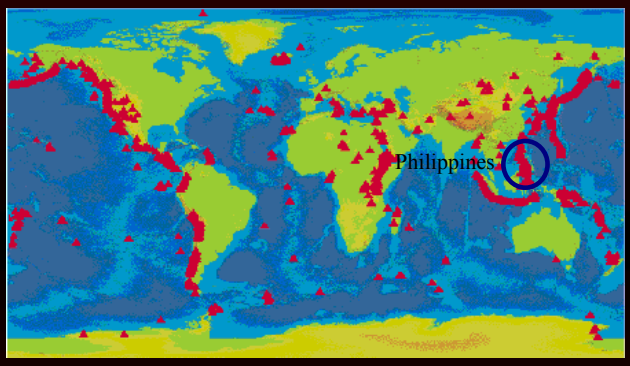
Map of Earthquakes as shown in red. Concentrated along tectonic plates boundaries of the world. [13]



Map of Earthquake generators in the Philippines [14]

Statement of the Problem

Where historically active volcanoes that generated earthquake are also located.



Map of historically active volcanoes that generated earthquakes as shown in red. Concentrated also along tectonic plates of the world. [15]

Distribution of active and inactive volcanoes in the Philippines.

Map of Active and inactive volcanoes in the Philippines [16]

Statement of the Problem

Map of Philippines [2]

It got physical attibutes that makes it beautiful and attractive, but at the same time makes it vulnerable to disaster as well.

It is the second largest archipelago in the world, composed of 7,107 islands with 28, 962 kilometers of coast line, which is said to be the longest in the world. [3]

Statement of the Problem

The Topography is Varied [4]...
From Low Swamps and
Coastal Plains,

To Mountain Ranges,

Volcanoes,

& Rolling Hills.

Land area of 115,739 sq. m.
(299,764 sq. km.).
60% percent of the land mass is
mountainous.

Statement of the Problem
Vulnerability of Philippines to Disaster

With these country's physical attributes [5]...

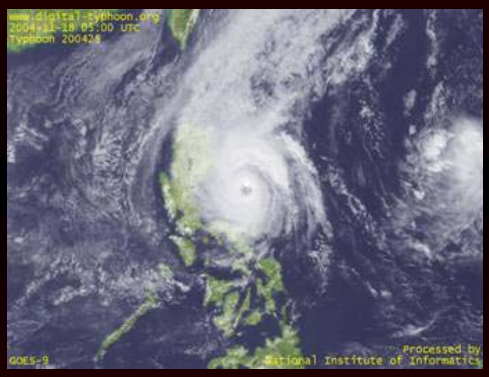
"Filipinos who settle along the coastlines and riverbanks learn to live with seasonal floods, storm surges, and tsunamis."

"Those who live further inland have to cope with other natural disturbances. Smaller islands are vulnerable to floods and drought because of denudation."

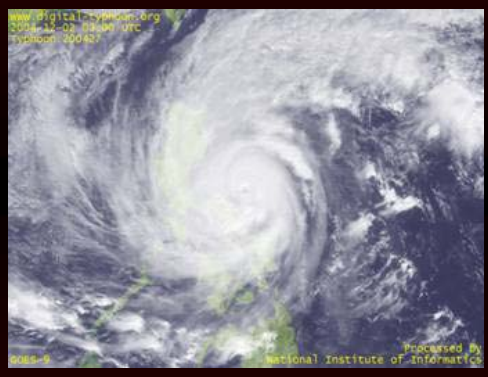
"The mountainous topography is conducive to soil erosion, aggravated by rampant destruction of the country's forest cover."

Statement of the Problem

An average of 20 tropical cyclones enters Philippines every year.
Between 1986 and 1990, at least 84 cyclones entered the Philippines.
32 were classified as destructive. [9]



November 18, 2004 [10]



December 2, 2004 [11]

Sample Satellite Picture of Actual Typhoons that entered Philippines

The strongest and most destructive is the Nov. 10-14, 1990 Typhoon.
Totally damage houses 222,026.
Damage cost P10.846 billion (€ 216.92 M). [12]

Statement of the Problem

Philippines have at least five earthquakes everyday
although most of the time too faint to be felt by humans. [17]

The country already had a total of 74 destructive earthquakes since 1599. But the most destructive earthquake in the country is the July 16, 1990 earthquake. Death Toll is 1,666 people, Total Cost of Damage is P12.2 Billion (€ 12.2 M).[18]

July 16, 1990 Earthquake [19]

March 6, 2002 Earthquake [20]

An example of earthquake destruction in the Philippines

Statement of the Problem

However, disasters do not occur only as result of natural and man made hazards. They only become disasters when they affect people who cannot cope with the physical, economic, and social impact.[21]

Therefore it is important to be prepared because "prevention is better than cure".

Source of Learnings

These samples mostly came from synthesis of learnings from experiences of the following island countries in Eastern Caribbean such as Antigua & Barbuda, St. Kitts & Nevis, St. Lucia, and Dominica.

World Map [48]

These technologies does not meant to restrict variation in the design but serves as a recommendations that could help economized construction expenses and at the same time making it disaster resistant against forces of typhoon and earthquake. Deviation would mean additional cost to strengthen the structure but decision still depends on the designer and the homeowner.

Definition of Disaster Resistant Technologies

Disaster Resistant Technologies to withstand typhoon and earthquake forces are design and construction techniques

which when applied to a structure,

"it is expected that the structure will not collapse or be destroyed but may still suffer some damage which however, can be repaired". [24]

In the case of catastropic hazards, "is likely to lead to a situation where the building cannot be repaired and must be demolished. In such event success is measured by the absence of deaths and serious injuries." [25]

Technology here is defined as "all of the means available for dealing with practical problems in the material world". [26]

Synthesis of Learnings

Disaster Resistant Technologies

The synthesis of learnings of this thesis is divided into the following nine categories or section:

- Locations of Sites and Placement of Houses on Site
- Site Preparation
- Building shape
- Foundations type and system of construction
- Concrete mixture and preparations
- Floor Design and preparation
- Exterior Wall Construction System
- Roofs Design, materials, and connections
- Doors and Windows safety measures

Synthesis of Learnings

Disaster Resistant Technologies

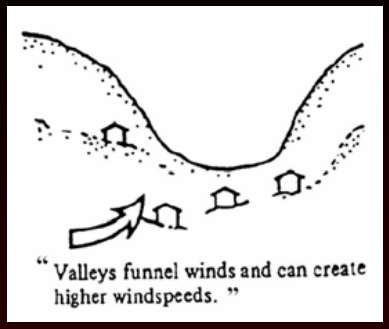
Locations of Sites and Placement of Houses on Site

Synthesis of Learnings

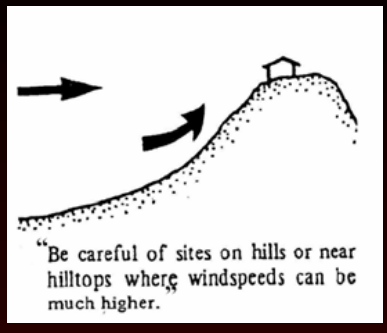
Disaster Resistant Technologies

Locations of Sites and Placement of Houses on Site

Hazard Prone Sites to Avoid



Valley [49]



Hilltops [50]

Slope Facing Wind Ward [51]

Near the Sea [52]

Synthesis of Learnings

Disaster Resistant Technologies

Locations of Sites and Placement of Houses on Site

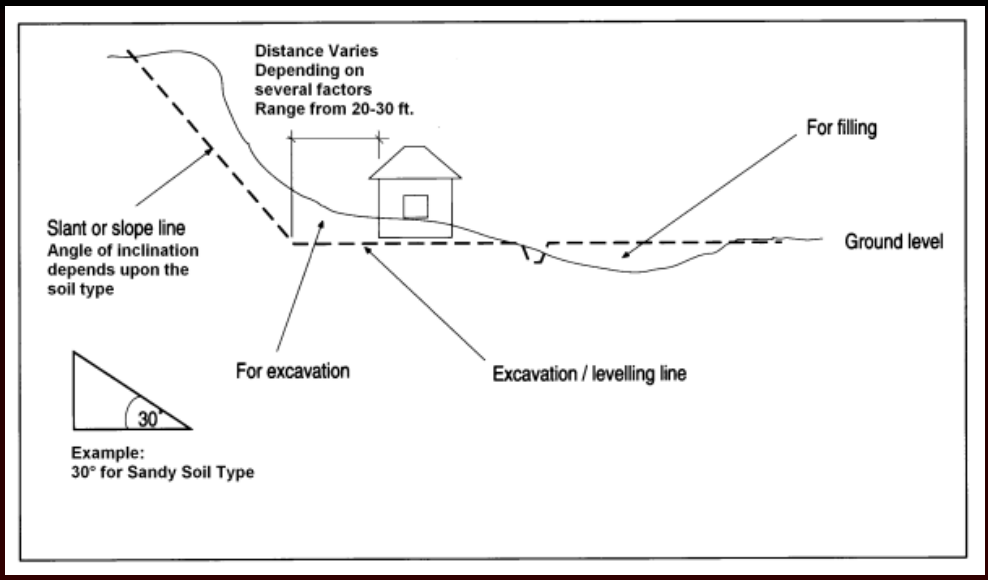


Figure showing Proper way to cut and fill slope and to locate a house 53

Synthesis of Learnings

Disaster Resistant Technologies

Locations of Sites and Placement of Houses on Site 54

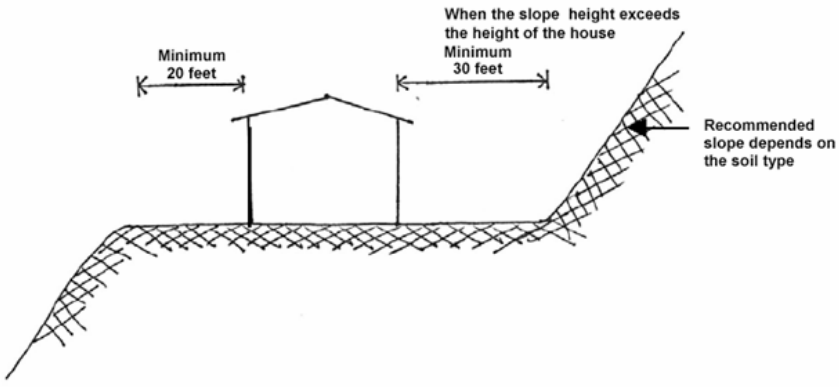


Table of Recommended Slopes for Common Soil Types

Soil Type	Recommended Slope
Clays and Loams	1:2; 65° or 200%
Silts	1:1; 45° or 100%
Sands	2:1; 30° or 50%

Synthesis of Learnings

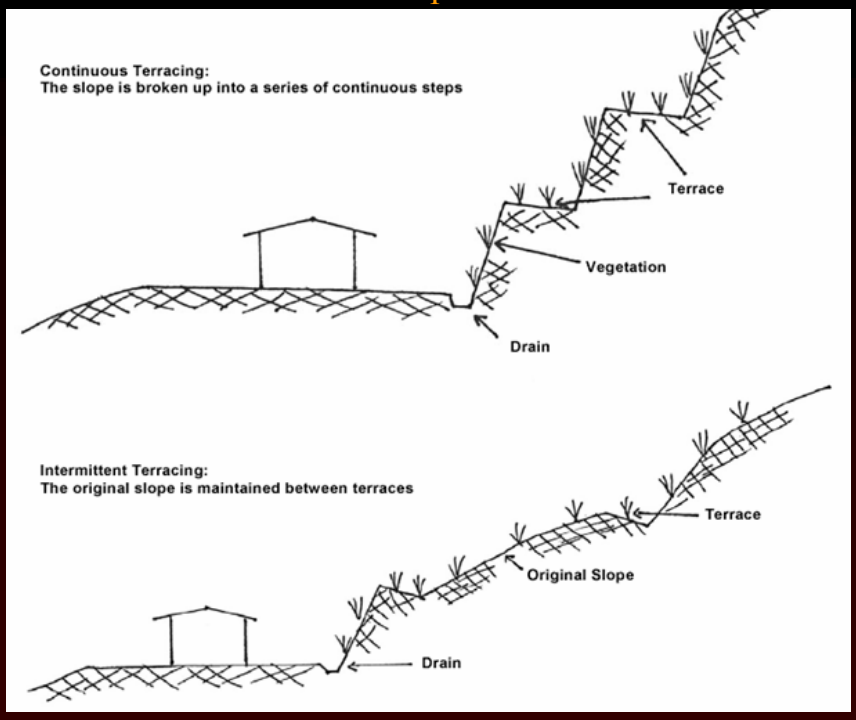
Disaster Resistant Technologies

Site Preparation

Synthesis of Learnings

Disaster Resistant Technologies

Site Preparation

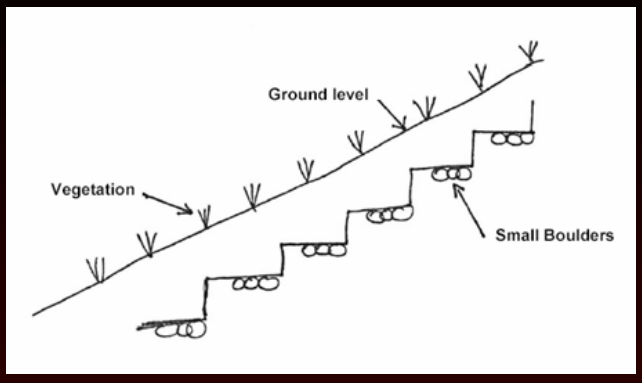


Reduction of Slope Height through Terracing each 6 feet or less in height for stability

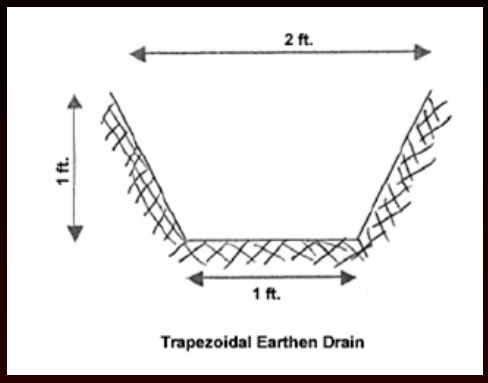
Synthesis of Learnings

Disaster Resistant Technologies

Site Preparation



Section of A Stepped Drain for Stable Down slope Conveyance Of Runoff in the Absence of a Natural Watercourse. [56]



Typical cross sections and Dimensions of earthen drains Constructed outside the house with sloped side for better stability. [57]

Synthesis of Learnings

Disaster Resistant Technologies

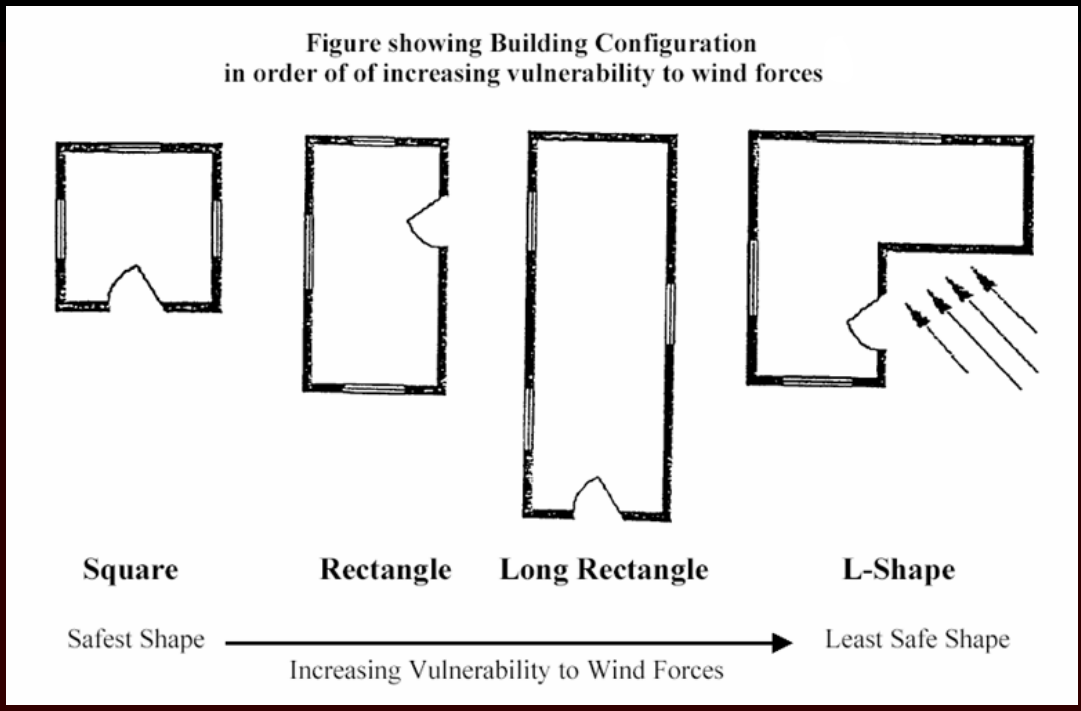
Building shape

3:1 Ratio

Synthesis of Learnings

Disaster Resistant Technologies

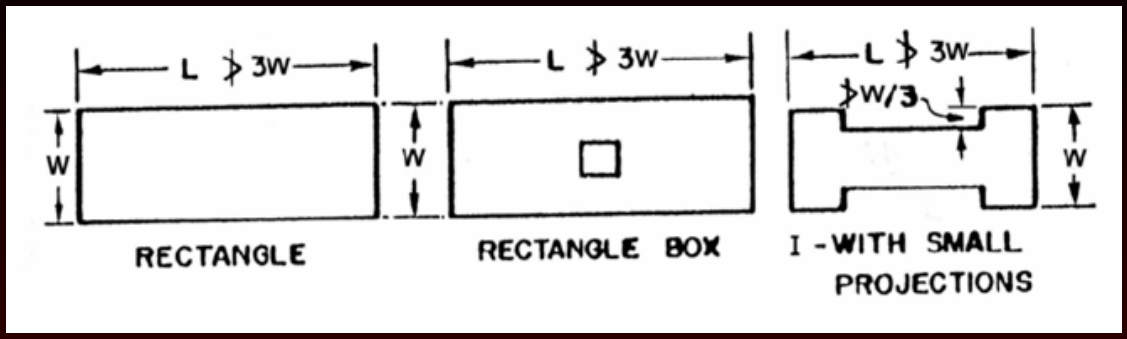
Building shape [58]



Synthesis of Learnings

Disaster Resistant Technologies

Building shape



Sample Symmetrical Desirable Rectangular Plans of Building for Earthquake Resistance [59]

Synthesis of Learnings

Disaster Resistant Technologies

Building shape

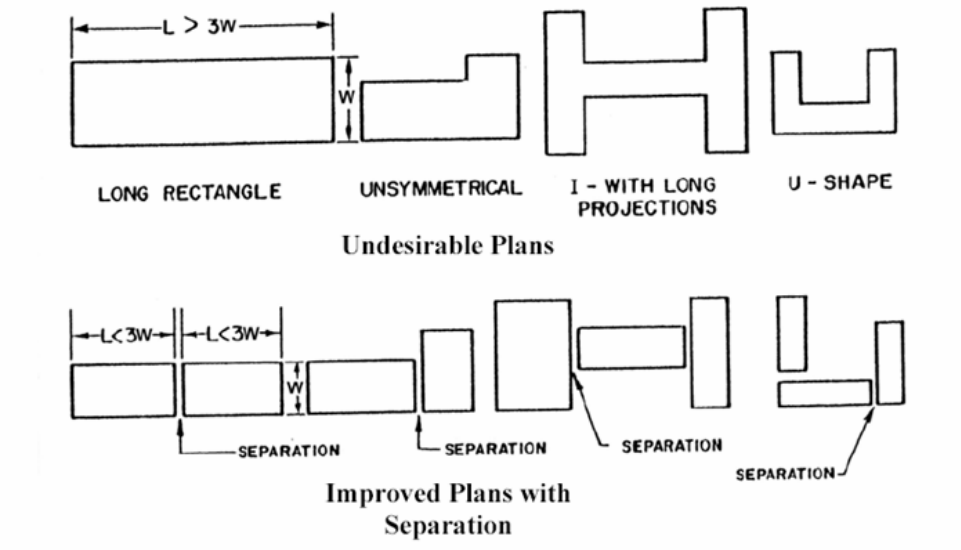


Figure Showing Use of Separation or corridor to improve resistance of Undesirable plan against earthquake and also typhoon forces. [60]

Synthesis of Learnings

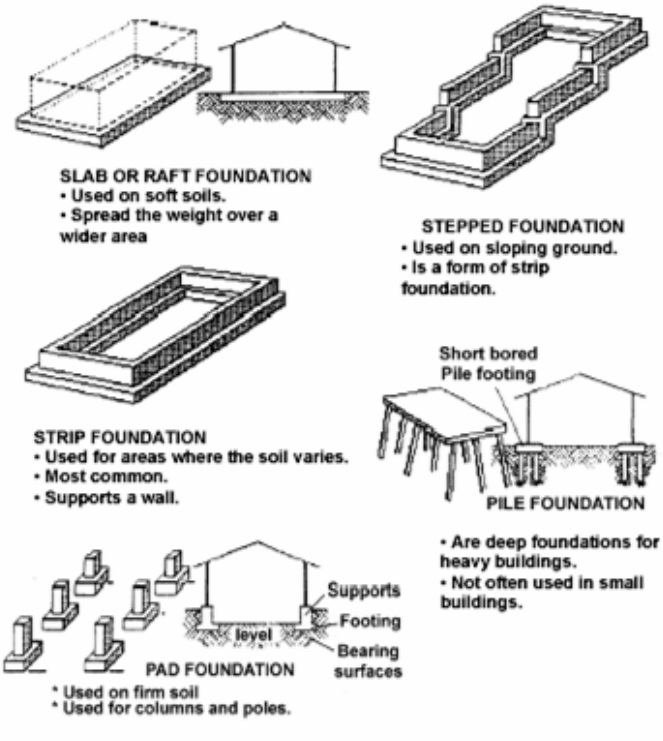
Disaster Resistant Technologies

Foundations type and system of construction

Synthesis of Learnings

Disaster Resistant Technologies

Foundations type and system of construction [61]

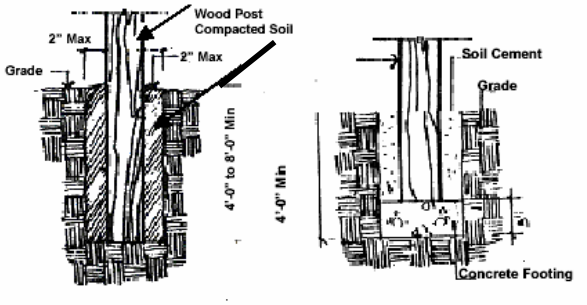


Synthesis of Learnings

Disaster Resistant Technologies

Foundations type and system of construction [62]

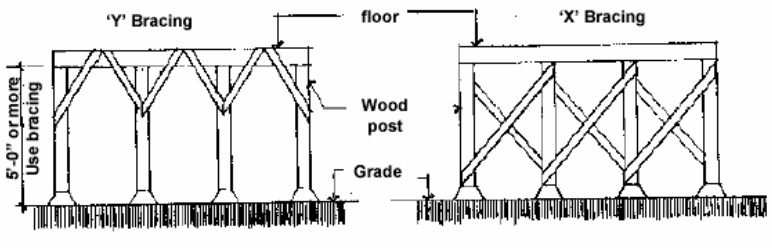
Figures Showing How to Strengthen Wooden Pillars



Notes:

- Minimum size of posts: 6"x6" or 8" diameter when round.
  Backfill: well-compacted materials
  Soil cement is made by mixing 5 parts each of crushed rock and sand and 1 part of cement plus water. All particles larger than one inch and all organic matter should be removed from the earth.
  Steel bars in the concrete pier should be covered with at least 3" of concrete.

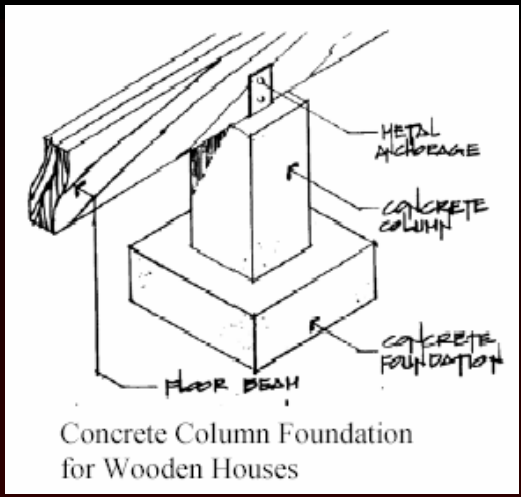
Figure Showing Details of Diagonal Bracing
to aid stability and isolated movements of Wooden Pillars [28]



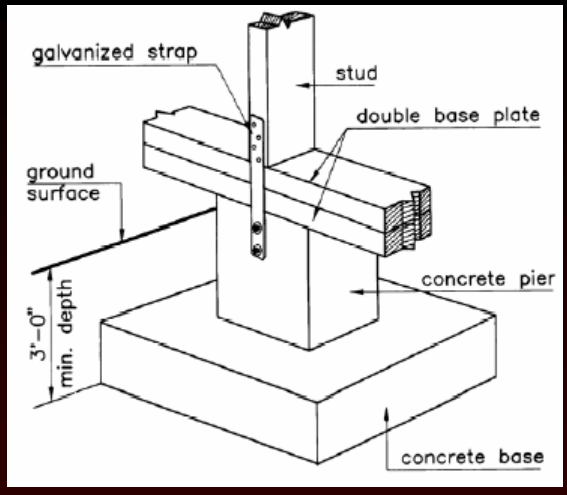
Synthesis of Learnings

Disaster Resistant Technologies

Foundations type and system of construction



Concrete Column Foundation
for Wooden Houses



Concrete Foundation for wooden houses
using metal strap or metal anchorage
for foundation connection to floor beam or base plate. 63

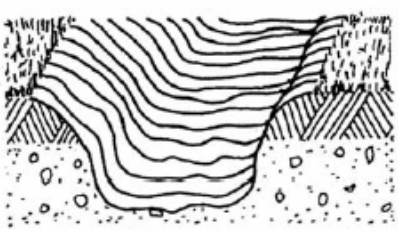
Synthesis of Learnings

Disaster Resistant Technologies

Foundations type and system of construction

"Foundation Trenches should be carefully dug to provide a hard, level bottom surface and side walls at right angles to it. Rounded edges must be avoided."

wrong



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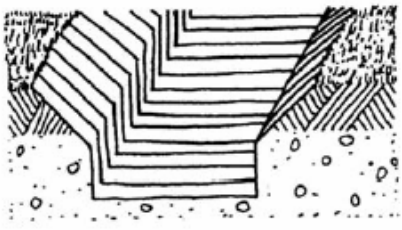


Preparation of Excavation. 63 b

Synthesis of Learnings

Disaster Resistant Technologies

Concrete mixture and preparations

Synthesis of Learnings

Disaster Resistant Technologies

Concrete mixture and preparations

Water/Cement Ratio

"Special attention must be given to the water/cement ratio, because if too much water is used when mixing, the potential strength will be reduced." [64]

"Strength improves with lower water/cement ratios. A 0.45 water/cement ratio most likely will hit 4500 psi (pounds per square inch) or greater. A 0.50 water/cement ratio will likely reach 4000 psi or greater." [64]

The water to cement ratio is calculated by dividing the water in the mix (in weight) by the cement in the mix (in weight). [65]

Use drinking/clean water. Do not use salty or greasy water." [66]

Synthesis of Learnings

Disaster Resistant Technologies

Floor Design and preparation

Synthesis of Learnings

Disaster Resistant Technologies

Floor Design and preparation

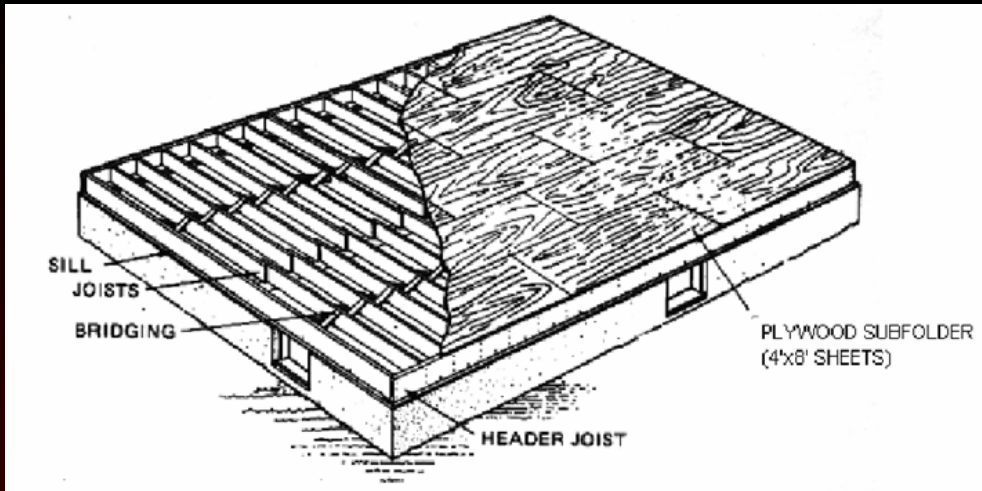


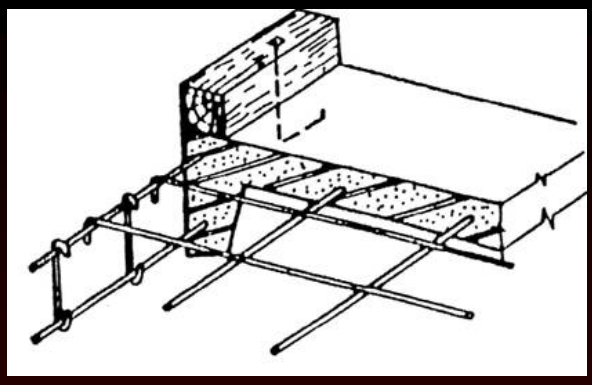
Figure of Wood Floor and Sub-flooring installation

Use of plywood as flooring which is stronger because it acts like a shear plate.

Synthesis of Learnings

Disaster Resistant Technologies

Floor Design and preparation



Sample Figure of Concrete Floor Slab Foundation [68]

"Construction of Concrete floor slab shall be done immediately after the foundation walls have been done. Under no circumstances house walling be constructed ahead of the flooring." This is in order to make a monolitic flooring that could settle evenly with the foundation in case there is ground settlement or ground movement. [69]

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System

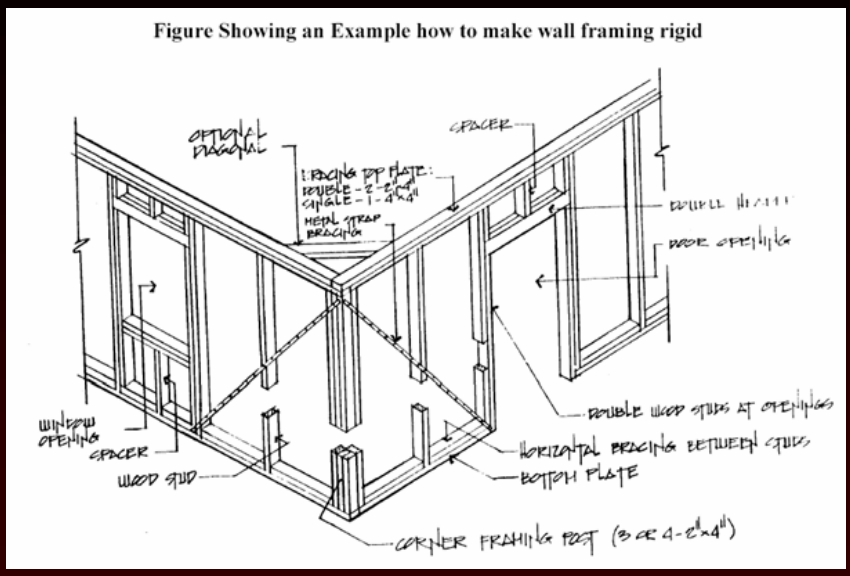
Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System

Wood Exterior Walling

Figure Showing an Example how to make wall framing rigid



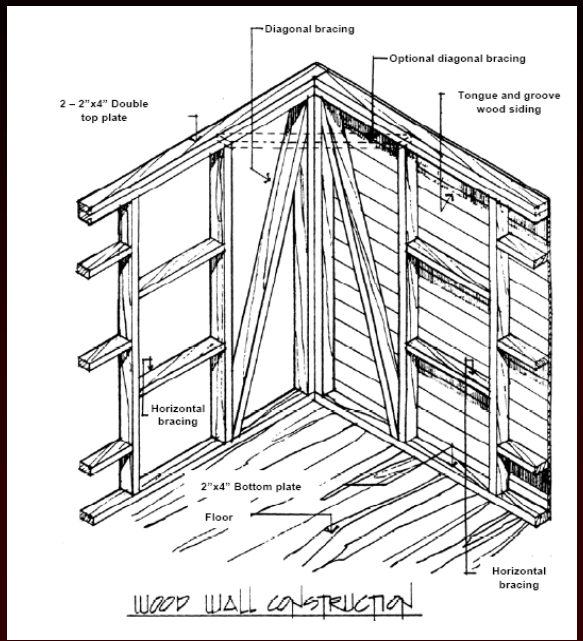
Use of bracing and Metal Staps to make the wall framing more rigid 70

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System

Wood Exterior Walling



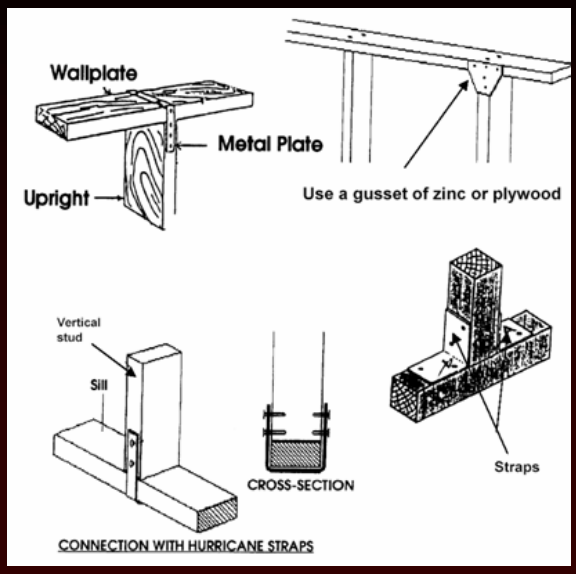
Use of bracing and Metal Staps to make the wall framing more rigid 70a

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System

Wood Exterior Walling

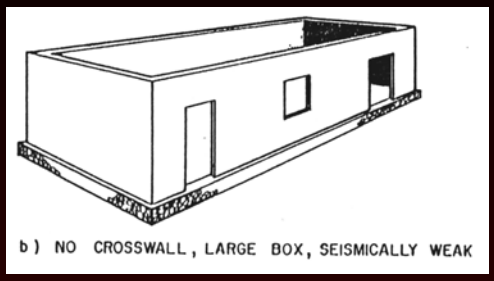


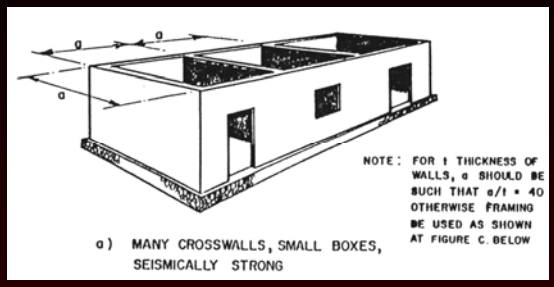
Use of Metal Staps, metal plates, gusset of Zink or plywood to strengthen connections [71]

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System - Masory Walls



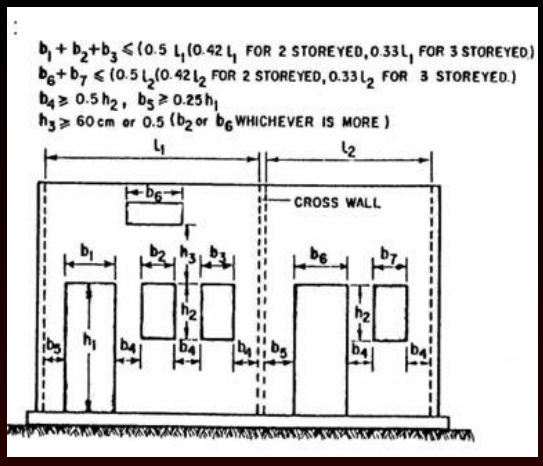


"In load-bearing wall construction, the wall thickness "t" should not be kept less than 190 mm; wall height not more than 20t; and wall length between cross walls, not more than 40t." [72]

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System - Masory Walls



Size and position of openings on masonry load bearing wall construction 73

Distance Opening from the inside corner by at least ¼ of the height of the openings."

"The total length of openings should not exceed 50 % of the length of the wall between consecutive cross walls in a 1storey construction,

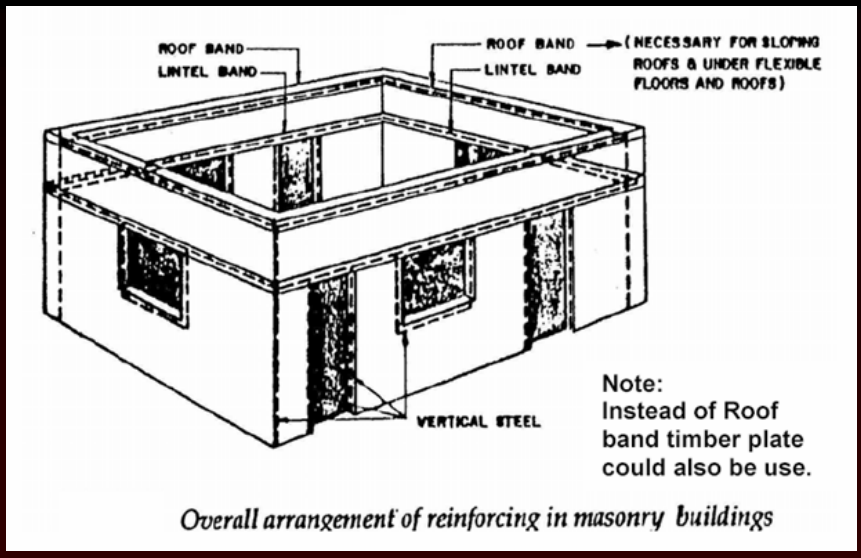
42% in 2storey construction, and 33% in 3 storey construction.

"The horizontal distance between two openings should not be less than ½ of the height of the shorter opening. The vertical distance from an opening to another opening directly above it should not be less than 600 mm nor less than ½ of the width of the smaller opening."

Synthesis of Learnings

Disaster Resistant Technologies

Exterior Wall Construction System - Masory Walls



Overall arrangement of reinforcing in masonry buildings

Use of lintel band and roof band and proper placement of reinforcement to make the wall more resistant to forces. 74

Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and connections

Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and connections

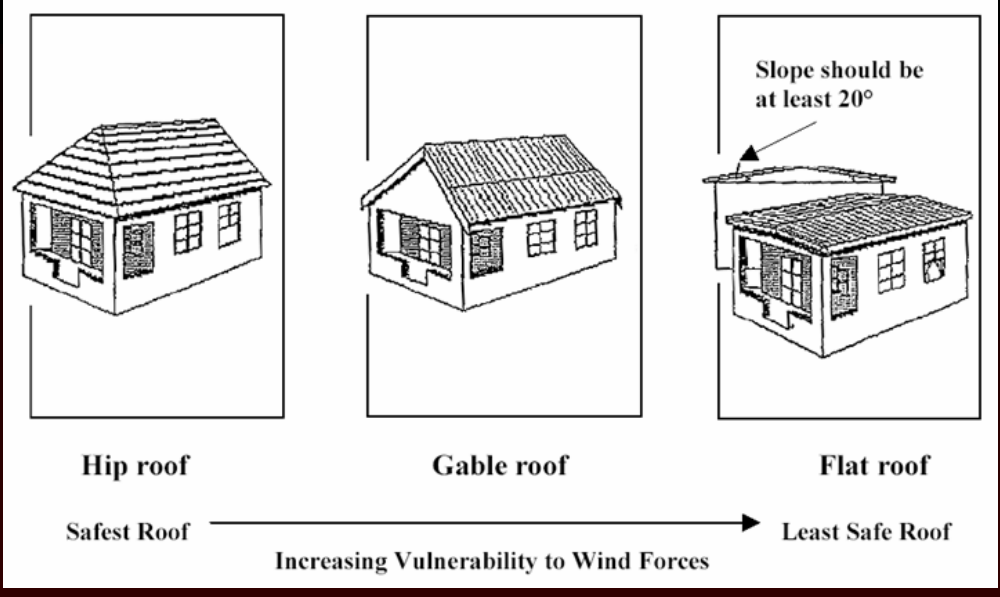
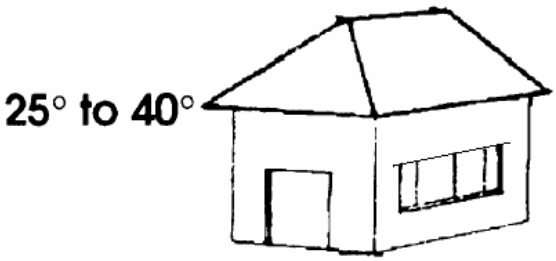


Figure showing Building Configuration in order of of increasing Vulnerability to wind forces

Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and connections



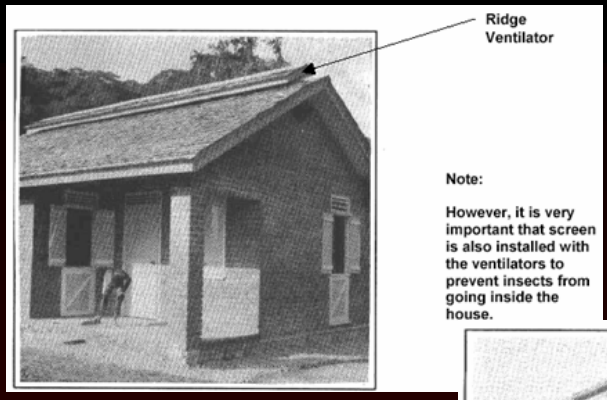
"Experience and experiment have shown that the hip roof with the pitch in 25° to 40° range has the best record of wind resistance."

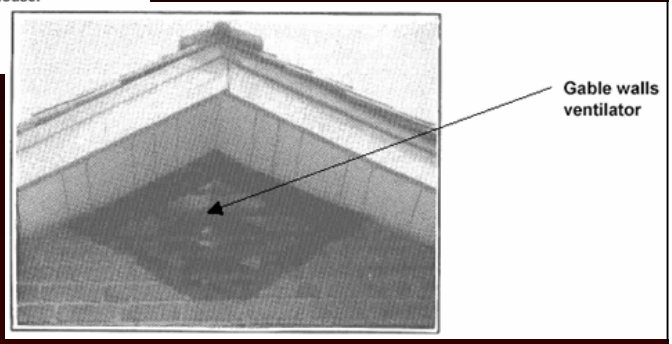
Hip Roof Plan and Isometric 76

Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and connections



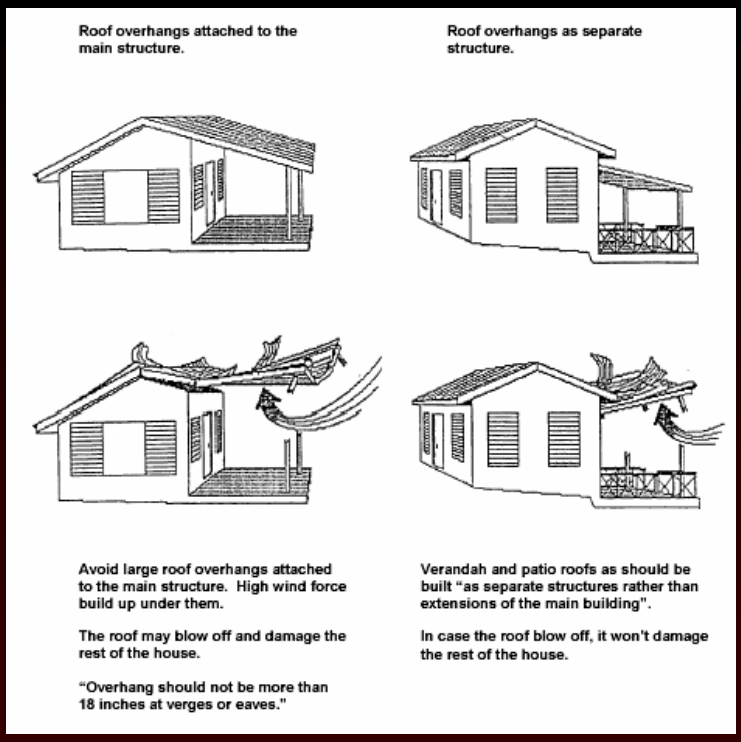


Other Ways of Handling Gable Roof 76 b

Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and connections [77]

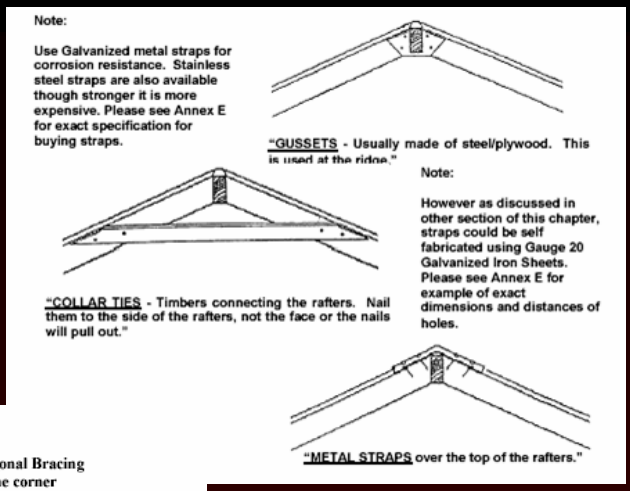


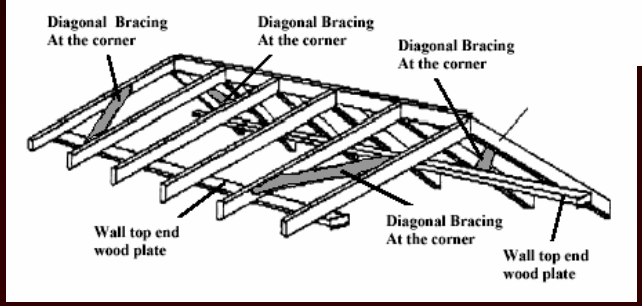
Synthesis of Learnings

Disaster Resistant Technologies

Roofs Design, materials, and Connections

Different Ways To Held Roof Ridge Together to avoid failure due to strong winds. [78]





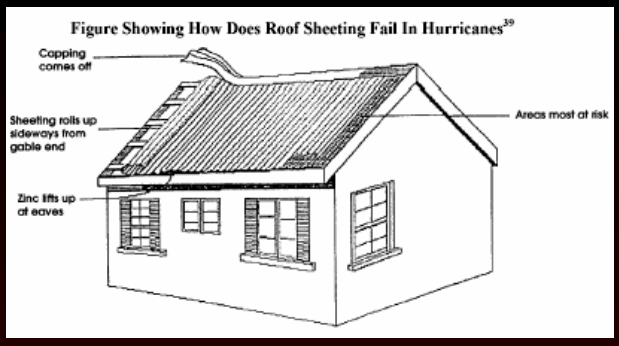
Putting extra diagonal braces at the four corners of the end gable trusses can strengthen [79]

Synthesis of Learnings

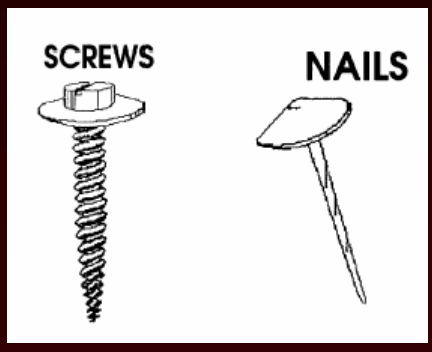
Disaster Resistant Technologies

Roofs Design, materials, and connections

"use of 24 gauge galvanized sheet metal is recommended. 26 gauge galvanized can be used, but extra attention must be paid to proper fastening of edges and overhangs. Gauges thinner than 26 (i.e. 28 and higher) are not acceptable, as they can easily be torn loose by strong winds." [80]



Use drive screws or nails with wide heads for corrugated galvanized roof sheets. [81]



Synthesis of Learnings

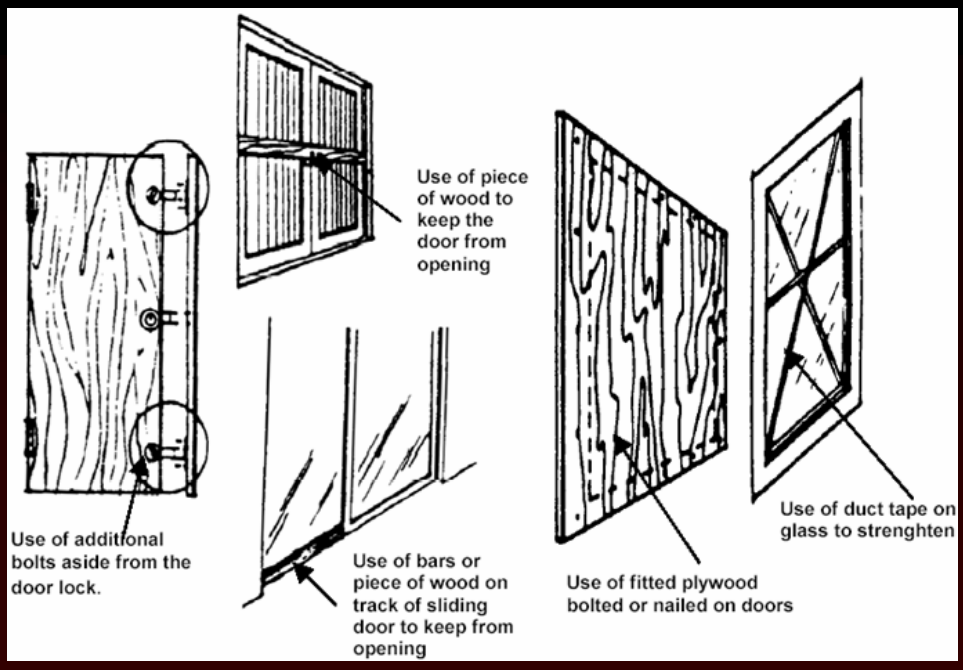
Disaster Resistant Technologies

Doors and Windows safety measures

Synthesis of Learnings

Disaster Resistant Technologies

Doors and Windows safety measures

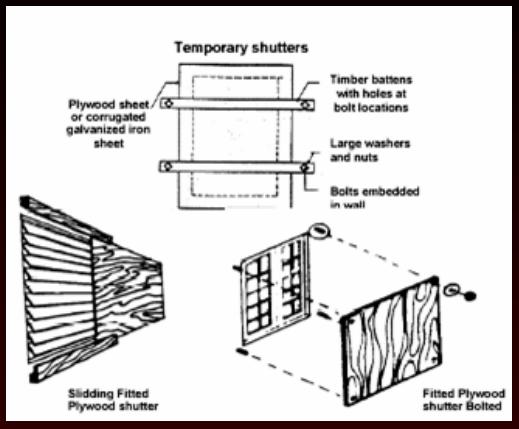


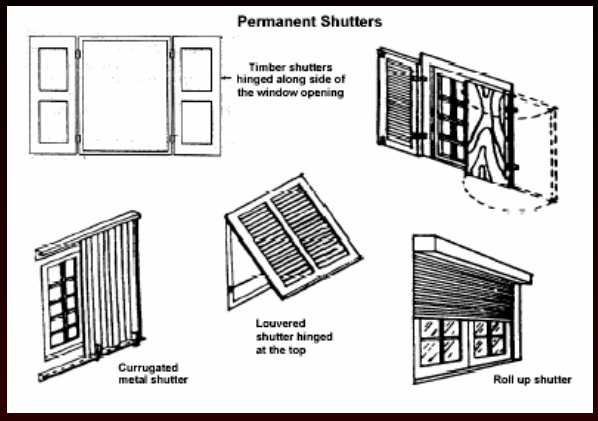
Use of Door safety measures in the absence of shutter [82]

Synthesis of Learnings

Disaster Resistant Technologies

Doors and Windows safety measures





Use of Different Types of Window shutters

that could be use to protect the window [83]

Synthesis of Learnings

Disaster Resistant Technologies

And many more details in my thesis book...

Conclusion

- Earthquake and typhoon disaster situation can be prevented and/or mitigated.

  As proven by the long list of synthesis of learnings of this thesis.

- Prevention is much better than cure.

  Implementation of disaster resistant technologies both in new construction and retrofitting of old structures in the Philippines is more sustainable, better, and cheaper alternative than merely providing emergency shelter and reconstruction of houses after being destructed by hazards.

  Additional Cost is affordable according to various cost studies of the following groups:

  3% for favorable bldg shape [84] – Organization of American States (OAS)

  7.5% for unfavorable shape bldg.[85] - OAS

  0.24% - 2.2 % only [86] - US Dept of housing & urban dev't.

Recommendations

- Information on disaster resistant technologies be disseminated to all concerned stakeholders in the Philippines, as preventive measure for disaster.

Concerned stakeholders are the following:

Government – for support, promotion and endorsement

Professional Building sector, NGO's in housing, Union of Workers – for integration to current practices.

Academic Institution – for integration into the curriculum

Home Owners – for awareness and equip them with knowledge on how strong their house should be.

Recommendations

- Disaster resistant technologies information such as this be disseminated as form of guidelines that could be continually reviewed, improved, and grow, instead of a law.

"Rather than enforce them, people could be stimulated to apply guidelines voluntarily via appropriate communications methods and the right type of support." [87]

Determining the right style and appropriate means of information dissemination for each sectors then is what is needed.

Recommendations

- Coordination between existing different organizations of different sectors in the Philippines should be established for dissemination and monitoring assistance on the progress and result on different levels.

  NDCC (The National Disaster Coordinating Council) policy and coordinating body for disaster management at the national level

  Local Disaster Coordinating Council of the Local Government Unit (of each province, city, and municipality) the one that prepare and integrate the disaster management plans to the local development of their constituents.

  Civic and non-government organizations active in addressing human settlements issues and disasters for example (e.g. Technical Assistance Organization (TAO-Pilipinas), Gawad Kalinga, Alterplan, Panirahanan, National Union of Building Construction Workers, Habitat for Humanity Philippines etc.)

The End

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