# Retrofitting / building hospitals safe from disasters

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## Sources of Information, Photographs and Sketches used in presentation:

1. Seismic Safety of non structural elements and contents in Hospital Buildings- GoI, UNDP
2. A homeowner's guide to hurricane retrofitting- Institute for business and home safety
3. Improving wind/ cyclone resistance of buildings- Guideline by Prof A S Arya, GoI
4. Manual on Hazard Resistant Construction in India- UNDP, NCPDP
5. Tool kit for Safe Hospitals- UNISDR
6. Field manual on capacity assessment of health facilities responding in emergencies, WHO
7. Training Manual on earthquake, cyclone, flood and tsunami safe construction in Fiji by Mr. Robert Pole and Josefani Bola
8. Various documents of WHO Regional office of South East Asia (SEARO), Pan American Health Organisation (PAHO), FEMA, www.safehospitals.org

*The most costly hospital is that fails*

# Repair, Restoration, Retrofitting

A. **Repairs**

- Actions taken for patching up superficial defects
- Include cosmetic works only

**B. Restoration**

- Actions taken for restoring the lost strength of structural elements of the

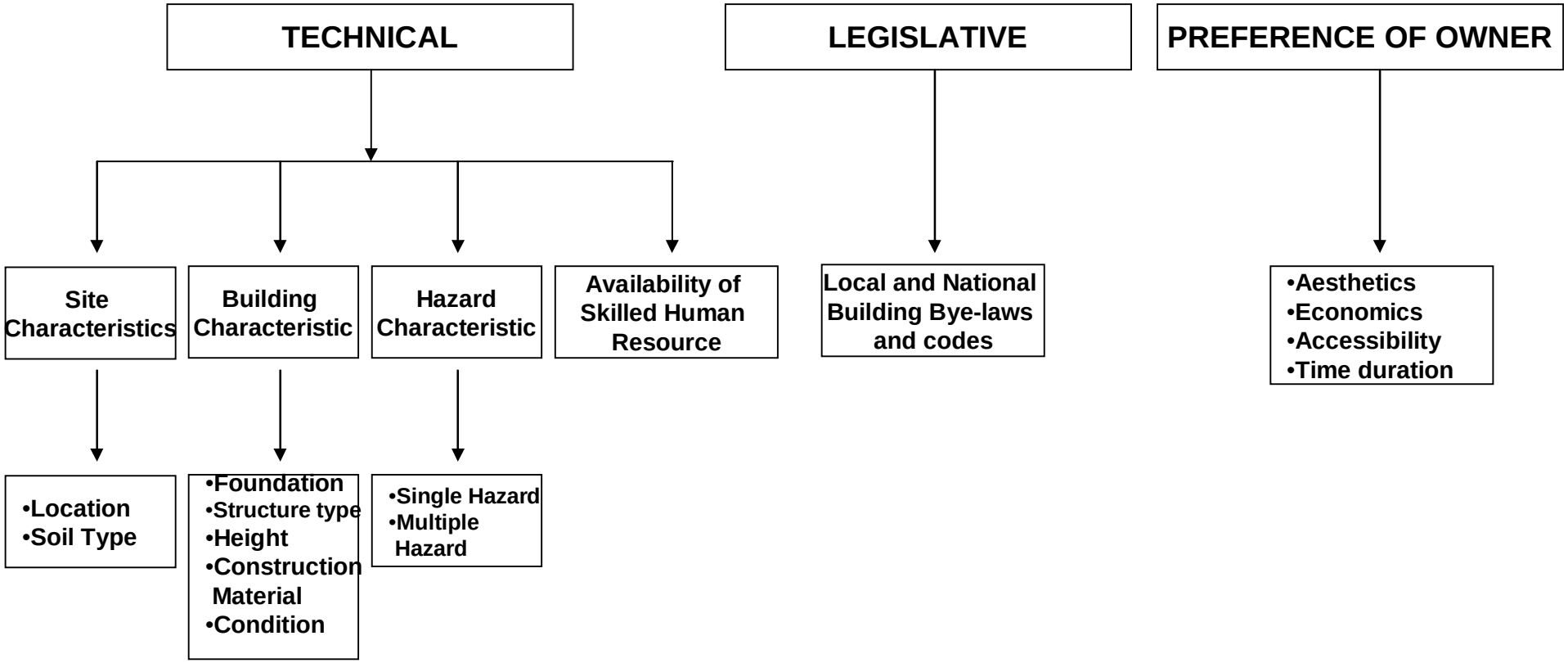
C. **Retrofitting**

- Preparing a structure in scientific manner to withstand forces of natural hazards
- Up gradation of existing building for increasing the resistance against natural hazards

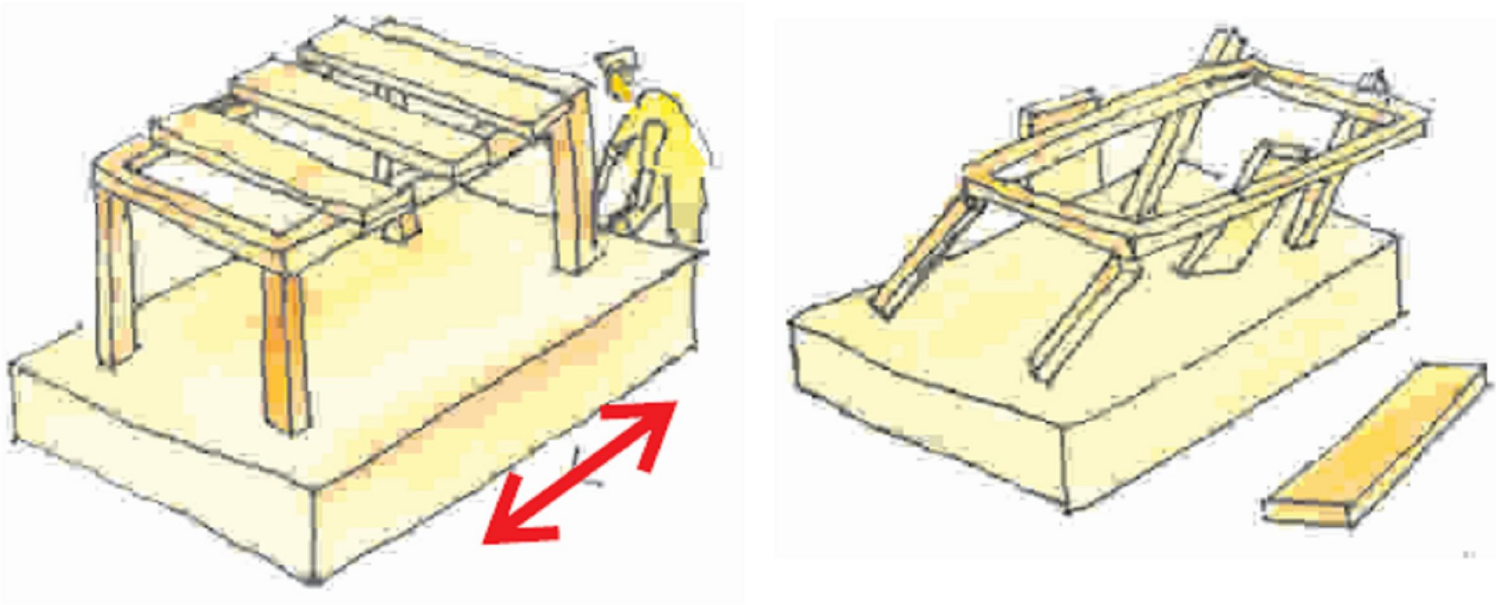
# Advantages of retrofitting

- Can be done in phased manner.
- Elimination of need of temporary structure
- Elimination of cost of total demolition of the building

# Parameters for selection of Techniques for Retrofitting



# Basics of building functions

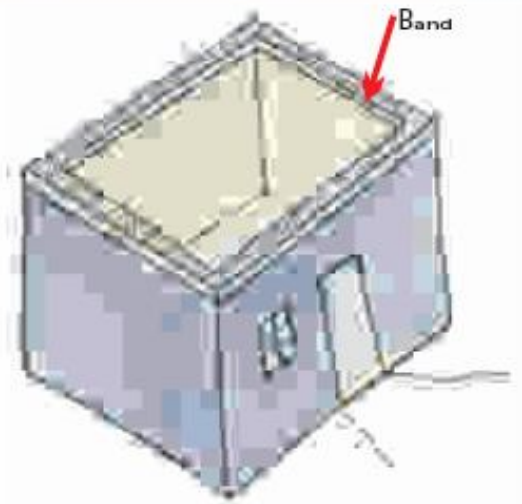


If a table, with heavy top that is poorly attached to its supports, is shaken violently, the supports can break off and the table can collapse.
A building with heavy roof is like the table. If its roof is not attached well to its supports and supports are weak, then it can collapse in an earthquake.

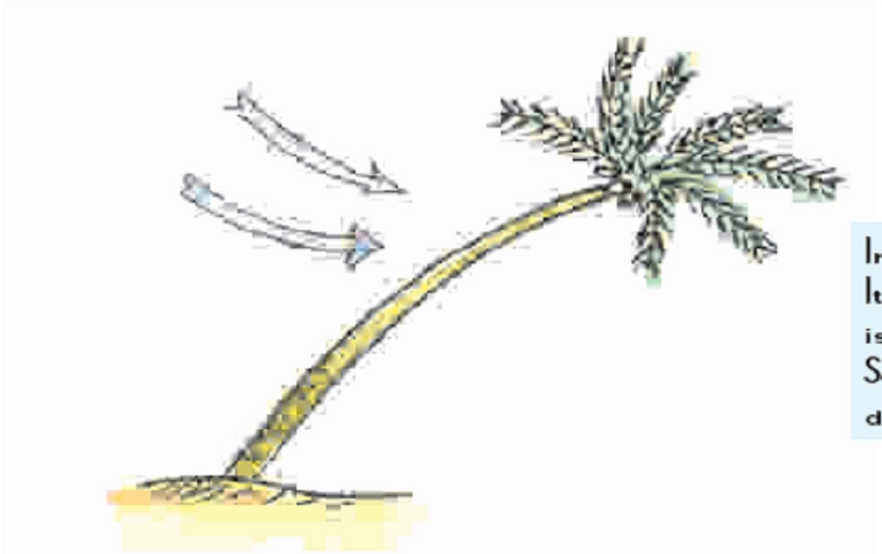
# Basics of building functions

The top rim of a plastic bucket is folded. This makes the top rim stiff. When a bucket full of water is picked up it does not deform or crack.

In a building some features have to be added in the masonry wall so that in earthquake or cyclone it does not deform or crack.

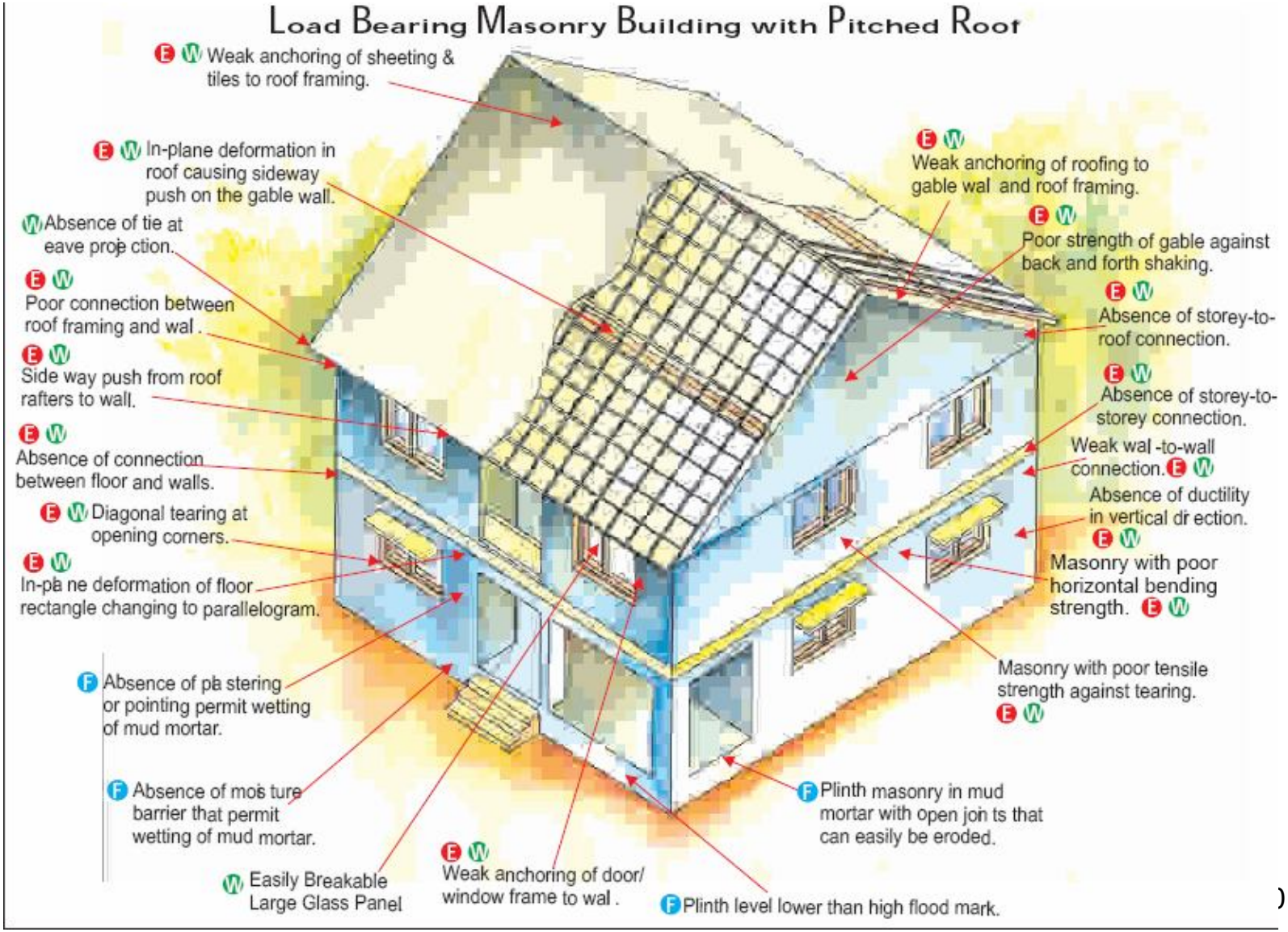


# Basics of building functions



In an earthquake or cyclone a tree does not collapse. It bends and returns to its original position because it is elastic and strong. Masonry walls bend and crack. Some features need to be added to make them ductile/ elastic.

# Vulnerabilities to various disasters

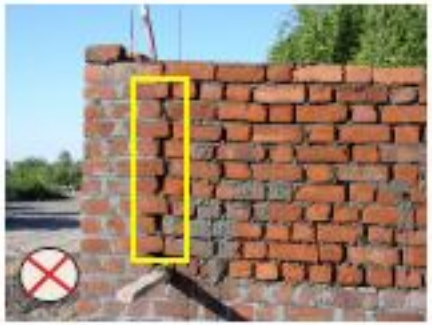


# Most Common Mistakes in Masonry

Never construct stone masonry by simply stacking one stone over another without proper fitting and using mortar.

Never leave vertical joints unfilled without mortar.

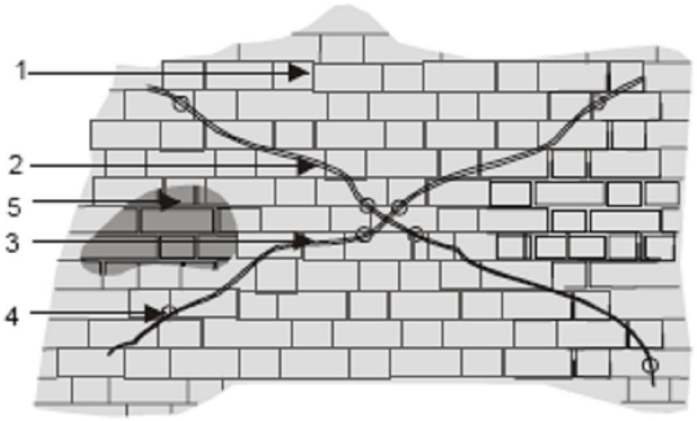

1. Never provide RC columns without providing RC beams.
2. Never construct fat RC column on top of thin RC column or on top of masonry.
3. Never construct one column on another with their centre lines not matching.

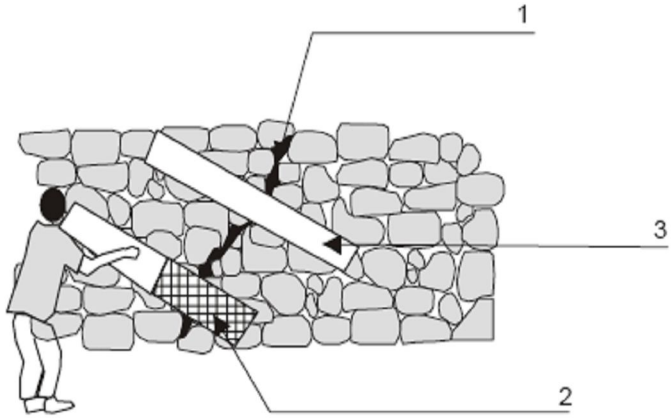


Never connect one wall to another through the use of toothing left out in the wall that is built first.

# RETROFITTING- EARTHQUAKE

1. **Repair of crack and chip-off in walls, RCC elements**
   - Through application or injection of cement slurry grouting
   - Application of polymer in case of severe crack/chip off before grouting
   - Application of wire mesh coated with cement grouting



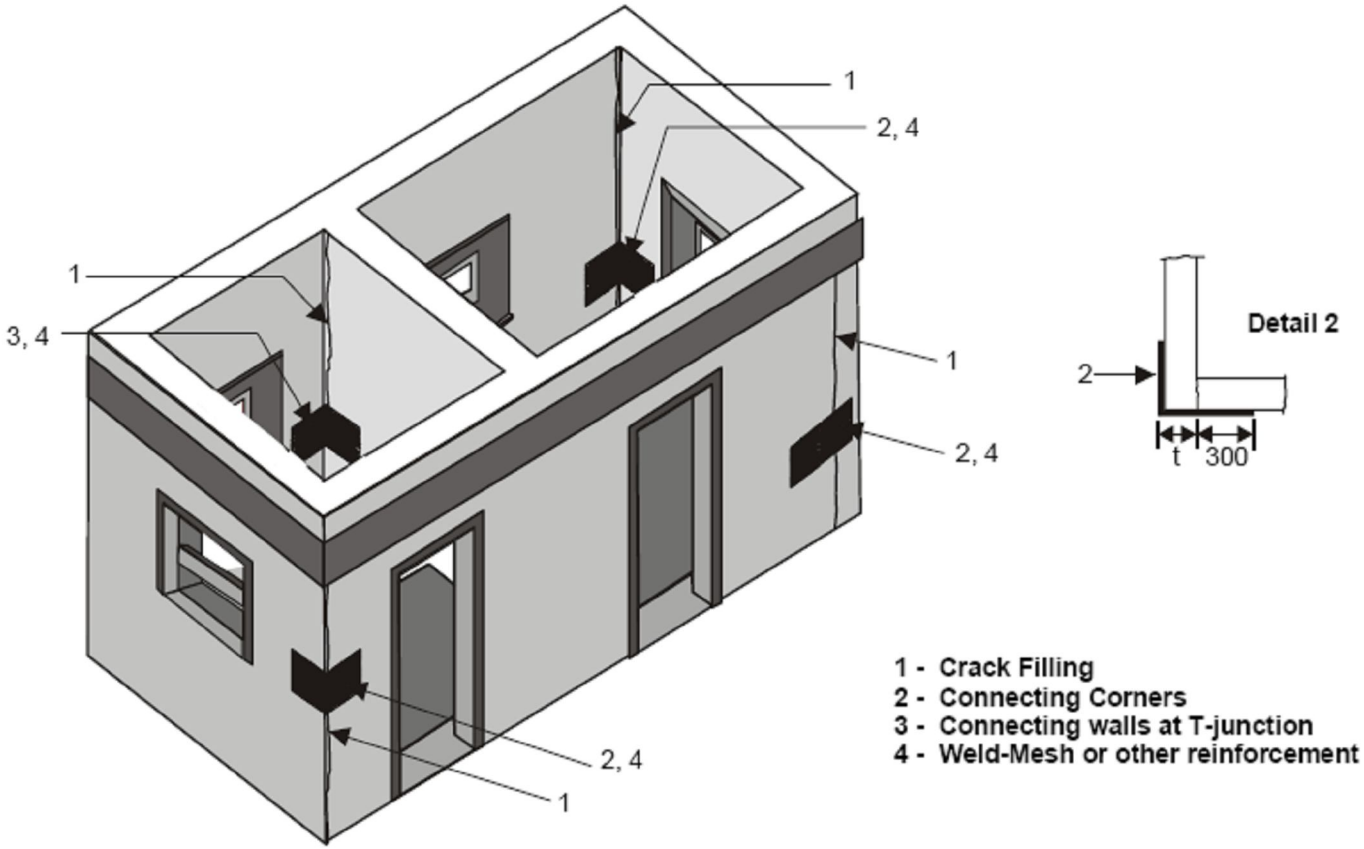




1 - Wide Crack
2 - Wire mesh
3 - Plaster on mesh

1- Plaster
2- Plaster removed and cracks cleaned
3- Cracks sealed with mortar or putty
4- Grout ports
5- Plaster fallen to be done again

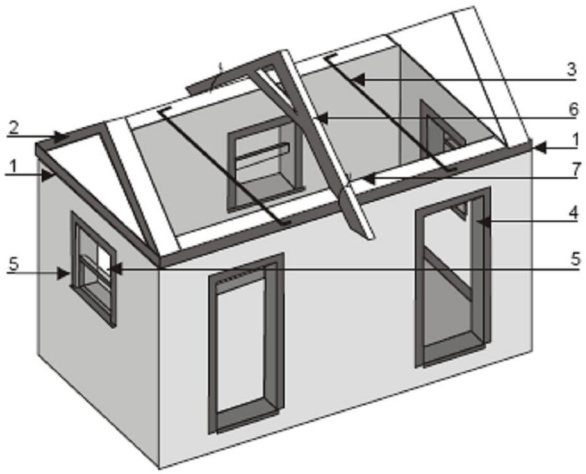
# RETROFITTING- EARTHQUAKE

2. Rebuilding portions of damaged walls
3. Rebuilding portions of damaged RCC elements
4. Installation of ferro cement plates at the corners of walls to give stability to the building

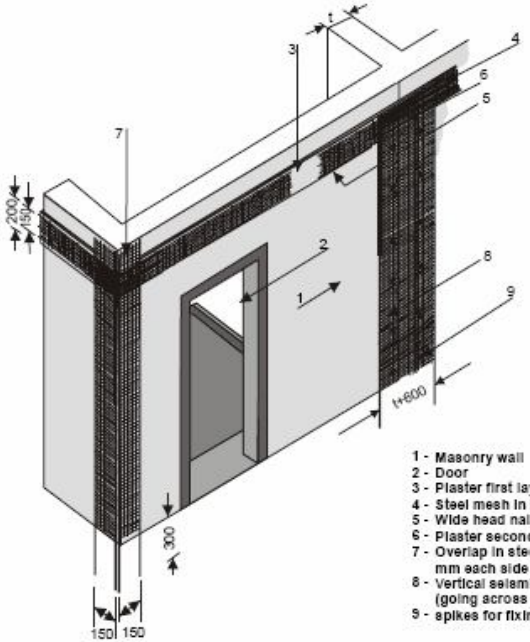


# RETROFITTING- EARTHQUAKE

5. Provision of horizontal seismic belts at plinth, lintel and gable level of building
6. Provision of vertical seismic belts at corners of building and around door-windows




1 - Seismic belt above openings and below roof at eave level
2 - Seismic belt on gable wall
3 - Tie at eave-band level
4 - Door
5 - Window
6 - Rafter with collar tie
7 - Tying of rafter with band




1 - Masonry wall
2 - Door
3 - Plaster first layer
4 - Steel mesh in belt
5 - Wide head nails 150 long
6 - Plaster second layer
7 - Overlap in steel mesh, 200 mm each side of corner
8 - Vertical seismic belt at junction (going across horizontal belt)
9 - spikes for fixing mesh

7. Restoring RCC slab through cement grouting over wire mesh and coating of polymer etc.
8. Stiffening of wooden floor with galvanized metal strips of additional wooden planks

# Retrofitting methods

Weld Mesh cover

Corner reinforcement

Bracing at roof

Concrete gable band

# Retrofitting methods

Sealing with
Cement Mortar

Grouting with
plasticiser

Stitching with
strap

# Flood effects

Foundation Settlement due to rising ground water level

Uneven Settlement

Scouring of mud mortar from open joints by fast moving water

Scouring

# Retrofitting- floods

1. Elevation

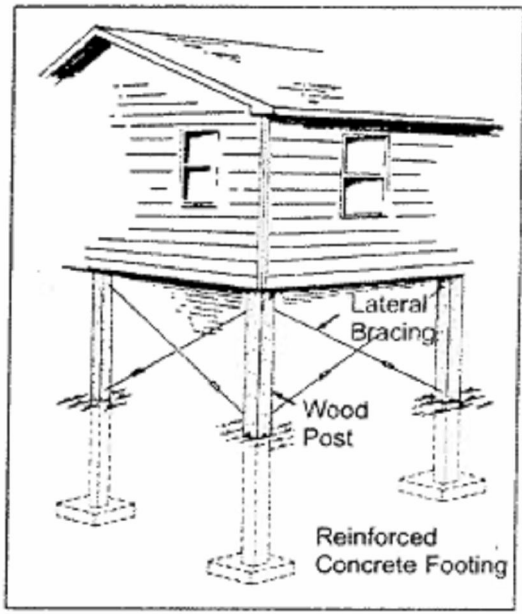
- Elevation of the existing structure on fill or found solid perimeter walls, piers, posts, columns etc

2 Relocation

- Relocating existing structure outside the flood plain

3. Dry Flood Proofing

- Strengthening of existing foundation, floors and walls
- Sealing the portion of structure below flood level.
- Use of sealants, wall coating, water proofing for sealing components
- Door-window, sewer and water lines and vents closed with permanent or removable vales



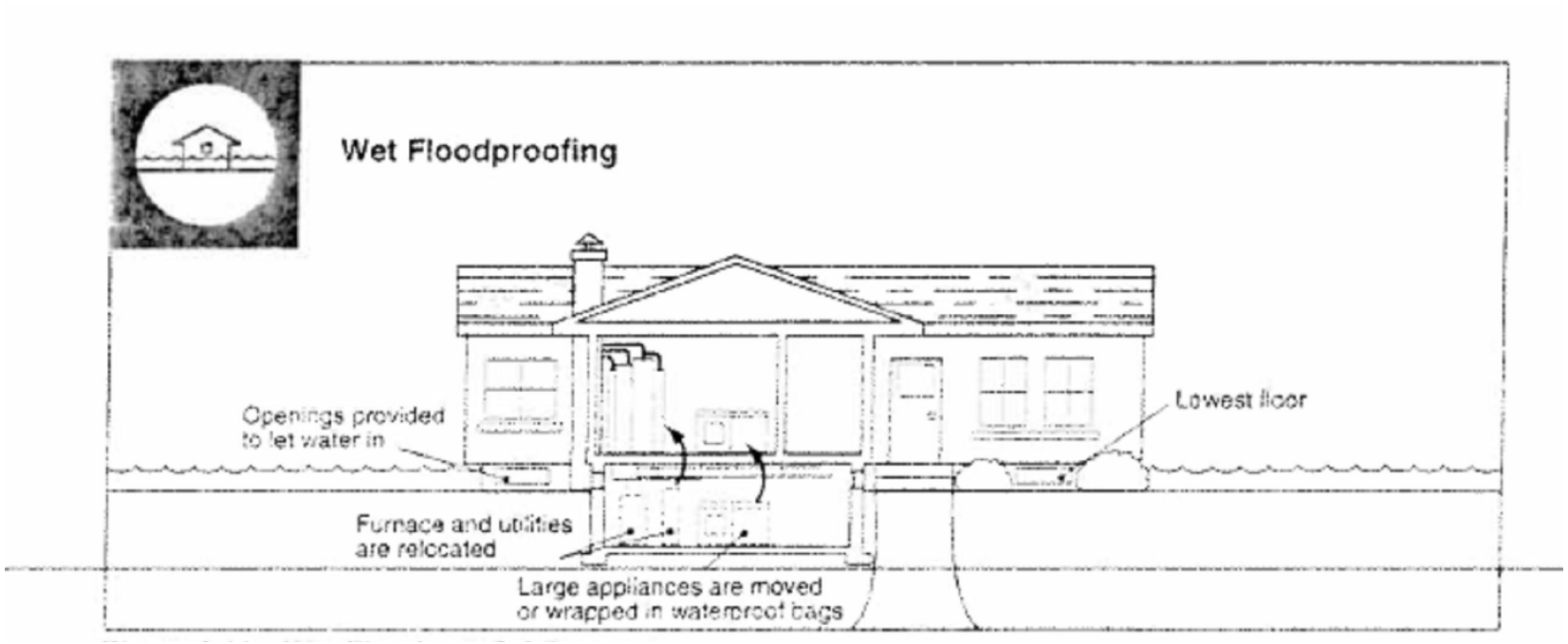
# New construction for floods

*Fig. 5.11 Stilted houses near Mawa*
*1. Example of a stilted house*
*2. Stilted house being built*
*3. Stilt construction detail showing connection between RC Post and timber members*

# Retrofitting- floods

4. Wet Flood Proofing

- Making utilities, Structural Components and content flood and water resistant during the period of flood within the structure
- Modifying structure to allow flood water to enter in a way to minimize damage
- Feasible only if structure has space available, basement etc



# Retrofitting- floods

**Measures for protection against Flood damage**

- Proper drainage system around the building, slope adjustment etc
- Raising the plinth level to HFL
- Grounded edge near the building to protect against scouring by pitching, vegetation etc
- Flood Wall/Levee

**Measures for protection against rain damage**

- Water Proof Plastering on Leaky Roofs
- Proper drainage of roof through adequate slope adjustment
- Plastering the top of parapet wall to avoid water absorption in walls
- Damp proof layer on wall upto minimum 450 mm or till high flood level

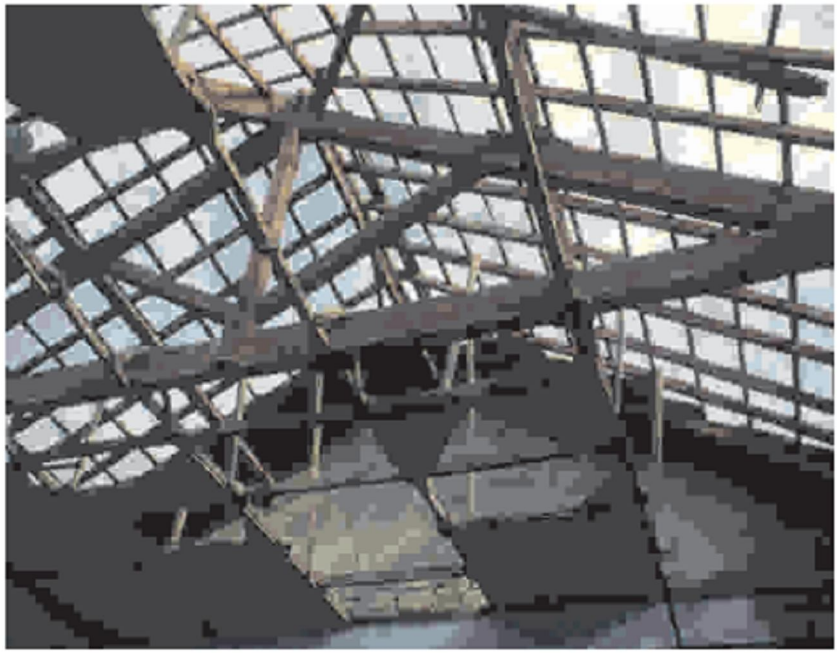
# Parameters for design safety in cyclone prone areas

- Site selection
- Plan form / orientation
- Roof Structure
- Openings
- Glass panels
- Foundation

# Retrofitting for cyclone safety

| Sl. No. | Type | Retrofit/Maintenance Measures | Approximate cost as a proportion of cost of building |
|---|---|---|---|
| 1. | Non Engineered Building Thatched House | - Provisions of metal straps and nails at joints<br>- Holding down coir ropes<br>- Replacement of worn out fibre ropes | Retrofit -4.5%<br>Maintenance-1% |
| 2. | Tiled Building | - Concrete strips<br>- Holding down rods<br>- Metal straps for connection to trusses<br>- Provision of eaves holding down angle/metal strap<br>- Maintenance replacement of broken tiles, worn out bolts, metal straps, etc.<br>- R.C.C. holding down rafters | Retrofit -8%<br>Maintenance-1% |
| 3. | Compound Wall | Checking the available capacity and detailing retrofit measures consisting of reinforced concrete bends to obtain the required strength | Additional cost varies in the range of 25 to 60% of new construction satisfying the design requirements. Retrofitting cost + existing structure cost approximately equals the cost of new construction. |
| 4. | Lamp Masts | - Provision of a foundation block and extending it upto a certain height above ground level to ensure natural frequency is greater than 1.5 Hz.<br>- Underground cables to reduce load on lamp mast/failure of masts by falling branches of tress. | Cost of individual lamp mast with foundation will be increased by 40 to 50% |
| 5. | Water Tanks Ferrocement/Other Lightweight Tanks | Provision of holding down/preventing sliding etc. | Marginal |

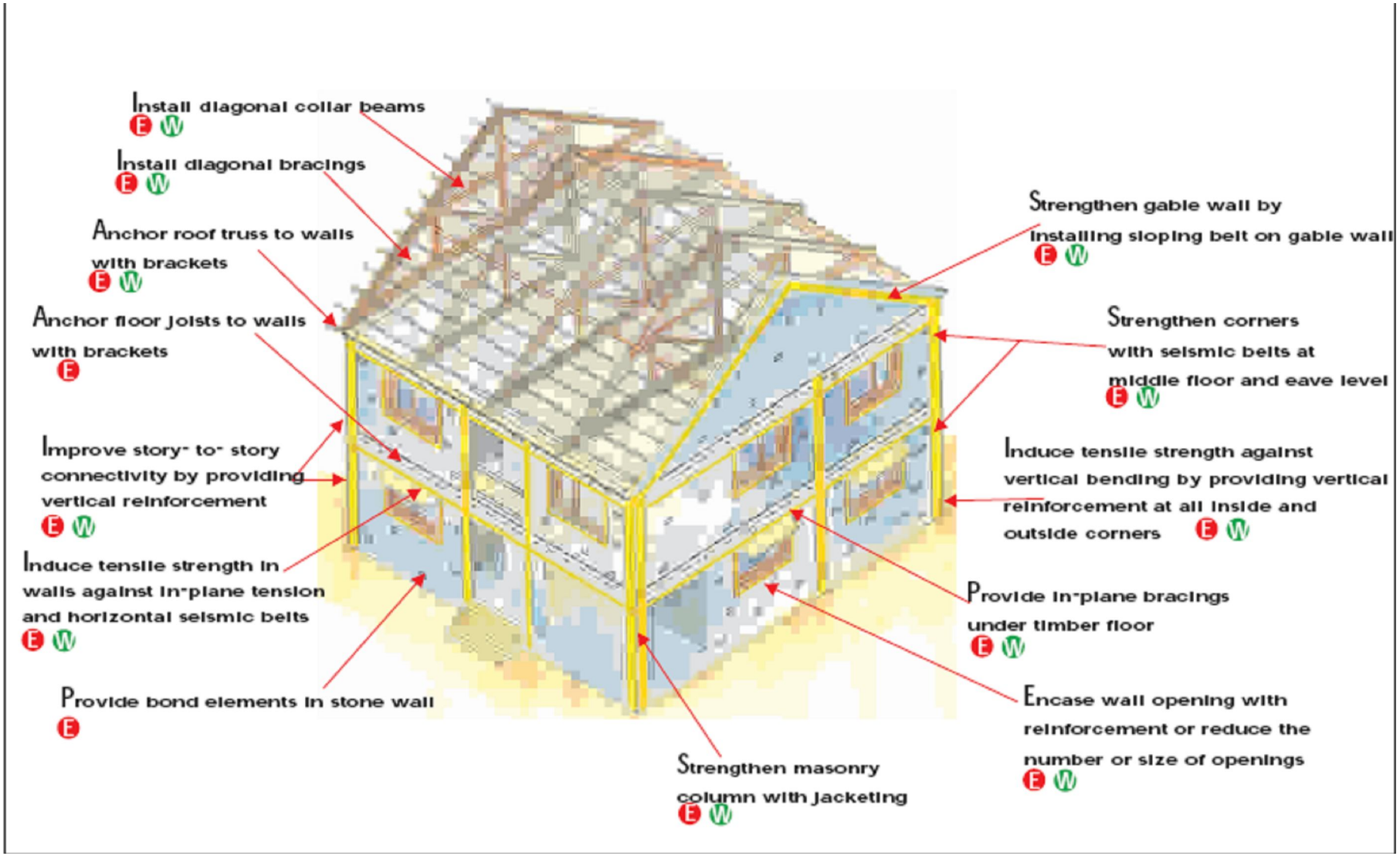
# Cyclone effects



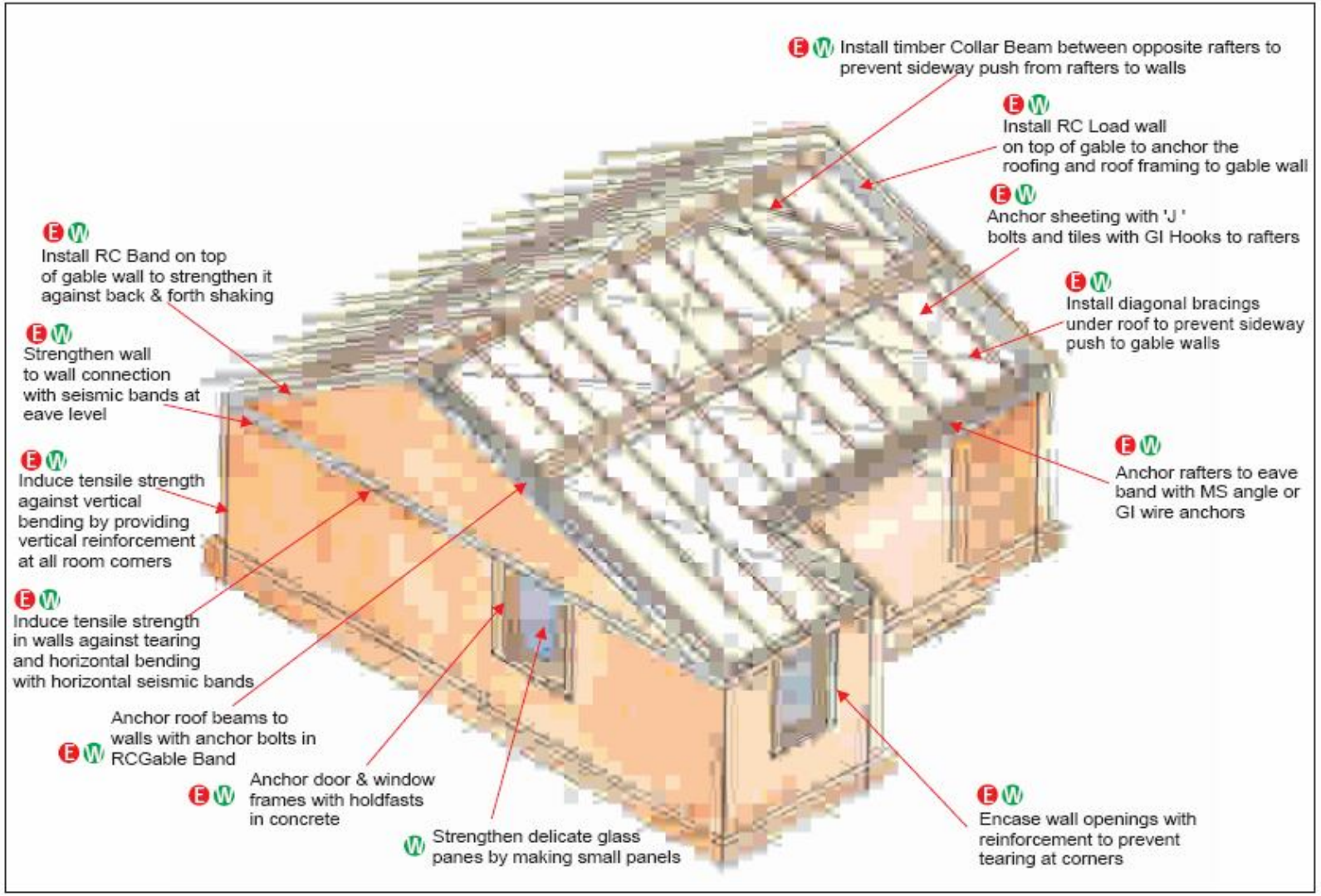
Blown off tiles due to high winds

Wall collapse due to tidal surge

# Retrofitting measures at glance



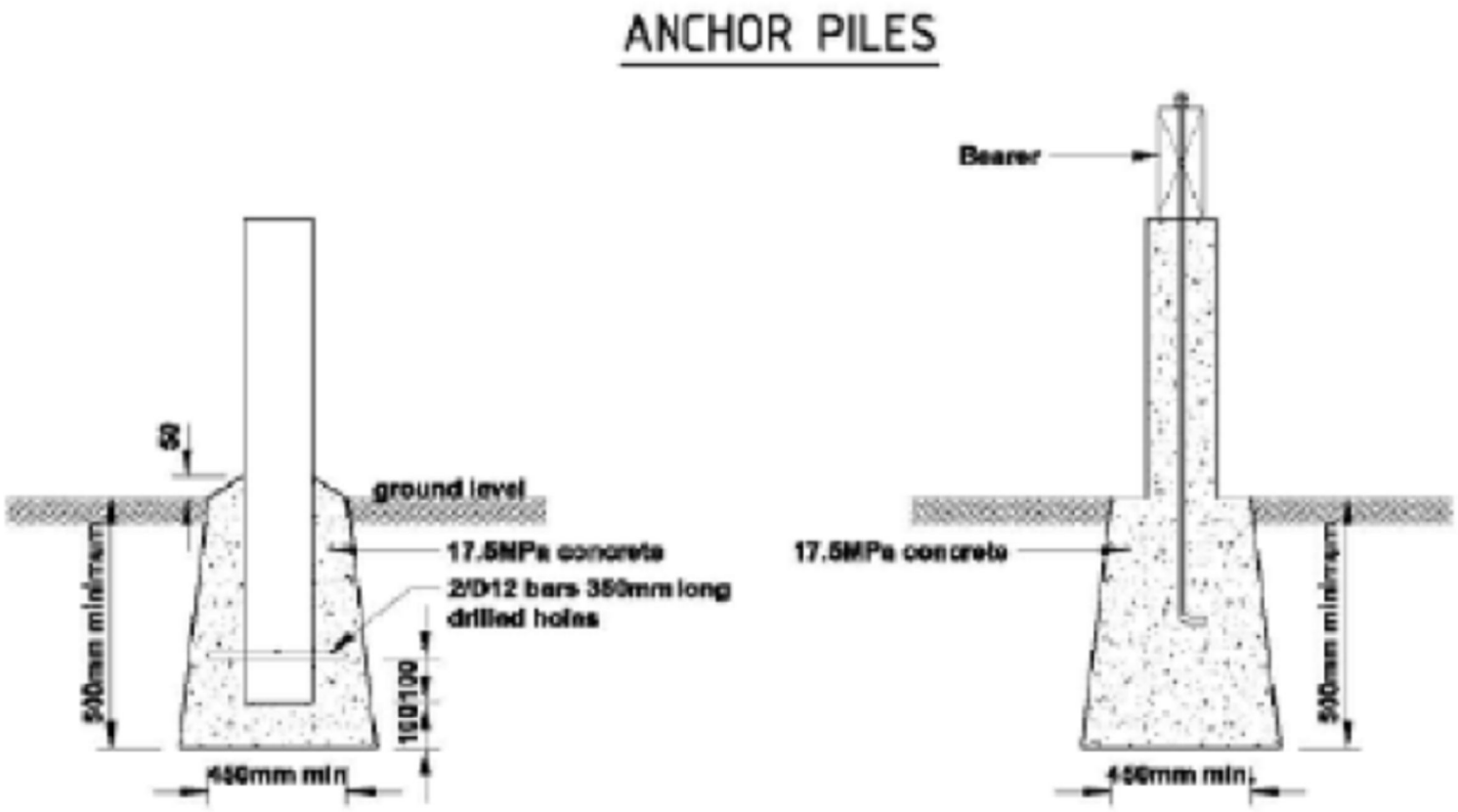
# Disaster Resisting Features for New Construction



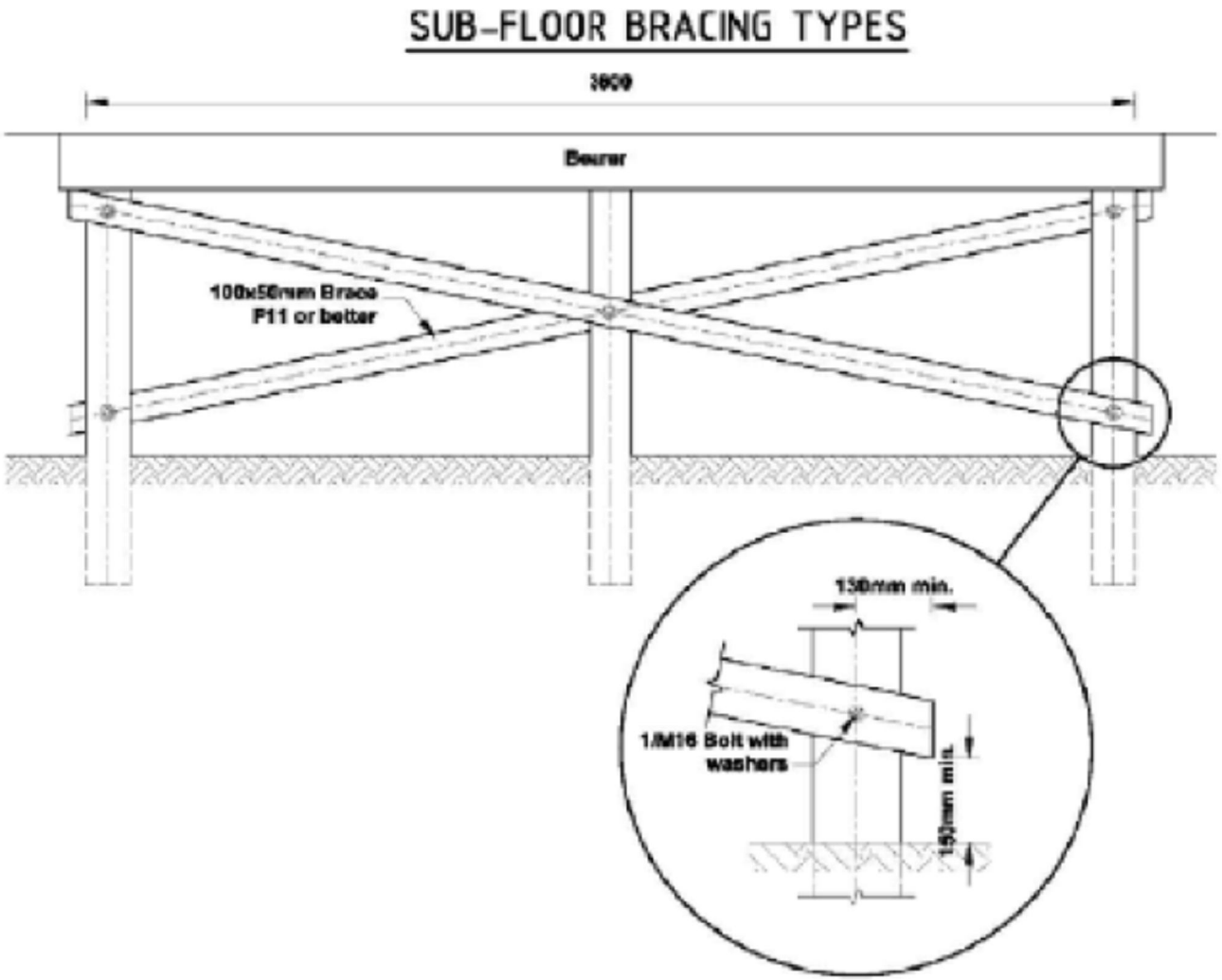
# Retrofitting - Cyclone

- Improving connection of wall to roof
- Wind bracing through diagonal strap with metal/RCC on walls and roof to prevent pushing against wind
- Installation of load wall/parapet on roof hold the roof firmly
- Provision of vertical bands at corners of building and door-window openings to provide them tensile strength against vertical bending
- Additional anchorage of door-window frames with holdfasts
- Connecting metal sheets to roof through ‘J’ or ‘U’ bolts
- Connecting tiles to rafter through GI hooks

# Retrofitting - Cyclone

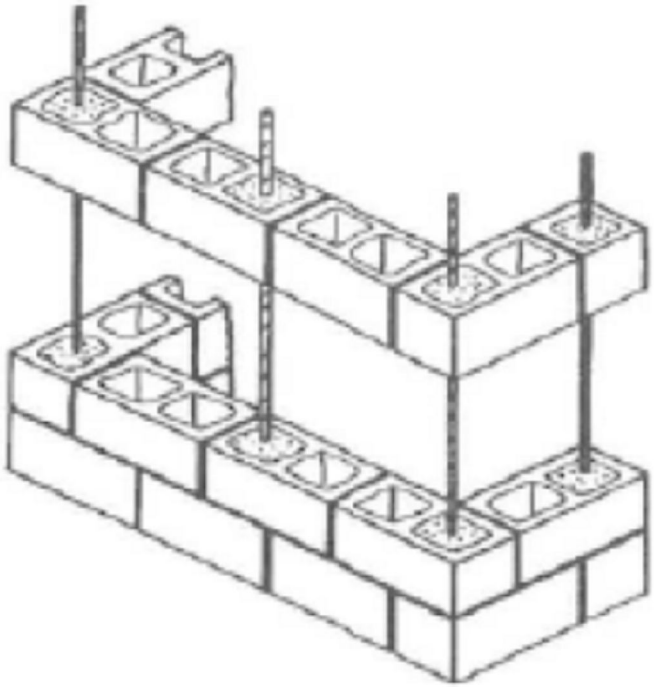


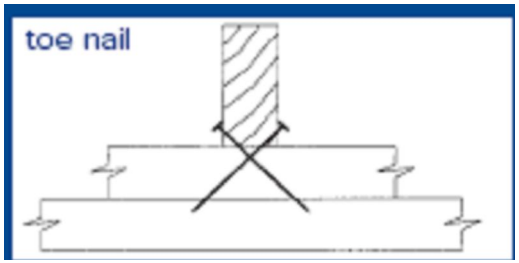
# Retrofitting - Cyclone



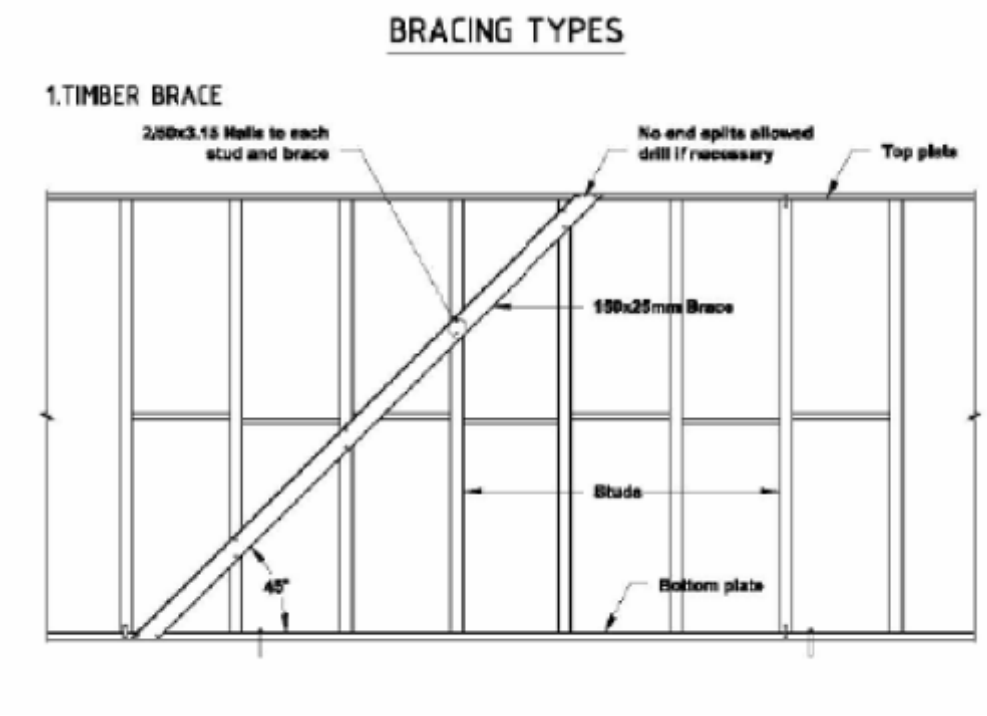
# Retrofitting - Cyclone

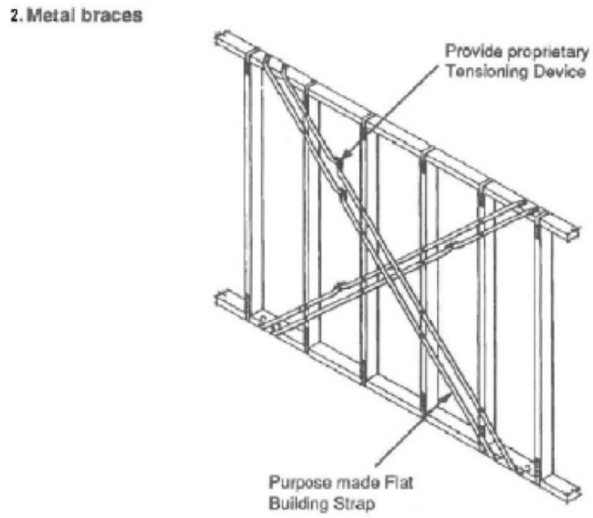
CORNER DETAILS FOR PARTIALLY GROUTED MASONARY WALL



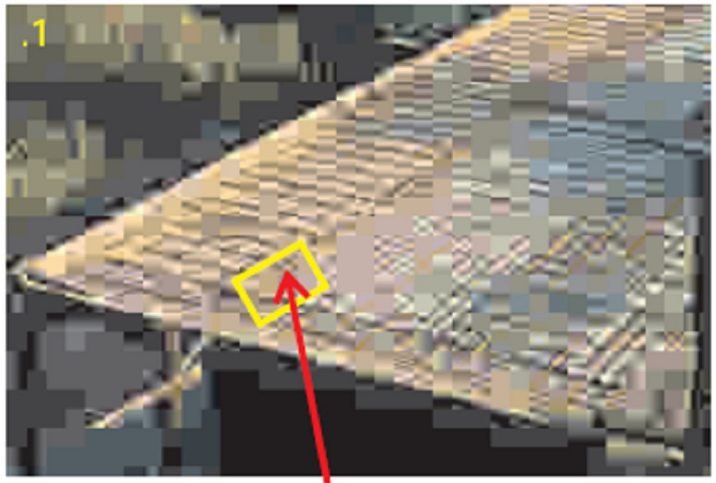


# Retrofitting - Cyclone

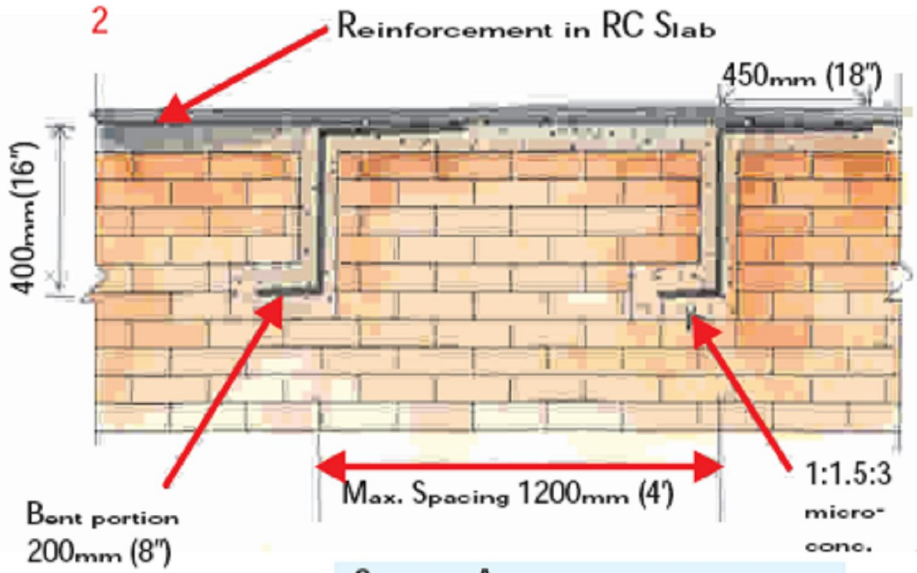


# Retrofitting - Cyclone

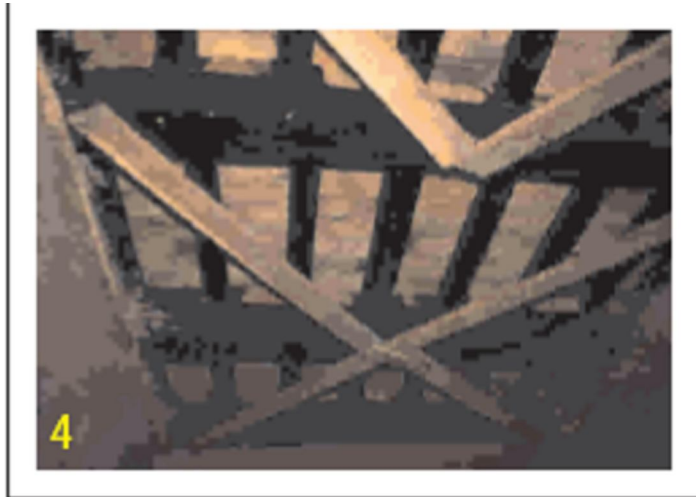


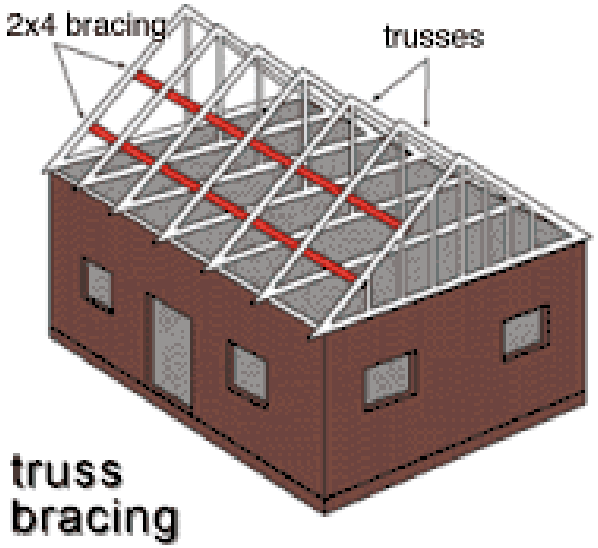

Connect all vertical rebars in the wall at corners and openings to rebars in slab by bending and making 450mm (18") overlap, and tie with binding wires.



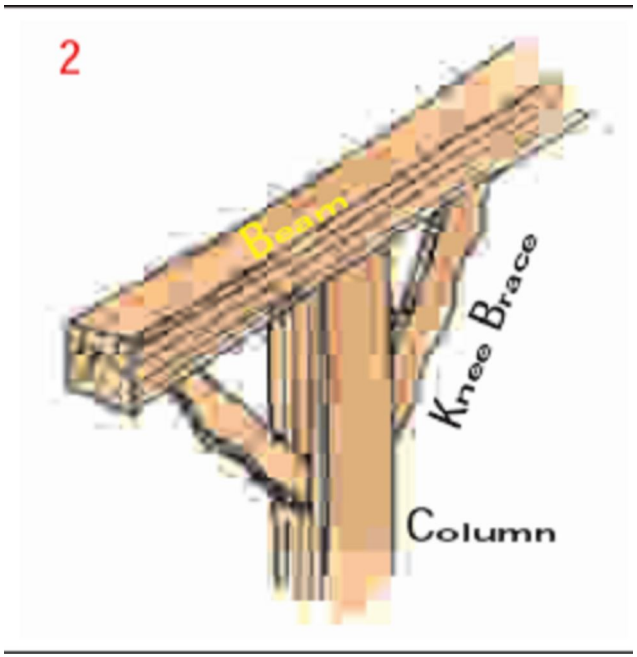

Special Anchor for
Seismic & Wind Speed Zones V

# Retrofitting - Cyclone



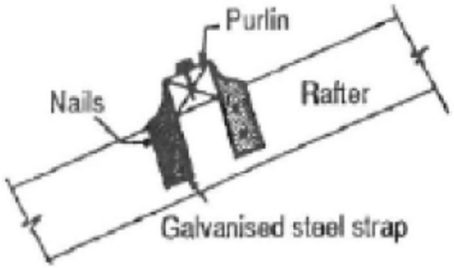



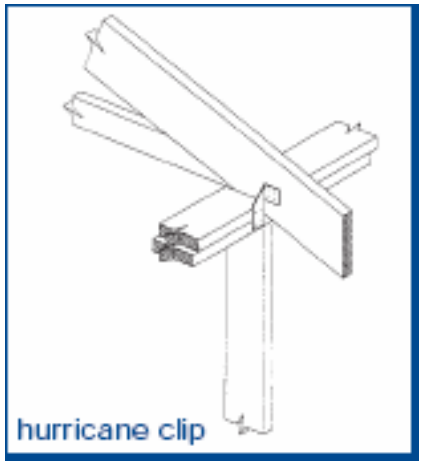


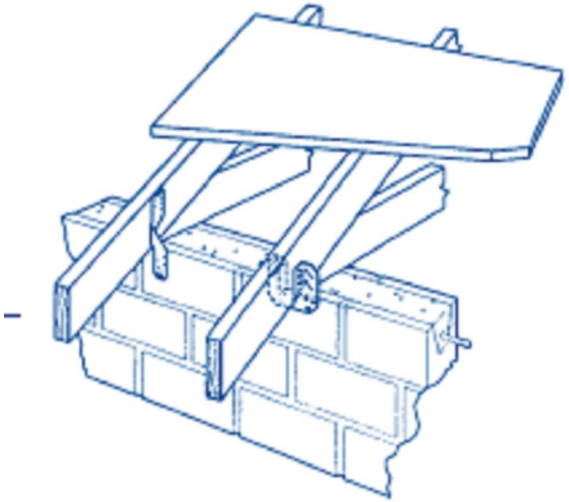


# Retrofitting - Cyclone

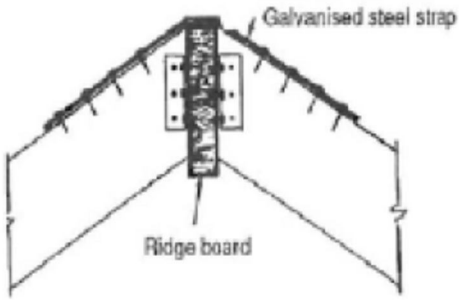
CONNECTION OF PURLINS



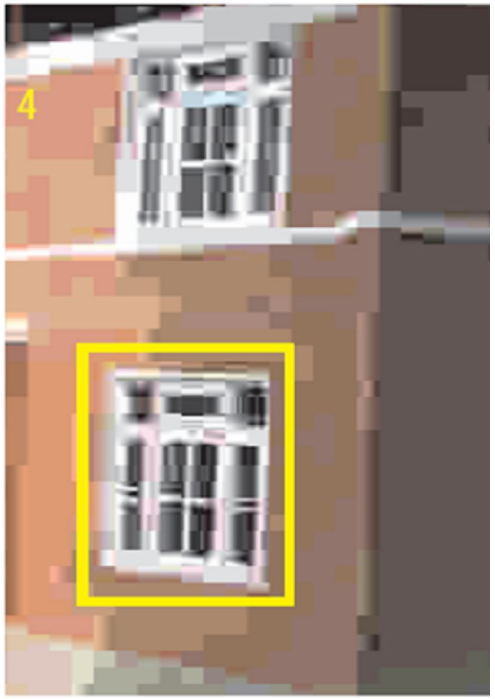



CONNECTION AT THE RIDGE JOINT

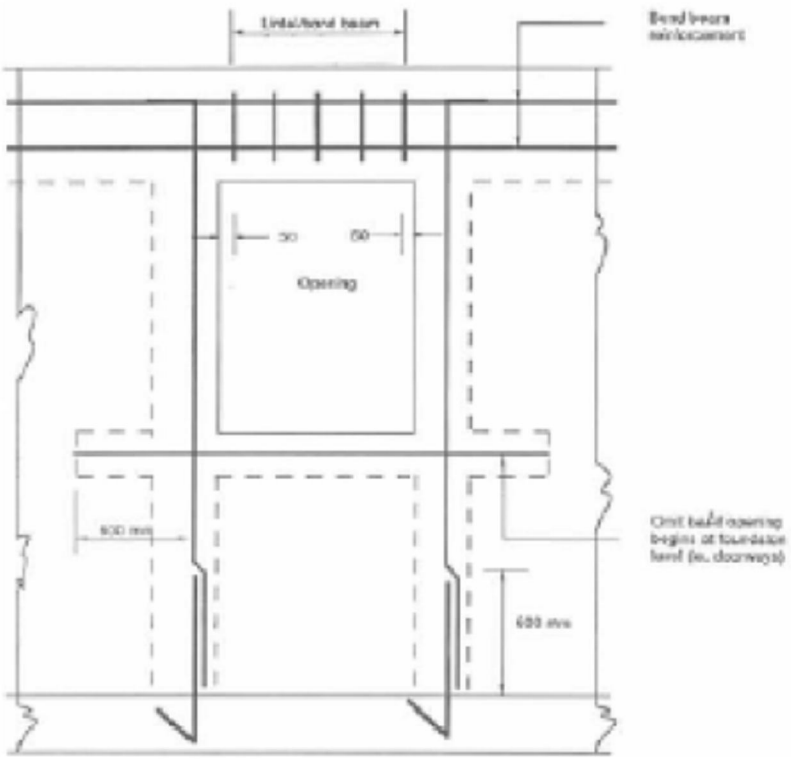



# Retrofitting - Cyclone

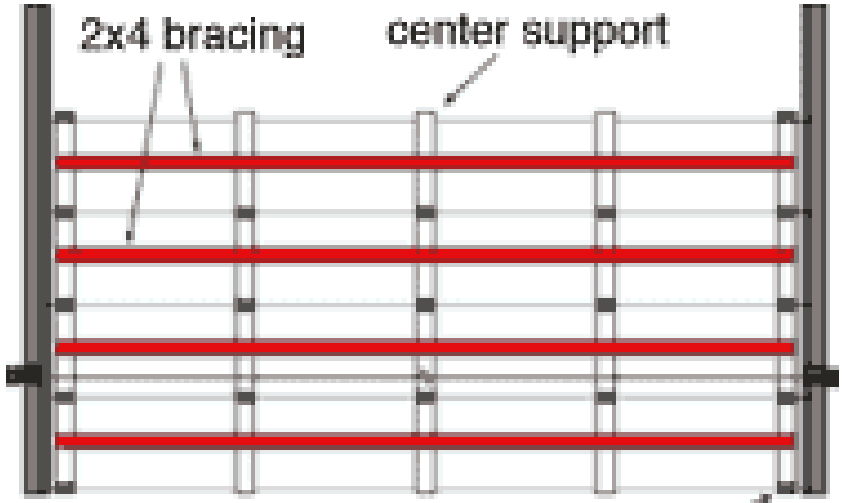
- Make smaller glass panes, or
- For low cost place plastic film on glass, or
- Install metal screen on the



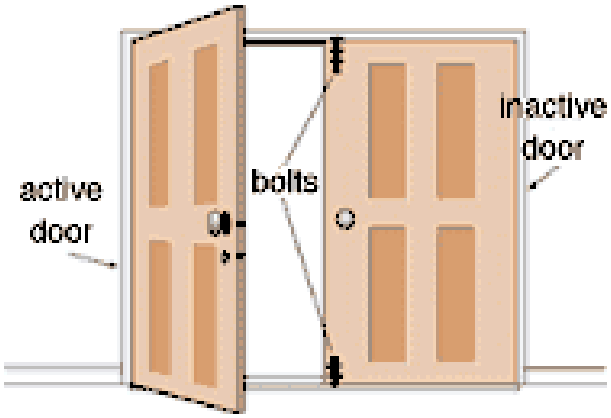

REINFORCEMENT DETAILS AROUND OPENINGS IN WALLS

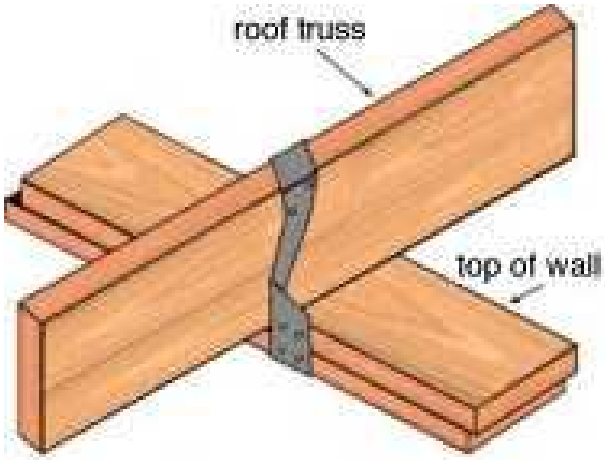


# Retrofitting - Cyclone




garage door bracing




hurricane strap

THANK YOU