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
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
The most costly hospital is that fails
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
   - Upgradation 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

**TECHNICAL**

- Site Characteristics
  - Location
  - Soil Type
- Building Characteristic
  - Foundation
  - Structure type
  - Height
  - Construction Material
  - Condition
- Hazard Characteristic
- Availability of Skilled Human Resource
- Local and National Building Bye-laws and codes

**LEGISLATIVE**

- Preference of Owner
  - Aesthetics
  - Economics
  - Accessibility
  - Time duration

**PREFERENCE OF OWNER**
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

Load Bearing Masonry Building with Pitched Roof

- Weak anchoring of sheathing & tiles to roof framing.
- In-plane deformation in roof causing sideways push on the gable wall.
- Absence of tie at eave projection.
- Poor connection between roof framing and wall.
- Side way push from roof rafters to wall.
- Absence of connection between floor and walls.
- Diagonal tearing at opening corners.
- In-plane deformation of floor rectangle changing to parallelogram.
- Absence of plastering or pointing permit wetting of mud mortar.
- Absence of moisture barrier that permit wetting of mud mortar.
- Easily Breakable Large Glass Panel
- Weak anchoring of door/window frame to wall.
- Masonry with poor horizontal bending strength.
- Masonry with poor tensile strength against tearing.
- Plinth masonry in mud mortar with open joints that can easily be eroded.
- Plinth level lower than high flood mark.
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 centres lines not matching.

4. Never connect one wall to another through the use of tooth 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
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
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

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

Uneven Settlement

Scouring
Retrofitting- floods

1. Elevation
   - Elevation of the existing structure on fill or foundation elements like 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 valves
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
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

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type</th>
<th>Retrofit/Maintenance Measures</th>
<th>Approximate cost as a proportion of cost of building</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Non Engineered Building</td>
<td>- Provisions of metal straps and nails at joints&lt;br&gt;- Holding down coir ropes&lt;br&gt;- Replacement of worn out fibre ropes</td>
<td>Retrofit -4.5%&lt;br&gt;Maintenance-1%</td>
</tr>
<tr>
<td></td>
<td>Thatched House</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Tiled Building</td>
<td>- Concrete strips&lt;br&gt;- Holding down rods&lt;br&gt;- Metal straps for connection to trusses&lt;br&gt;- Provision of eaves holding down angle/metal strap&lt;br&gt;- Maintenance replacement of broken tiles, worn out bolts, metal straps, etc.&lt;br&gt;- R.C.C. holding down rafters</td>
<td>Retrofit -8%&lt;br&gt;Maintenance-1%</td>
</tr>
<tr>
<td>3.</td>
<td>Compound Wall</td>
<td>Checking the available capacity and detailing retrofit measures consisting of reinforced concrete bends to obtain the required strength</td>
<td>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.</td>
</tr>
<tr>
<td>4.</td>
<td>Lamp Masts</td>
<td>- 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&lt;br&gt;- Underground cables to reduce load on lamp mast/failure of masts by falling branches of tress.</td>
<td>Cost of Individual lamp mast with foundation will be increased by 40 to 50%</td>
</tr>
<tr>
<td>5.</td>
<td>Water Tanks</td>
<td>Provision of holding down/preventing sliding etc.</td>
<td>Marginal</td>
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<td></td>
<td>Ferrocement/Other Lightweight Tanks</td>
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</tbody>
</table>
Cyclone effects

Blown off tiles due to high winds

Wall collapse due to tidal surge
Retrofitting measures at glance

- Install diagonal collar beams
- Install diagonal bracings
- Anchor roof truss to walls with brackets
- Anchor floor joists to walls with brackets
- Improve story-to-story connectivity by providing vertical reinforcement
- Induce tensile strength in walls against in-plane tension and horizontal seismic belts
- Provide bond elements in stone wall
- Strengthen masonry column with jacketing
- Strengthen gable wall by installing sloping belt on gable wall
- Strengthen corners with seismic belts at middle floor and eave level
- Induce tensile strength against vertical bending by providing vertical reinforcement at all inside and outside corners
- Provide in-plane bracings under timber floor
- Encase wall opening with reinforcement or reduce the number or size of openings
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- 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
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ANCHOR PILES

- 17.5MPa concrete
- 2/012 bars 350mm long drilled holes
- 456mm min

Bearers
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SUB-FLOOR BRACING TYPES

100x50mm Brace
F11 or better

130mm min.

1/16th Bolt with washers

190mm min.
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CORNER DETAILS FOR PARTIALLY GROUTED MASONARY WALL
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**BRACING TYPES**

1. **TIMBER BRACE**
   - 2.80x3.15 Nails to each stud and brace
   - No end splits allowed when necessary

2. **Metal braces**
   - Bridging
   - 180x35 mm Brace
   - 45°
   - Top Plate
   - Bottom Plate

- Provide proprietary Tensioning Device
- Purpose made Flat Building Strap
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1. Connect all vertical rebar in the wall at corners and openings to rebar in slab by bending and making 450mm (18") overlap, and tie with binding wires.

2. Special Anchor for Seismic & Wind Speed Zones V

Reinforcement in RC Slab

- 450mm (18")
- Max. Spacing 1200mm (4"")
- Bent portion 200mm (8")
- 1:1.5:3 micro-conc.
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- Make smaller glass panes, or
- For low cost, place plastic film on glass, or
- Install metal screen on the

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**REINFORCEMENT DETAILS AROUND OPENINGS IN WALLS**

4. ---

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THANK YOU