

# Why Retrofit Your Building ? How?



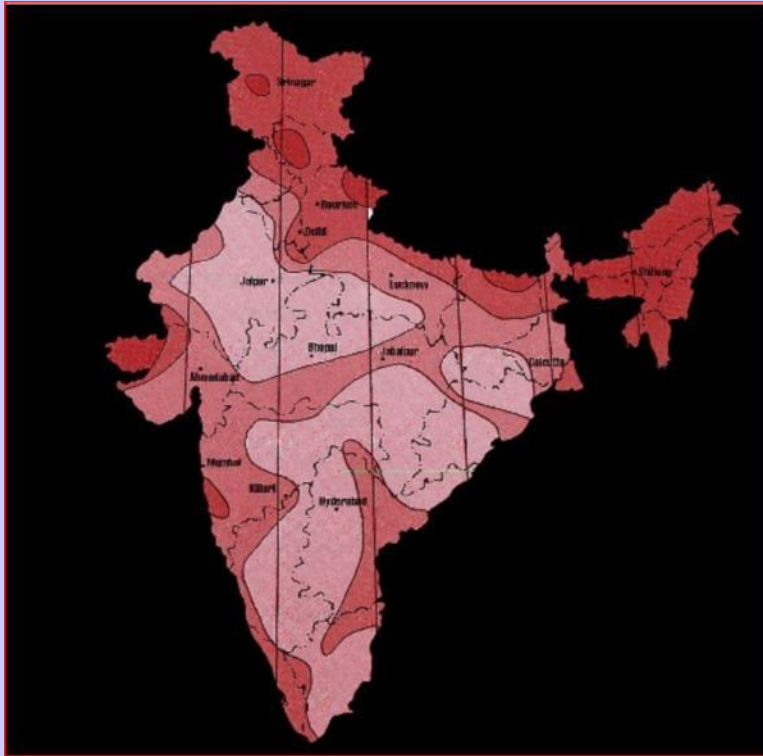
National Centre for Peoples'-Action In Disaster Preparedness, Ahmedabad





# Past Earthquakes at a Glance

Location	Year	Magnitude	Villages Affected	Cities Affected	Houses Severely Damaged or Destroyed	Houses Damaged	No. of Deaths
Latur	1993	6.4	1200	0	35,000	2,00,000	9,000
Jabalpur	1997	6.1	45	1	5,600	57,000	45
Chomoli	1999	6.8	4175	0	19,300	86,000	135
Kutchch	2001	7.7	8000	6	1,50,000	7,50,000	14,000

**It is in your hands that you do not become a part of such statistics in a future earthquake.**

## Seismic Zone Map of India



-  Zone 2 - Lowest Risk
-  Zone 3 - Moderate Risk
-  Zone 4 - High Risk
-  Zone 5 - Very High Risk

**Do you know that earthquakes can occur in the area you live in ?**

**Do you know that earthquake can damage or destroy your house ?**

**See the map of Seismic Zones of India. Locate your town in this map. Determine the earthquake risk.**

**If earthquake risk was not taken care of in the construction of the building you are living in or working in then in the event of an earthquake you are not safe.**

**Just retrofit your existing building  
To Ensure Your Safety there is no need to  
demolish your building and reconstruct it.**



Re-Construction

Retrofitting or Strengthening



# Why retrofit ?

- Reconstruction means first demolition and removal of debris, and then reconstruction.
- Retrofitting means making small changes to only some components of an existing structure
- Retrofitting is five times cheaper than reconstruction.
- Retrofitting is faster than reconstructing.
- Retrofitting means all the conveniences created in the house are not lost. Reconstruction means re-doing all that.
- Retrofitting can be done in phases - only one or more parts of the house at a time. Hence, its use can be continued and economically it is more manageable.
- Finally. It ensures long term safety against future earthquakes for most number of people with least amount of money

# Present Retrofitting Scenario...

There has been little retrofitting as a part of pre-disaster action. In the aftermath of disaster, the structures fit for retrofitting have largely been abandoned or demolished, and rebuilt.

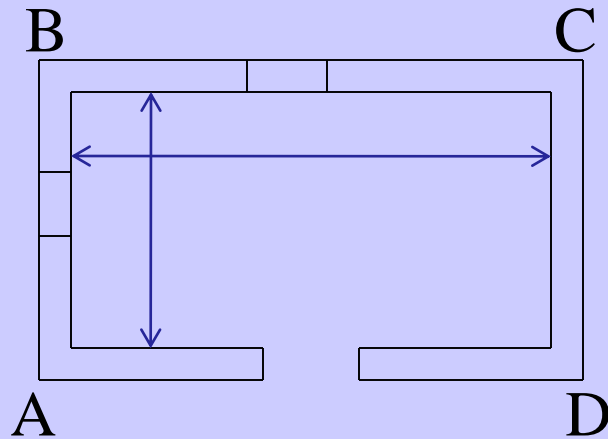
Because...

- Contractors/Masons are ignorant about **retrofitting**
- People do not readily accept **retrofitting** as an option that can be adopted
- Few authorities promote **retrofitting** as the most viable option for long term security against quake

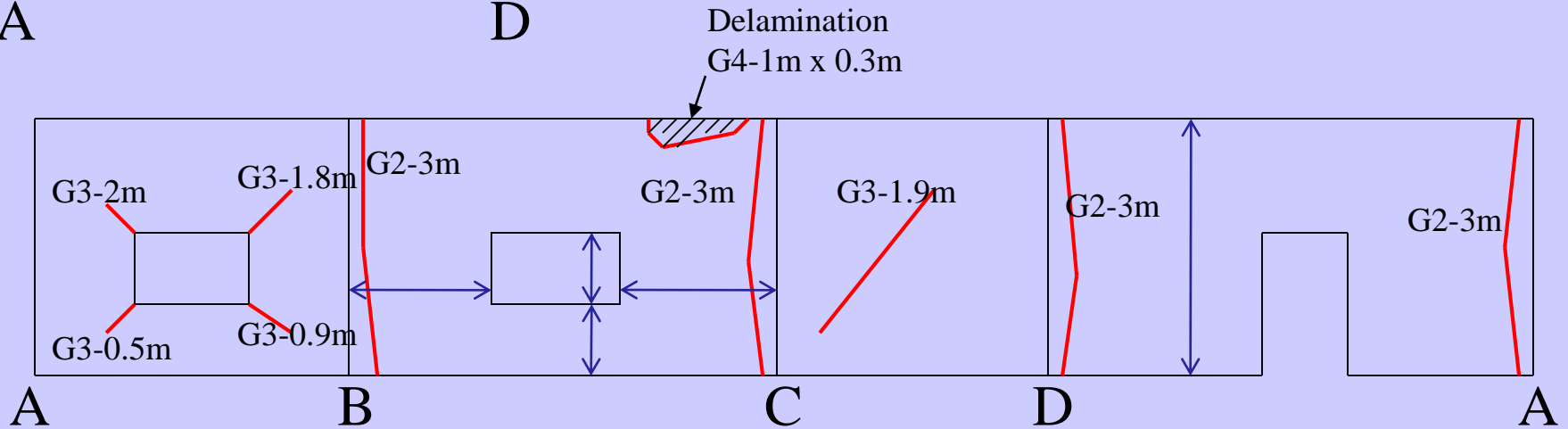
# How to retrofit a building ?

1. Document the structure
2. Repair the damage
3. Restore original strength
4. Identify weaknesses
5. Identity remedies
6. Decide sequence of operations and phasing
7. Procure materials
8. Apply Retrofitting measures
9. Apply finishing to match the original finish on the adjacent surfaces

# Document the damaged Bldg.



Bldg. Plan



Fold-out of Building showing damages



# Repair of Damage

These are non-structural items including

- Paint, plaster and tiles peeling off from walls
- Flooring disturbed
- Roofing disturbed – tiles, cement sheets etc.
- Plumbing damage
- Electrification damage
- Damage to doors and windows
- Damage to parapet

Some of these items must be repaired before taking up retrofitting and some at the time of finishing.

# Identify Weaknesses

Collapse of RCC Roof Due to collapse of block wall – **Poor wall construction**



Collapse of roof due to collapse of gable wall – **Indicates unrestrained gable due to absence of positive connection between roof and wall**



Collapse of full height brick gable wall – **Indicates absence of connection between walls -**



Severe diagonal cracking of concrete block wall – **Indicates poor in-plane shear strength**



# Identify Weaknesses

Cracks at window and door opening corners – **Indicate inadequate in-plane shear strength because of large openings**



Cracks along corners – **Indicate absence of wall to wall positive connection**



Cracks in wall - **Indicate window too close to corner causing narrow wall panel having inadequate in-plane shear strength**



# Identify Weaknesses



Wall delamination and collapse –  
**Indicates absence of through stones and interlocking of stones**



Gable wall cracks at its base –  
**Indicates unrestrained gable wall because of absence of positive connection between roof and wall, absence of roof diaphragm action**

# Identify Weaknesses



Roof slab sliding out – **Absence of wall to roof slab connection**

Roof collapse from wall collapse – **Poor wall construction with absence of through stones & interlocking, absence of wall to wall connection, absence of wall to roof construction, absence of diaphragm action in roof**



# Identify Solutions

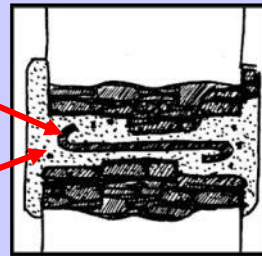
1. **Cast-in-situ RC Stitching Elements** for UCR walls
2. Ferro-cement **Seismic Belt**
3. Ferro-cement **Gable Belt** for Gable wall
4. **Tie rod** for restraining Seismic Belt
5. **Opening encasement** with Ferro-cement strapping around wall openings or blocking of wall openings
6. **Vertical corner reinforcement** in the form of Ferro-cement vertical corner straps or Single bar
7. **Roof Anchors** to walls
8. **Diagonal braces** of multiple GI wire ties or timber for tiled or stone roof
9. **Knee bracing** for timber beam-column connection
10. **Jacketing** of unreinforced masonry column

# 1. Stitching of UCR Wall Against Bulging and Delamination



8mm  
TOR Rod

1:2:4  
Concrete



## Caution

- Different types of stones require different ways of making holes
- Exercise extreme care not to damage wall
- Do not use crowbar

## 2. Seismic Belt against cracking due to corner separation, out of plane bending & in-plane shear



Shear  
Connector





### 3. Seismic Belt against cracking due to out of plane bending of gable wall

#### Caution

- All joints must be raked well before installing WWM for proper bond with wall
- The gap between wall and WWM must be min. 12mm to ensure mortar in rear
- WWM must be well encased in cement mortar to prevent corrosion by water



# Seismic Belt Making



Deciding alignment  
and preparing  
surface to ensure  
good bond



# Seismic Belt Making



Prepare Belts for  
Installation

# Seismic Belt Installing



Belts Installation

## 5. Ferrocement Strapping Around Openings or Closing of Openings To Prevent Corner Cracking



- Install straps same as seismic belt
- Ensure proper overlaps of WWM
- If too many openings in wall or wall panel too narrow then fill up an opening with masonry



# 5. Ferrocement Strapping Around Openings or Closing of Openings To Prevent Corner Cracking



# 6. Ferro-cement vertical corner straps or Single bar vertical corner reinforcement to strengthen corner

- Install vertical ferrocement strap similar to belt on both walls at corner, on inside and outside faces

- Install vertical rod (10 - 12mm TOR) in corner

- Connect to both walls with shear connector

- Ensure minimum 35mm micro concrete all around by keeping min. 35mm gap with walls



WWM Strap on both walls

## Caution

- Anchor bar well
- Ensure full encasement in concrete to prevent corrosion

8mm TOR Shear Connector



Concreting all around

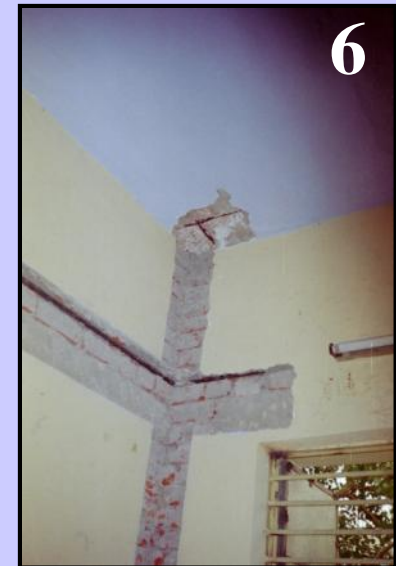


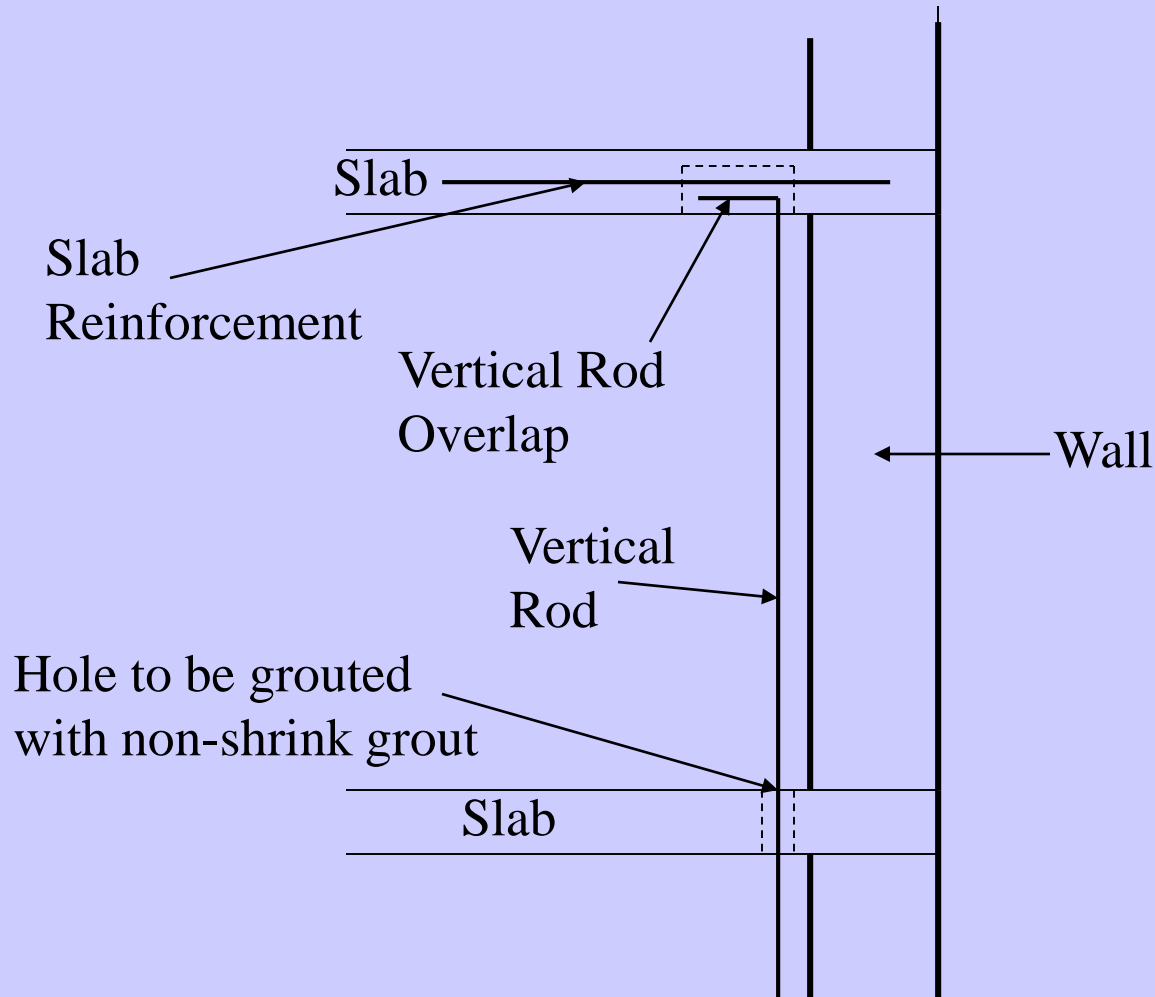
# Vertical Reinforcing Bars in corners - Cautions

- Like in belt, this too has to be anchored well with the wall
- It must be anchored at base in concrete
- Cautions
  - Gap between rod and walls must be 1.5” to ensure all around concrete cover
  - Wall plaster must be removed and joints raked, surface cleaned to ensure good bond with wall
  - Alignment must be ensured before grouting of shear anchors and bottom concreting
  - Concreting must not be lifts greater than 3’ and must be accompanied with continuous rodding
  - In case of double story ensure adequate overlap with the bar in upper story

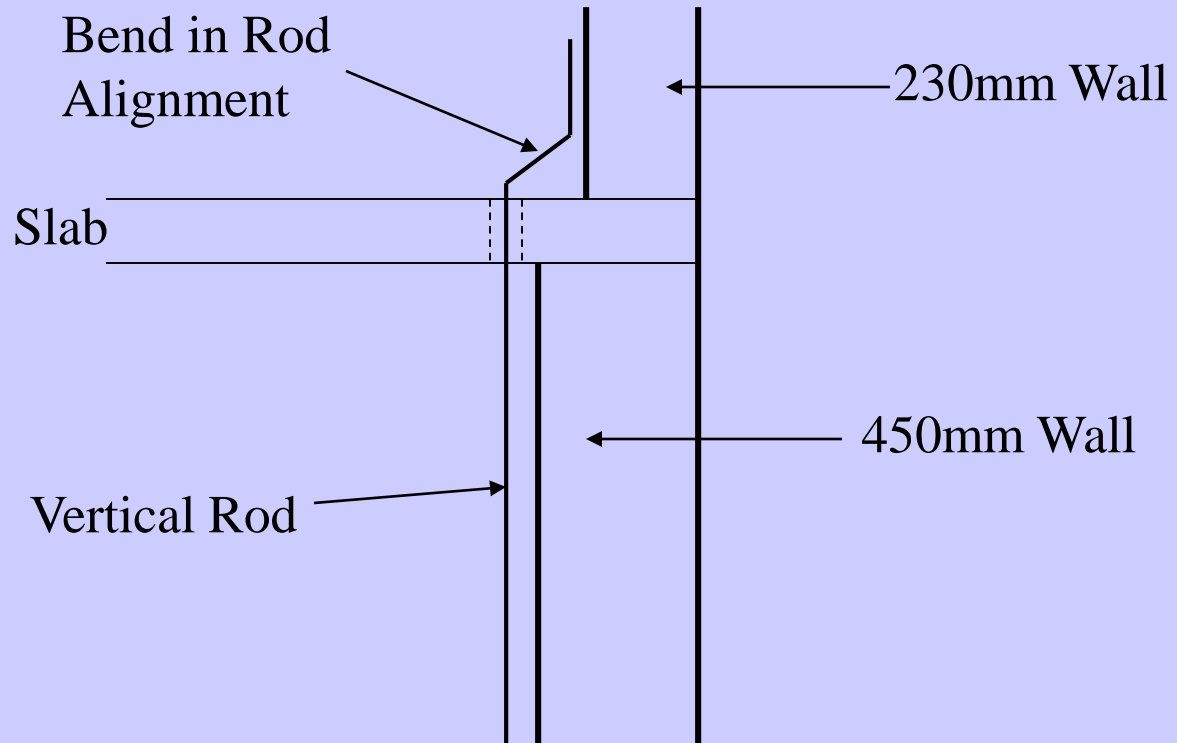


# Vertical Reinforcement Installation





Vertical Rod and Junction with Lower Storey Slab and Top Storey Slab



Vertical Rod Alignment Across Two Stories  
For Wall with Different Thicknesses

# 7. Roof Anchors to Walls for improved Diaphragm Action

- Anchor rafters and beams to ferrocement belt or other dependable element
- Use multiple strands of twisted pre-tensioned 13 gauge GI wire as anchor, or metal straps or bars drilled and cut to meet requirement
- Vert. Rods to connect with slab reinforcement



## Caution

- Placing such anchors inside of building will reduce corrosion problem



# 8. Diagonal Bracings in Roof for Diaphragm Action

- Use timber braces with bolted connection with plywood or steel gusset plate where feasible
- Connect bracing to rafters with nails where possible
- Follow stress path for deciding arrangement of braces



## Caution

- Roof members must be anchored for best diaphragm action



# 8. Diagonal Ties in Roof for Diaphragm Action

- 2-3 GI wires of 13 gauge to be cut, installed and twisted for pre-tensioning
- End connections involve simple tying



## Caution

- Too much twisting could break wires
- Install one wire at a time and twist all together

## 8. Miscellaneous Items

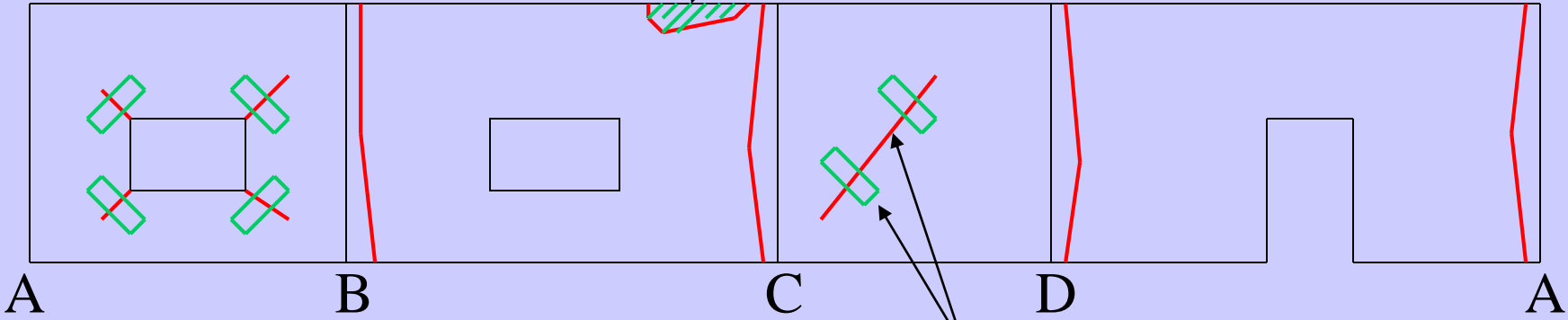
- Evolve solutions to suit the problems on hand
- Install wire hooks for holding roofing tiles
- Masonry columns may be jacketed with MS angles & straps or WWM
- Wooden frame structure may be provided with knee braces to reduce side sway



# How to retrofit a building ?

## Show Retrofitting & Repair Measures

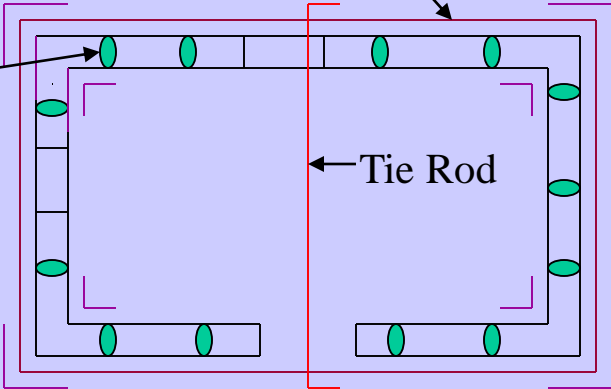
Dismantled and Recon.  
damaged masonry



Grout crack with non-shrink cement grout and install ferrocement bandages (Typ.)

Little level  
Seismic Belt  
on both faces

Cast in-situ RC  
Stitching Element



Tie Rod

Vertical Corner Ferrocement  
Strap on both faces



# Things to Remember

- Assess need for **repair** of damage, followed by **reconstruction** of dilapidated or severely damaged elements and **restoration** of original strength, and finally, **retrofit** of whole structure.
- Understand the situation, use engineering common sense, and **evolve solutions**
- Look at each **building element** and then the structure as a **whole**
- Be ready for **real life situations** rather than hypothetically simple text book situations
- Demand adherence to **right procedures** to ensure improvement in performance
- Exercise caution not to damage or weaken the structure – use **skill** and **trick** rather than brute strength

# Finally...

More than half of India falls under Seismic Zones  
Where

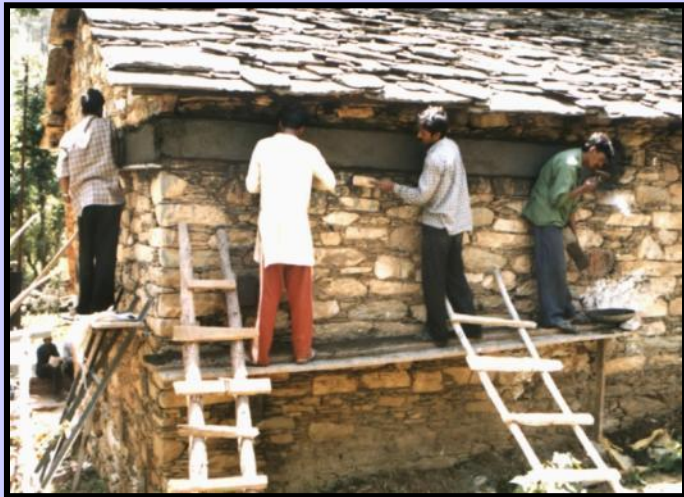
An Earthquake can Strike any Time,  
any place and of any Intensity.

Use retrofitting to bring long-term safety  
against future disasters without wasting  
scarce resource of the country

Retrofit critical facilities like schools, health  
care facilities, police stations, government office  
buildings, etc.



Thank  
You



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