Effective Response Mechanism in Earthquakes

From Rescue Capacity to Response Systems

Annual Conference

Relief Commissioners/ Secretaries (Disaster Management) and State Disaster Response Forces (SDRFs) of States/UTs – 2026

May 2, 2026 | Dronacharya Auditorium, NIDM, Rohini, New Delhi, India

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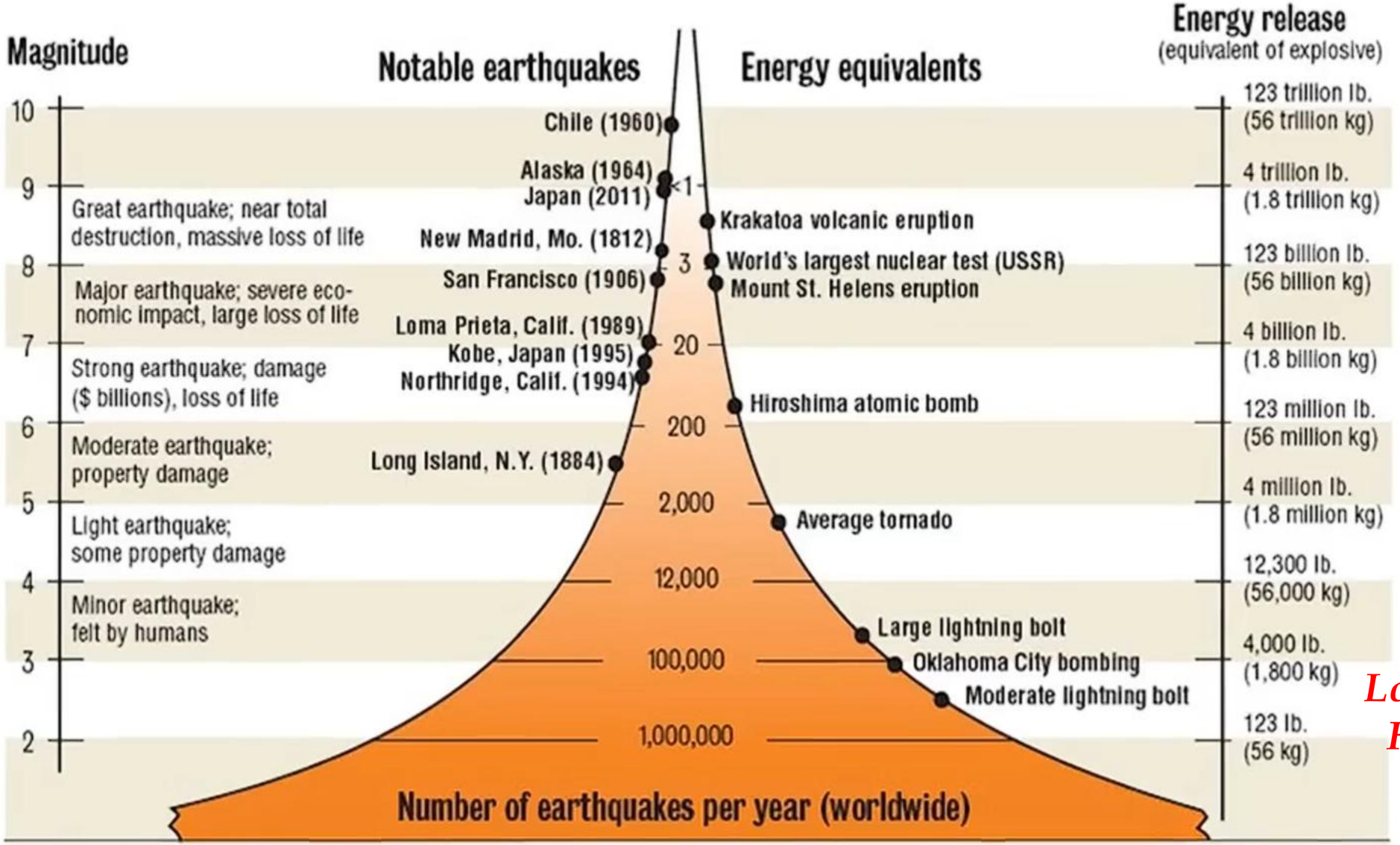
Earthquake frequency and destructive power

The left side of the chart shows the magnitude of the earthquake and the right side represents the amount of high explosive required to produce the energy released by the earthquake. The middle of the chart shows the relative frequencies.



Source: U.S. Geological Survey

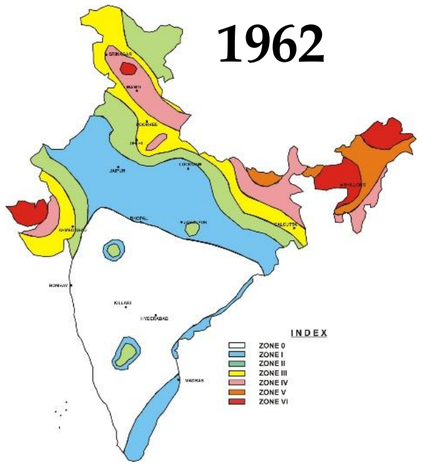
MCT

Low Frequency
High Impact

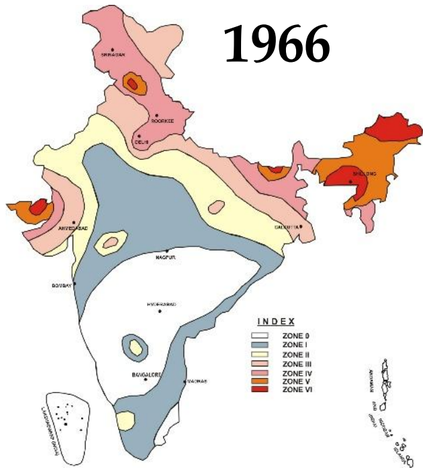
Earthquake Hazard

Deterministic
Intensity-based

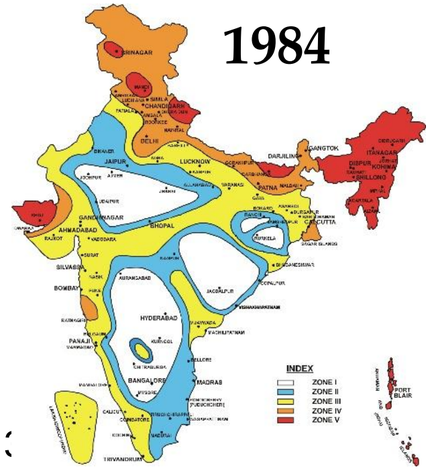
1962



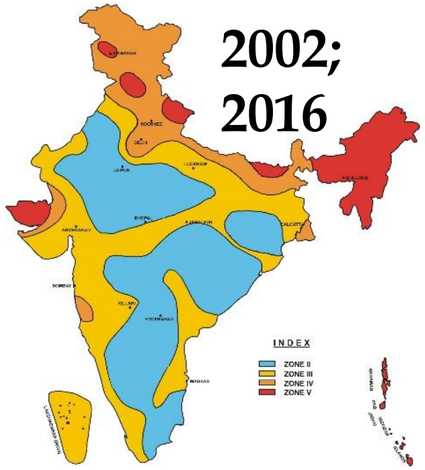
1966



1984

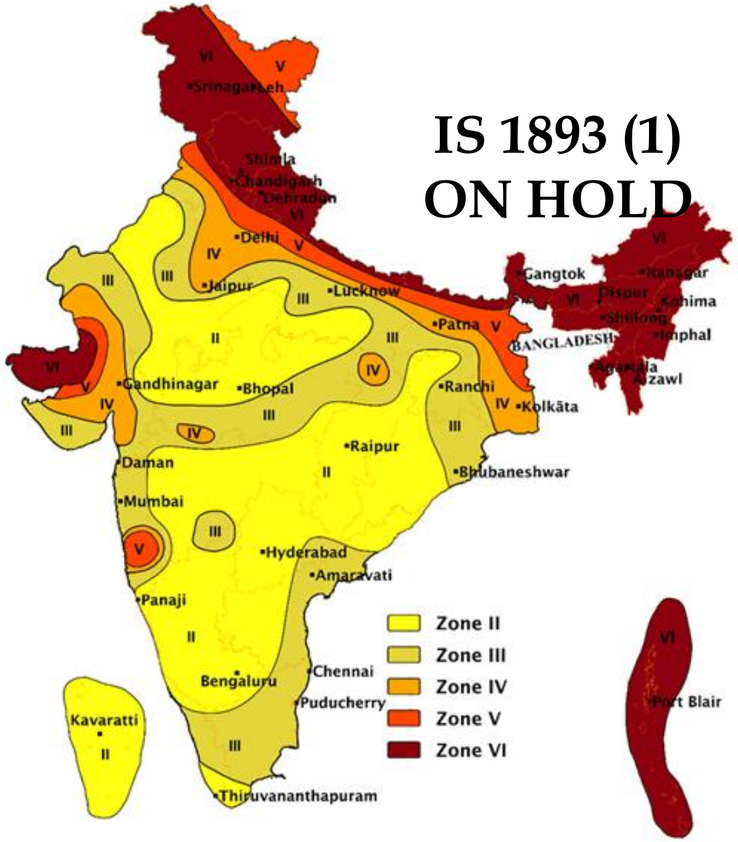


2002; 2016



Probabilistic
Deterministic Lower Bound

IS 1893 (1) ON HOLD



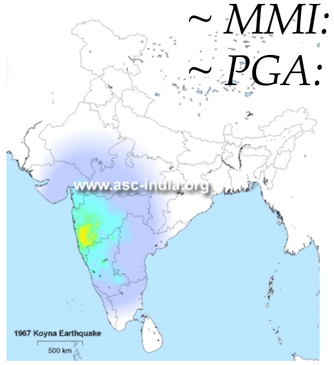
A Hard Truth

~ **80% Population**
in *Moderate* to *Severe* Earthquake Zones

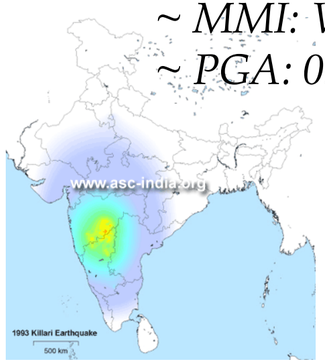
~ **50,000** lives lost since 1988

Surprise Earthquakes

1967 Koyna Earthquake
~ MMI: VIII
~ PGA: 0.63g



1993 Killari Earthquake
~ MMI: VIII +
~ PGA: 0.50g



"Earthquake response cannot depend on courage alone; it must rest on doctrine, discipline, coordination and engineering judgment."

Gujarat Earthquake

Nepal Earthquake

Mexico Earthquake

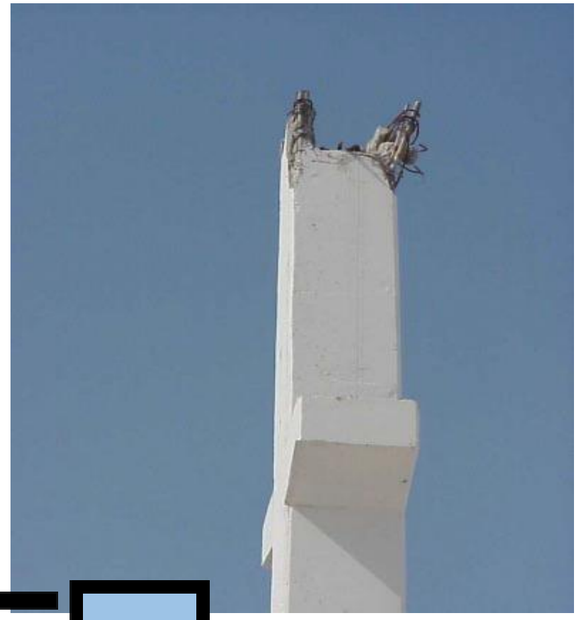
Turkey EQ 2023 : Mansory BuildingS

Turkey EQ 2023 : Historic Structures

Turkey EQ 2023: RC Building

Turkey EQ 2023 : Precast Building

Prefab Buildings

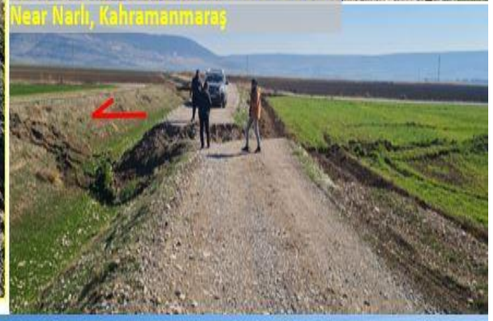


Bhuj Earthquake: Precast Buildings

- Inadequate connection
- Insufficient seating and anchorage of roof panels
- Lack of floor-diaphragm action

Turkey EQ 2023 : Bridge and Tunnels

Turkey EQ 2023 : Lifelines



Turkey EQ 2023 : Lifelines

Taiwan Earthquake: Dams

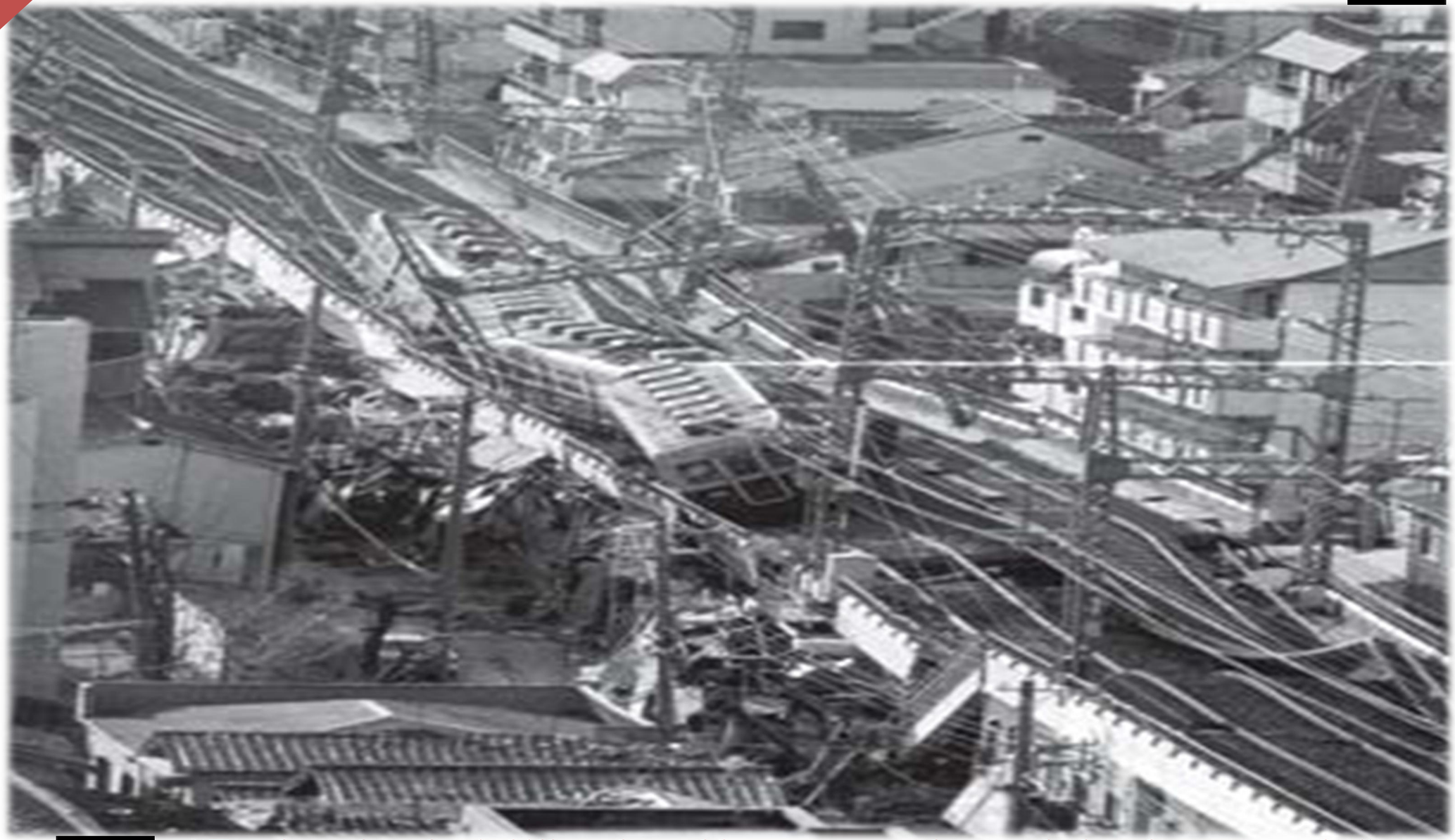
Power Sub-Station

Taiwan Earthquake, 1999

Communication Tower

Taiwan Earthquake, 1999

Railway Network



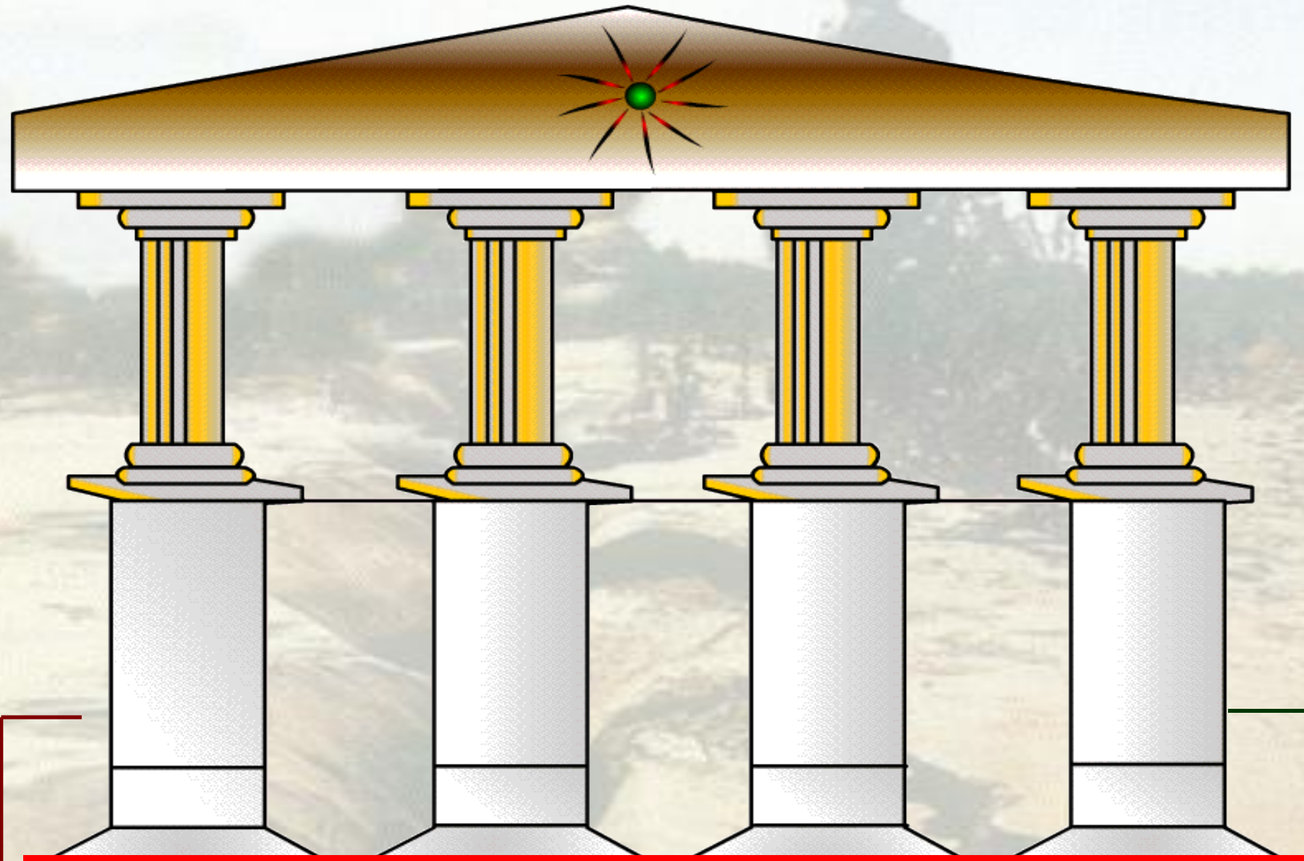
"Earthquakes don't kill; vulnerable systems and overwhelmed response do."

Calls for Coordinated System

Comparision Of 1999 & 2024 Eq. : Taiwan

ect	Hualien Earthquake (2024) April 03 @ 07:50 am	Chi-Chi Earthquake (1999) September 21 @ 01:47 am
Magnitude	**7.2**	**7.3**
Epicenter Location	Near Hualien City, offshore(in-land), 15 km south(14.9 km south-southwest)	Near Chi-Chi, Nantou County, central Taiwan
Depth	15.5 km (22.5km)	8 km
Quake Mechanism	Tectonic movement	Thrust faulting along the Chelungpu Fault
Affected Area	Primarily eastern Taiwan	Central Taiwan
Casualties	18 dead, over 1,115 injured	2,400 dead, over 11,000 injured
Damage	Severe damage to 84 buildings, widespread infrastructural damage, **temporary utility disruptions**	Destruction of over 100,000 buildings, **extensive infrastructure damage**
Secondary Effects	Triggered a small tsunami with waves up to 1 meter, leading to tsunami warnings	Extensive landslides, ground liquefaction, **widespread power outages**
Mitigation Efforts	**Extensive seismic retrofitting programs** initiated after the 1999 Chi-Chi earthquake	Limited compared to the present day, leading to greater damage and higher casualties
Emergency Response	Quick activation of emergency operations and deployment of emergency relief	Initial response efforts overwhelmed, leading to long-term recovery challenges
Reconstruction Efforts	Ongoing, significant focus on rebuilding and strengthening infrastructure	Extensive, led to the establishment of comprehensiv seismic safety programs
Economic Impact	Estimated in billions, **mitigated by improved preparedness and rapid response mechanisms**	the costliest disasters in Taiwan's history **pron building codes and disaster preparedness**

"Same earthquake intensity—but different outcomes."



Pillars of Effective Earthquake Response

- Situation Awareness
- Rapid Life-Safety & Collapsed Structure Assessment
- Unified Incident Command
- Recovery Transition Planning

ASSESS → DECIDE → ACT → SAVE

Golden 24 Hours: What Matters Most

- Save Lives
- Stabilize Hazards
- Restore Command & Communication
- Rapid Building Safety Tagging
- Prioritize Search & Rescue

not secured

Damage Tagging System

GREEN
(SAFE – Normal Entry)

No visible structural distress

Minor non-structural cracks

YELLOW
(RESTRICTED-Controlled Entry)

Local damage but stable load path

Falling hazards present

RED
(UNSAFE – No Entry)

Severe structural damage

Collapse Likely or ongoing

BLACK
(UNSAFE – No Entry)

Pancake Collapse

Lean-to Voids

"Needs Integration of Engineers into Rescue Decisions"

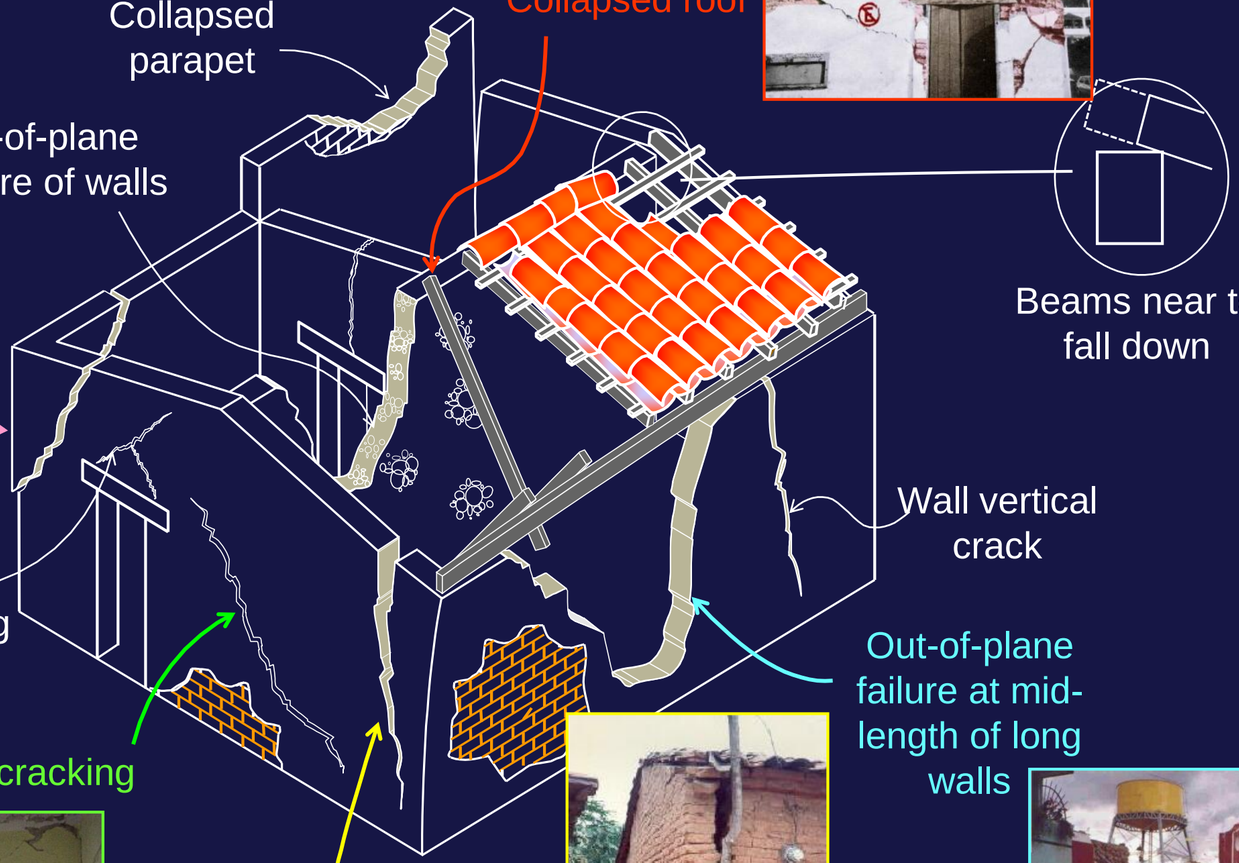
Typical Damage Patterns : Masonry Building

Collapsed roof

Collapsed parapet

Out-of-plane failure of walls

Corner failure



Beams near to fall down

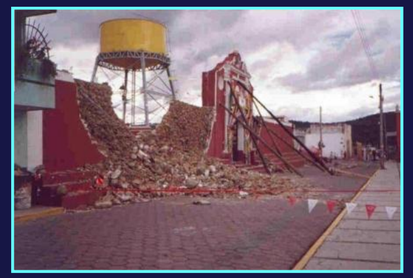
Wall vertical crack

Inclined cracking above lintels

Out-of-plane failure at mid-length of long walls

Wall inclined cracking

Vertical crack at corner due to wall rocking



Collapse Types

PANCAKE COLLAPSE

Vertical Multi-storey Failure

LEAN TO COLLAPSE

Leaning-Wall-over-roof structure

V-SHAPE COLLAPSE

Central roof fall with side walls standing

SOFT-STOREY-COLLAPSE

Failure at weak open ground level

PARTIAL COLLAPSE

Section of Building collapsed

Rapid Visual Structural Assessment

Global Stability Check

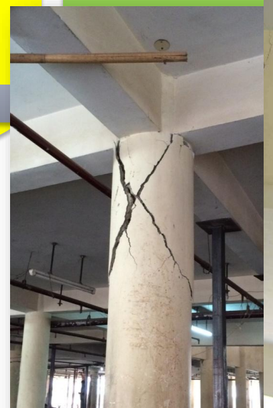
- Building tilted / leaning?
- Partial collapse observed?
- Foundation settlement / ground cracks?
- Adjacent building impact (pounding)?

Critical Structural Elements

- Columns: crushed / cracked / buckled?
- Beams: sagging / cracked?
- Beam-column joints damaged?
- Slab failure - collapsed or separated?

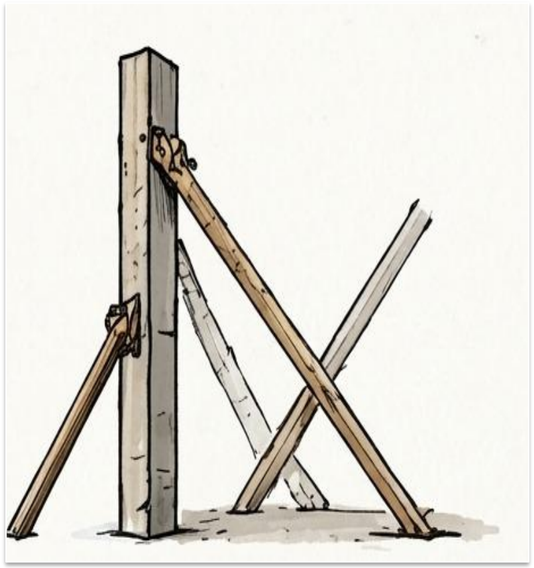
Non-Structural Hazards

- Falling debris (parapets, glass, cladding)?
- Staircase damaged (egress risk)?
- Heavy contents unstable?

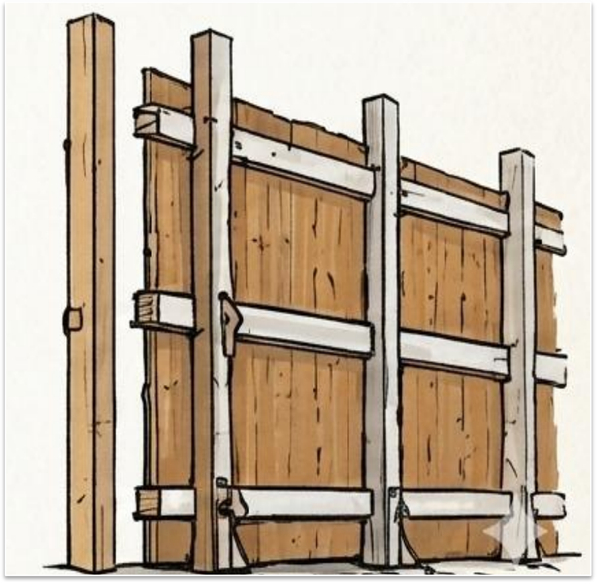


Shoring Basics (Temporary Support)

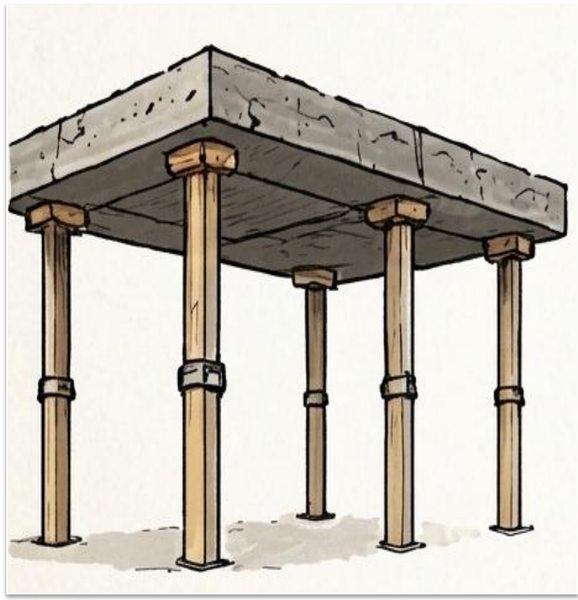
Cross bracing (improves stability)



Vertical shoring(under slabs/beams)



Walls shoring for out of plane walls

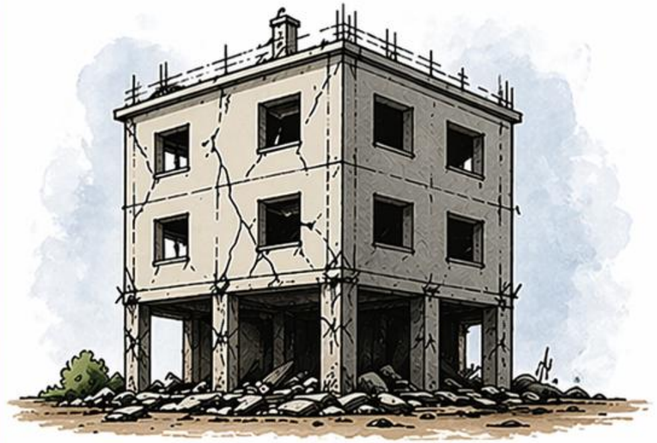


Strutting/Raking shores (against walls/ columns)

Simple Field Tools

Special Conditions

AFTER EARTHQUAKE



- Expect aftershocks
- Check soft storey failure
- Look for tilting or settlement

AFTER LANDSLIDE

- Check ground movement / instability
- Evaluate retaining structures
- Progressive movement

AFTER URBAN FIRE

- Assume hidden structural damage / weakness
- Avoid immediate re-entry without assessment
- Steel strength loss

Complex Collapses: Response Challenges

CHALLENGE	KEY ISSUES	WHY IT MATTERS
1 HIDDEN STRUCTURAL INSTABILITY	Undetected Instability in Damaged Structures	
2 PRESENCE OF SURVIVABLE VOIDS	Technical Challenge in Complex Collapses	
3 NEED FOR CONTROLLED DEBRIS REMOVAL	Strategic Approach Required for Safe Rescue	Cutting Structural Members Requires Engineering Judgment

Complex Collapses: Response Challenges

CHALLENGE	KEY ISSUES	WHY IT MATTERS
4 Multi-Hazard Environment Complex collapses often involve:	Fire Gas leaks Electrical hazards Aftershocks (in Earthquake scenarios) Routine response does not integrate multi-risk structural safety with rescue operations.	High Risk of Rescuer Entrapment
5 Requirement of Specialized Tools & Skills Complex collapse response needs:	Search cameras, acoustic sensors Breaching & breaking tools Structural shoring systems **Routine teams typically lack:** Training in technical search & rescue Structural stabilization capability	Risk of Destroying Survivable Voids
6 Time-Sensitive Survival Window Survival probability drops sharply after 24–72 hours.	**Rescue must be:** Fast but controlled Technically precise **Routine approaches are either:** Too slow (due to uncertainty), or Too aggressive (causing further collapse)	Uncontrolled Removal Can Trigger Progressive Collapse

Strengthening Priorities For India

1 Engineer-led Rapid Structural A

✓ *Embed engineers with NDRF/SD*

2 National Collapsed Structure Re

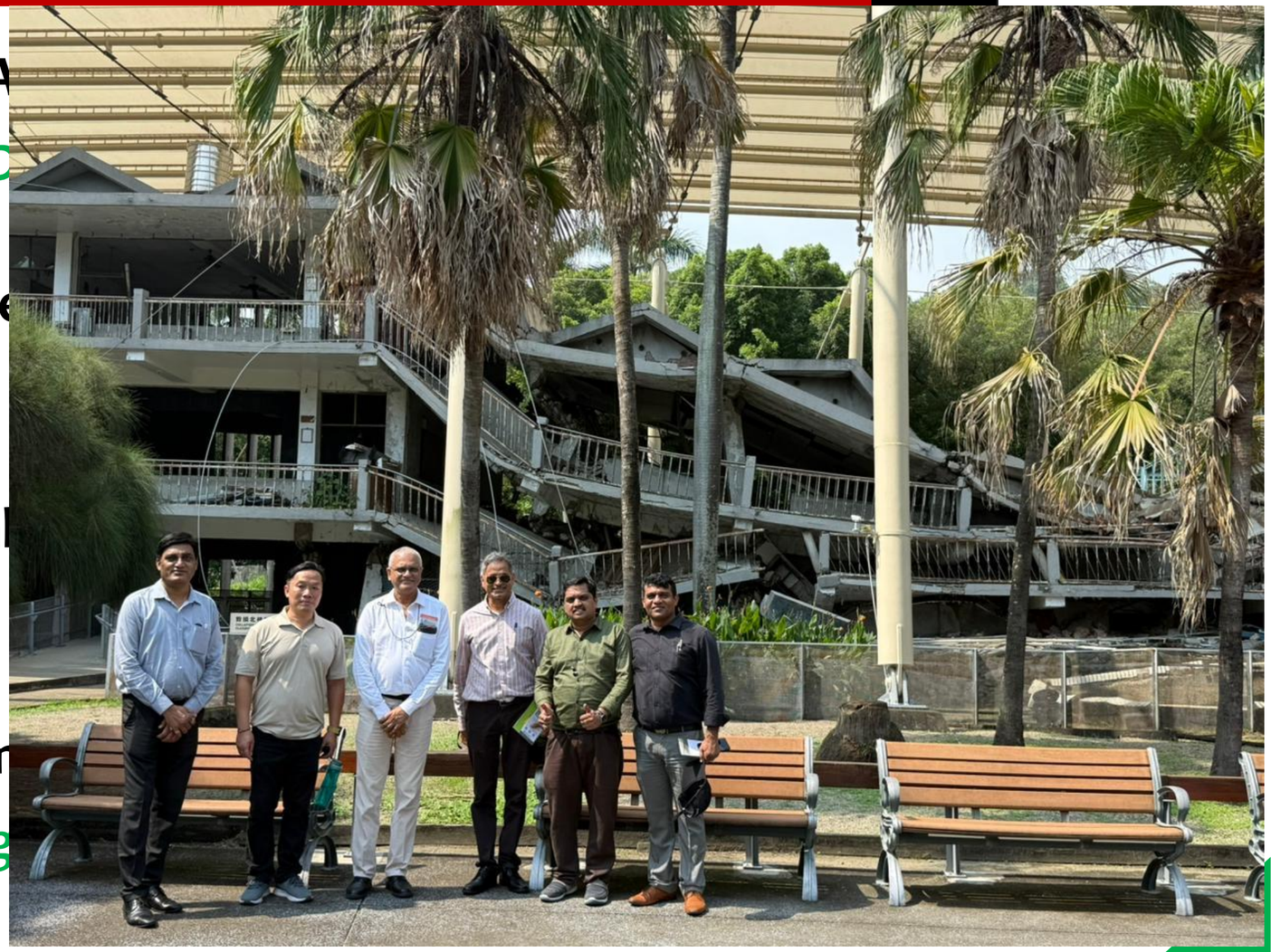
✓ *Dedicated doctrine.*

3 State-Level USAR Capability En

✓ *Move beyond debris rescue.*

4 Building Safety Tagging System

✓ *Standard post-earthquake tagg*



5 Scenario-Based Multi-Agency Earthquake Drills

✓ *Not table-top only — full-scale.*

"Technology Supports Judgement, It does not replace Command."

Closing Thoughts …

- “First 72 hours define outcomes.”
- “Preparedness is response in advance.”
- “Complex collapse demands specialized response.”
- “Engineering judgment must be embedded in rescue.”
- “Move from heroic response to institutionalized systems.”

“Resilient nations are defined not by avoiding earthquakes,
but by responding effectively when the ground shakes.”

Grateful

- *Dr. Hari Om Gandhi, DIG (Trg), HQ NDRF*
- **Organizer :** *National Disaster Response Force*
- **Government of India**
  - *Ministry of Home Affairs*
  - *Ministry of External Affairs*
  - *National Disaster Management Authority*
  - *CSIR CBRI*

Iternet for Clipart

"आज मरना है, ऐसे जियो;
सदा जीना है, ऐसे सीखो"

"Learn as if you will live forever, live like you will die tomorrow."

— Mahatma Gandhi

"ΓΗΡΑΣΚΩ ΑΕΙ ΔΙΔΑΣΚΟΜΕΝΟΣ"

"i grow old, always learning"

- Solon (638BC – 558BC)

Never stop learning because knowledge has no limits!

Jai Hind!!