MITIGATION AND MANAGEMENT OF EARTHQUAKE – A NON-RECURRENT NATURAL DISASTER

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NON-RECURRENT NATURAL DISASTERS

- Earthquakes, tsunami, landslides, cyclones, etc. are the non-recurrent natural disasters in the Indian context.
- Earthquake is one of the most devastating natural disasters that the mother earth unleashes.
- According to the United States Geological Society (USGS), most earthquakes have occurred in Indonesia. But most devastating earthquakes have occurred in China, Japan, Iran and Turkey as shown in the next slide:

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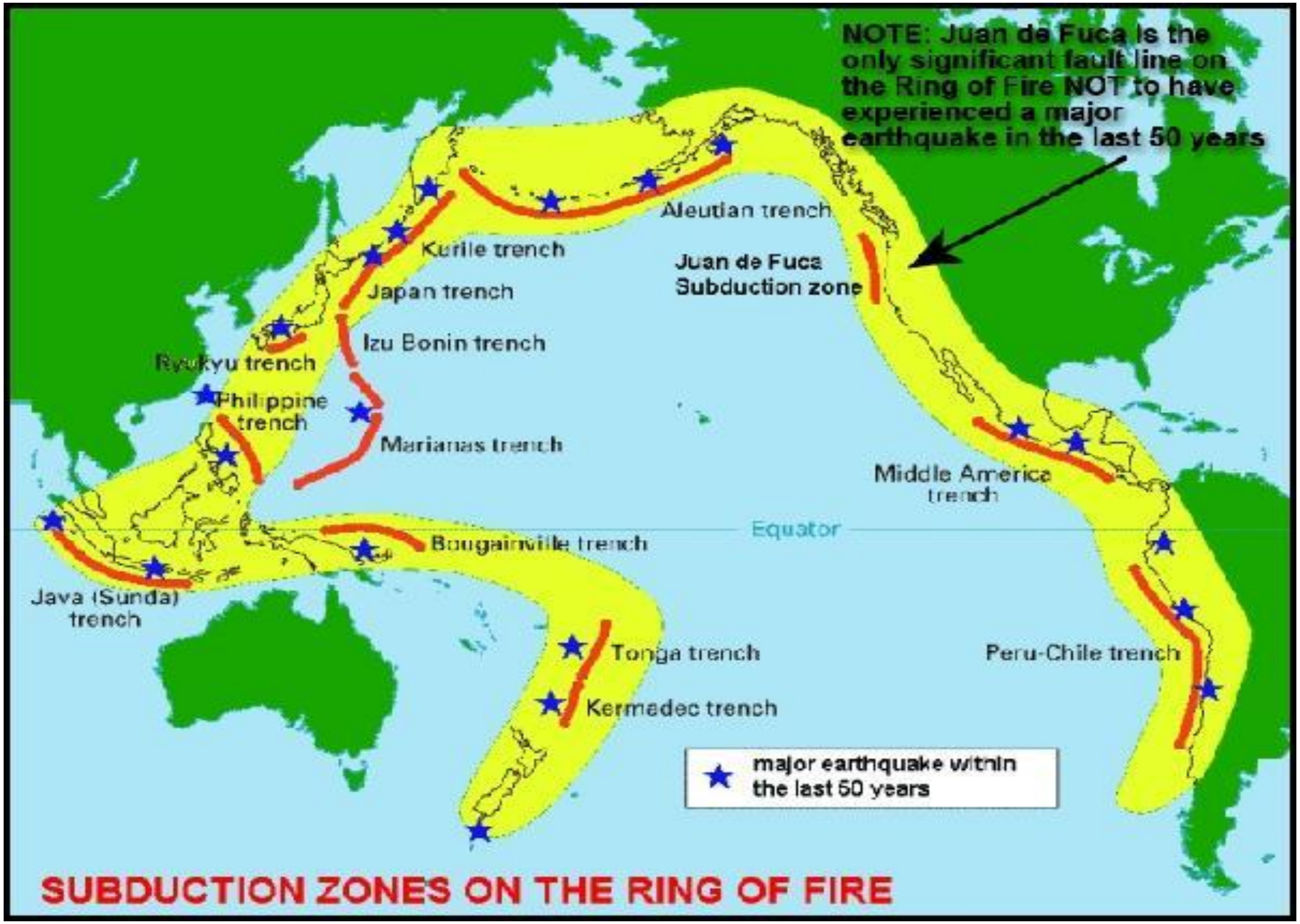

USGS Report on Major Earthquakes since last 60 years

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- **The earthquake is the only natural disaster which is not predictable. But it is known to occur in places where it has already occurred in the past.**
- **Therefore natural disasters in this country have to be understood also in a historical perspective.**
- **It is indispensable for realizing the looming seismic risk to several parts of our country.**
- Seismic maps of India and Bihar showing earthquake zones are shown in the subsequent slides.

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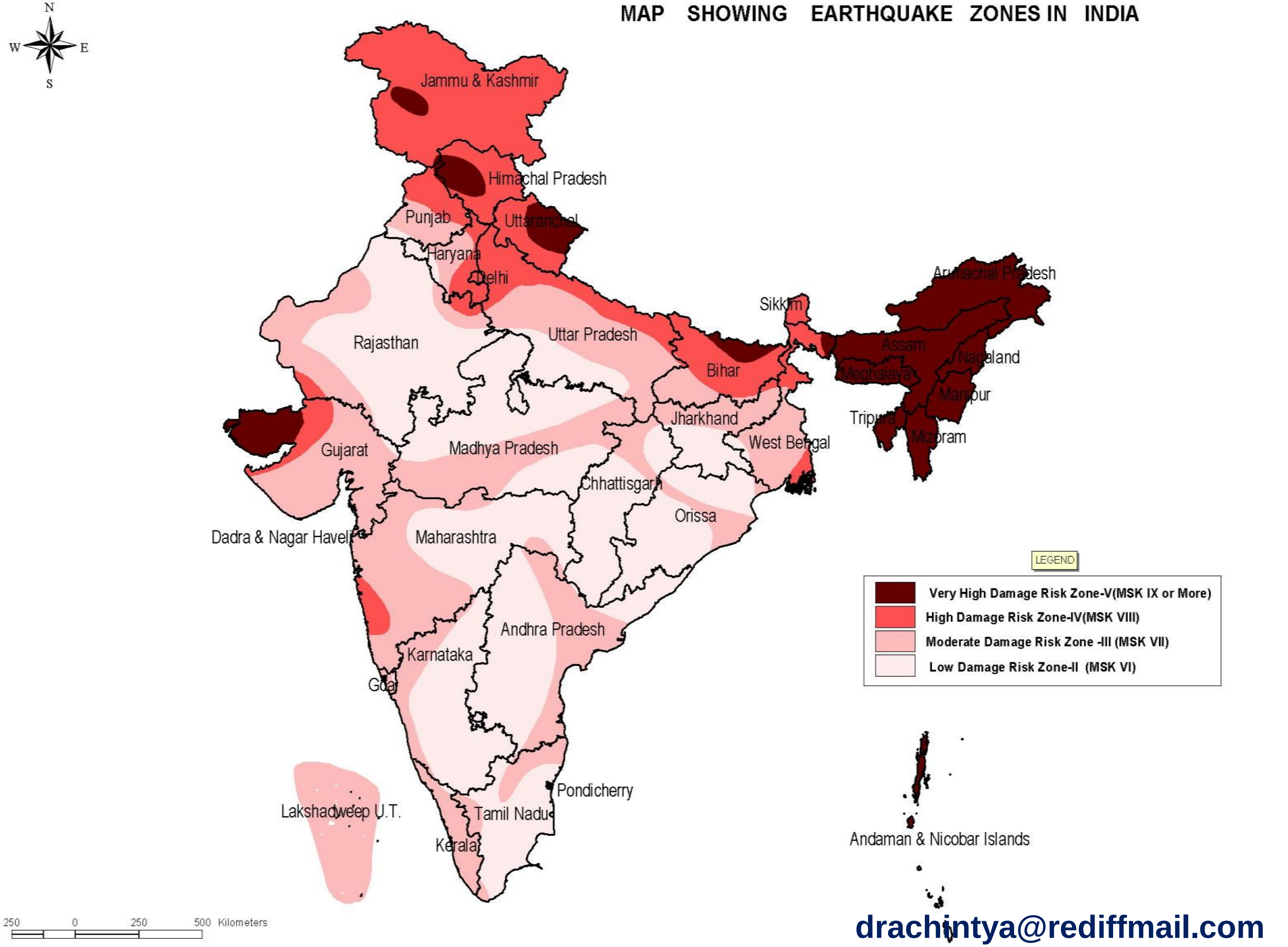
MAP SHOWING EARTHQUAKE ZONES IN INDIA



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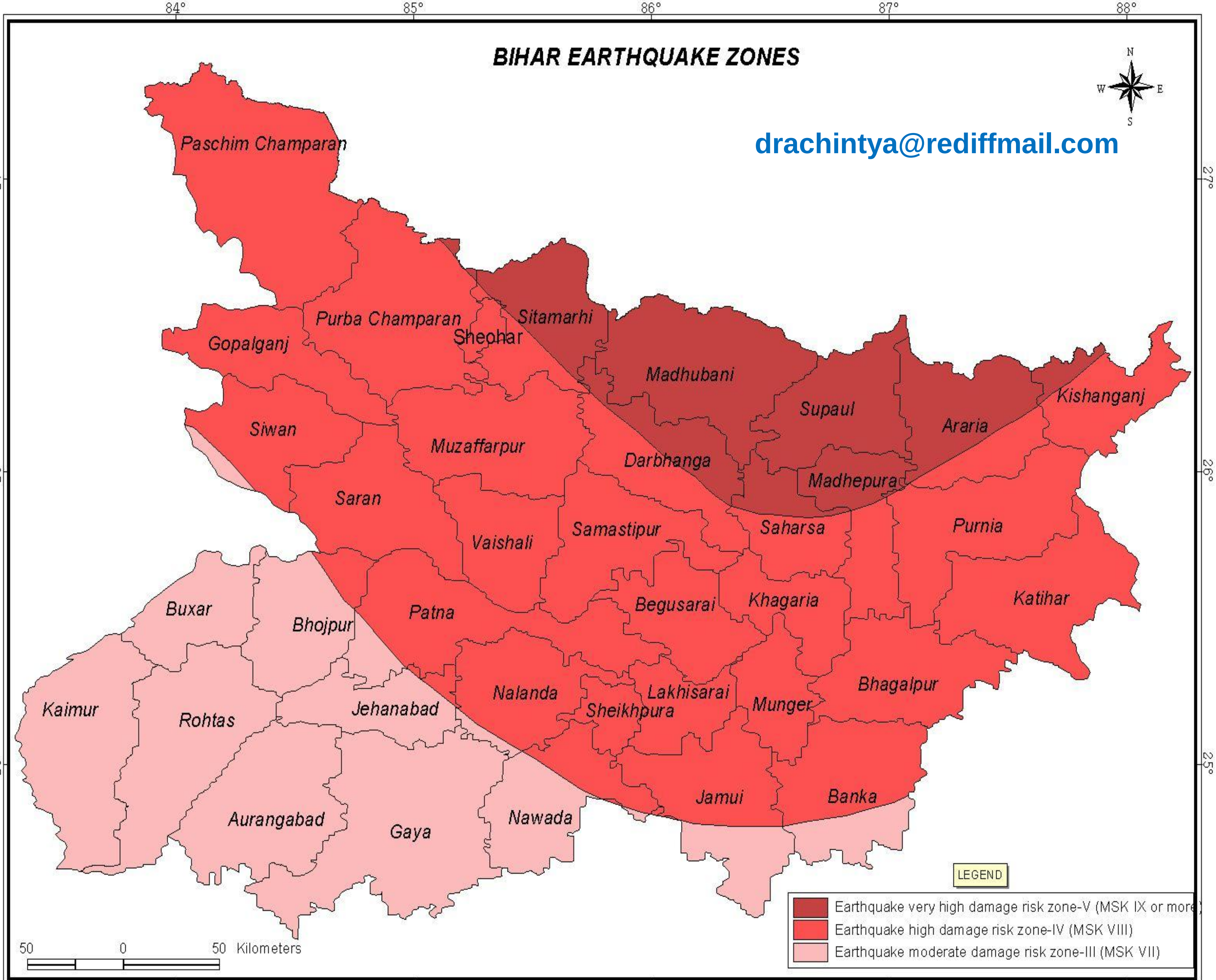

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- In India, the northern region of the Himalayas and its foot-hills fall under the most active seismic zone.
- Indian lore is full of references to earthquakes since the dim dawn of history. In this decade, i.e. from 1991 to 2001, India has experienced several devastating earthquakes.

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- On October 20, 1991, Uttarkashi in Garhwal Hills of the Himalayas witnessed the nightmare of the earthquake of magnitude 6.6.
- Just after couple of years, Latur in Maharashtra had experienced a major earthquake of magnitude 6.3 on September 30, 1993. The earthquake of magnitude 6.0 took place at Jabalpur on May 22, 1997.
- **And the most recent earthquake of Bhuj in Gujarat on January 26, 2001 was so massive that it defies all imagination. It was of magnitude 7.5 on Richter scale. The Kutch and Saurashtra regions were said to be the most affected. Some photographs depicting effect of Bhuj earthquale are shown in the following few slides.**

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GROUND RUPTURE NEAR THE EPICENTRE

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LIQUEFACTION
BHUJ EARTHQUAKE (26.1.01)

BACHAU

PREFAB
SCHOOL
KUKMA

Apollo APT.
AHMEDABAD

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Effects of Ground Rupture near Epicentre of BHUJ Earthquake


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TAPAR TOWN

ADHOI (45 km)

$a_c = 0.62g$

BACHAU

(11km)

Tilted Buildings

Yawing Motion


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BHUJ (66km)

GANDHINAGAR

MANFERA TOWN

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KANDLA PORT (53km) NANALAKHIA(100km)

- **And in the Context of Bihar, the earthquake is the most FATAL non-recurrent disaster.**
- The great alluvial trough of the Ganga is a tectonic one and the changes at the bottom of this trough still appear to be taking place, resulting in earth tremors of low or high magnitude. **The Bihar earthquakes of 1833, 1934 and 1988 had their origin in this very trough.**

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- Incidentally, the great Indian epic, the Ramayan, inadvertently deals with the geophysical nature of this particular region of Bihar and bordering Nepal even during the very very long past.
- According to the Ramayan, Lady Sita, wife of Lord Ram, prayed to the mother earth to yield space so as to engulf her for her eternal departure.

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- **The earth then shook and some tremors took place resulting in fracture of the floors, etc. and Lady Sita went within the earth.**
- Though the whole story was crafted long long ago and is still being remembered from religious point of view; yet it cannot be ignored that at the time of Lady Sita's eternal departure, the shaking of the earth and sufficient fracture to accommodate her within the earth **suggests some sort of earth tremor.**

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- During the post-earthquake investigation, one often observes that the damage varies from total destruction to only minor effects and included to varying degrees such as partially or completely damaged walls, broken windows, uprooted roofs, downed transmission poles, etc.
- **Difference in the degree of damage to the structures is primarily due to the quality of construction and the lack of continuity and redundancy in the structural system.**

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Earthquake causes shaking of the ground. So a building resting on it will experience motion at its base.

In the building, since the walls or columns are flexible, the motion of the roof is different from that of the ground (Figure 1).

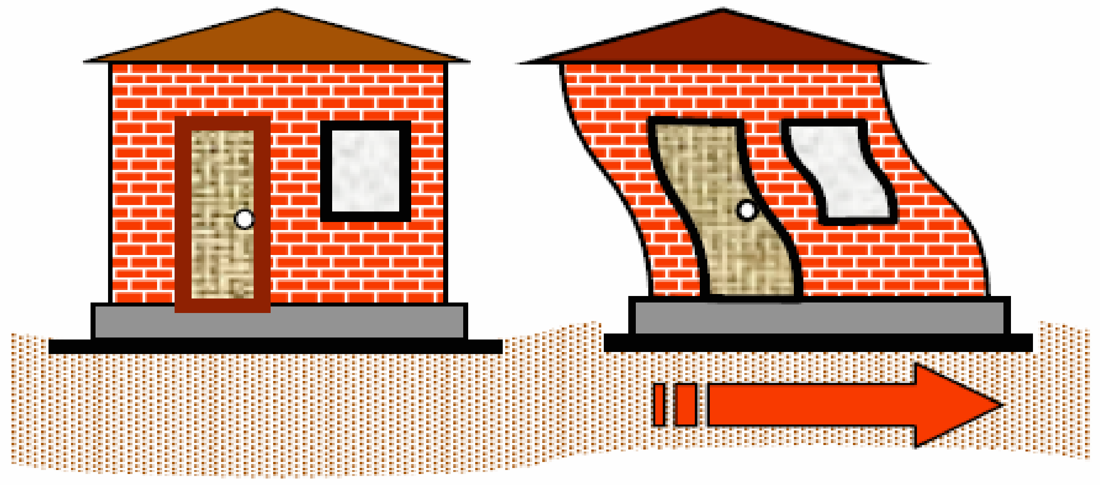

Figure 1: Effect of Inertia in a building when shaken at its base

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In Figure 2, this movement is shown as quantity **u between the roof and the ground**. But, given a free option, columns would like to come back to the straight vertical position, *i.e., columns resist deformations.*

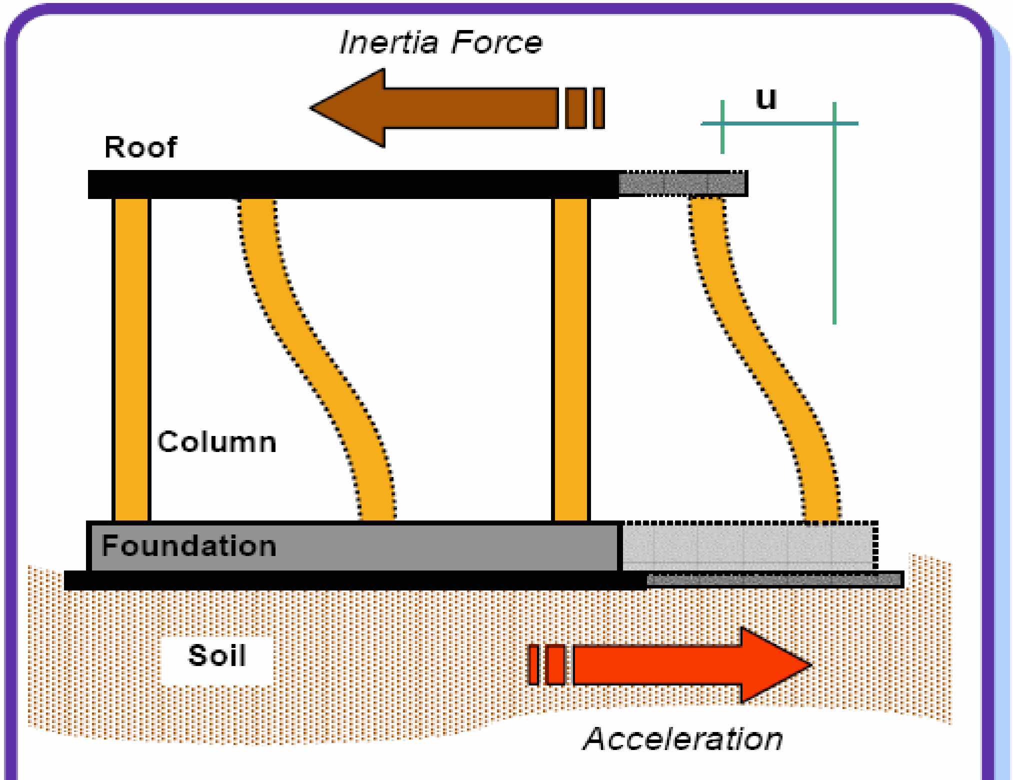

Figure 2: Inertia force and relative motion within a building

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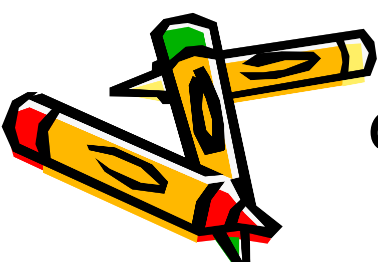
- Most of the post-earthquake studies from the 1988-Bihar earthquake, 1991-Uttarkashi earthquake, 1993-Latur earthquake and 2001-Bhuj and Ahmedabad earthquake have repeatedly pointed out that **the damage from these earthquakes** has primarily been caused by lack of earthquake resistant design and construction rather than the severity of earthquakes.
- ➢ This is because most of the construction of buildings has progressed on the Rule of Thumb.



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- The common damage patterns result from one or combination of the following:
- Lack of understanding of interactions between structures and forces due to earthquake.
- Inadequate design and/or inefficient construction practice.
- Deficiency in the building codes or standards.
- Seismic forces exceeding that provided in design codes.

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MITIGATION MEASURES

- The earthquake resistance of buildings considerably depends on their structural systems.
- It is, therefore, required to pay careful attention while designing a mixed structural system composed of structural elements and materials having significantly different mechanical properties.

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A non-separating and tight fit interface condition between filler walls and boundary frame may be achieved with some additional constructional efforts as follows:

- By the application of good quality and high strength mortar.
- By minimizing the initial lack of fit between brick masonry infill and frame due to vertical shrinkage of masonry.
- By ensuring water-absorbent quality of bricks.
- By anchoring of reinforcement of frame inside the filler walls.
- By simultaneous construction of frame and filler walls using filler walls as part of shuttering.

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In view of the fact that seismic zones IV and V are zones of intense seismic intensity as defined in the code IS : 1893 – 2016 (Part 1), the following earthquake strengthening measures should be adopted in design and construction of buildings:

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- *Columns, the vertical members in RC buildings,* contain two types of steel reinforcement, namely:
- (a) long straight bars (called *longitudinal bars) placed* vertically along the length, and
- (b) closed loops of smaller diameter steel bars (called transverse *ties)* placed horizontally at regular intervals along its full length (Figure 1).

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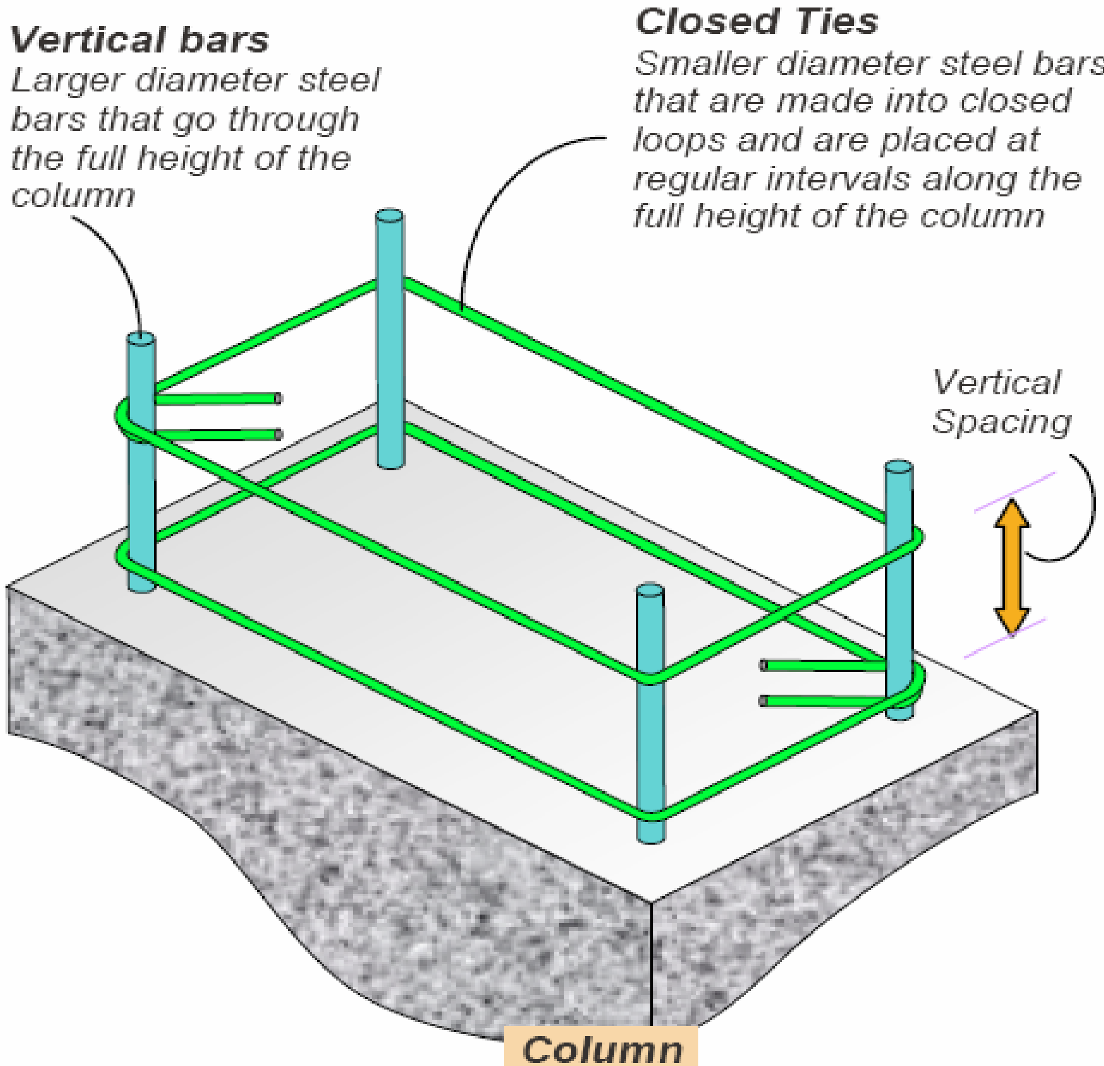

Figure 1: Steel reinforcement in columns – ***closed ties at close spacing improve the performance of columns under strong earthquake shaking.***

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- The ends of the ties must be bent as 135° hooks (Figure 2).
- Such hook ends prevent opening of loops and consequently buckling of concrete and buckling of vertical bars.

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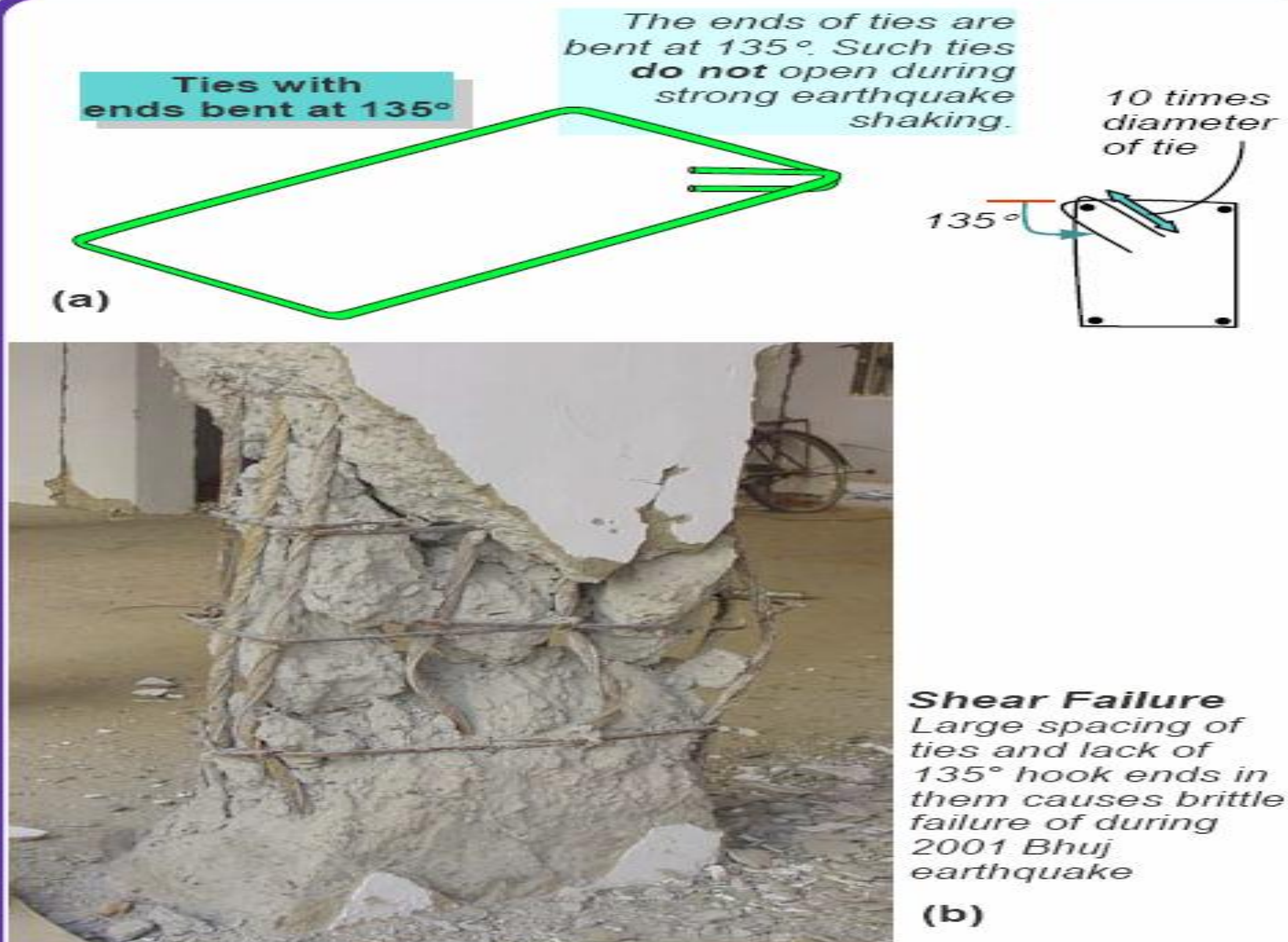

Figure 2: Steel reinforcement in seismic columns *– closed ties with 135° hooks are required as per Indian Ductile Detailing Code IS:13920-1993.*

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- Steel dowels are provided at sill and lintel levels at all junctions of walls.
- Openings are strengthened as per provisions of IS : 4326 – 1993 as shown in Fig. 3.
- All elements of earthquake resistant structure must be tied together to ensure box type action.

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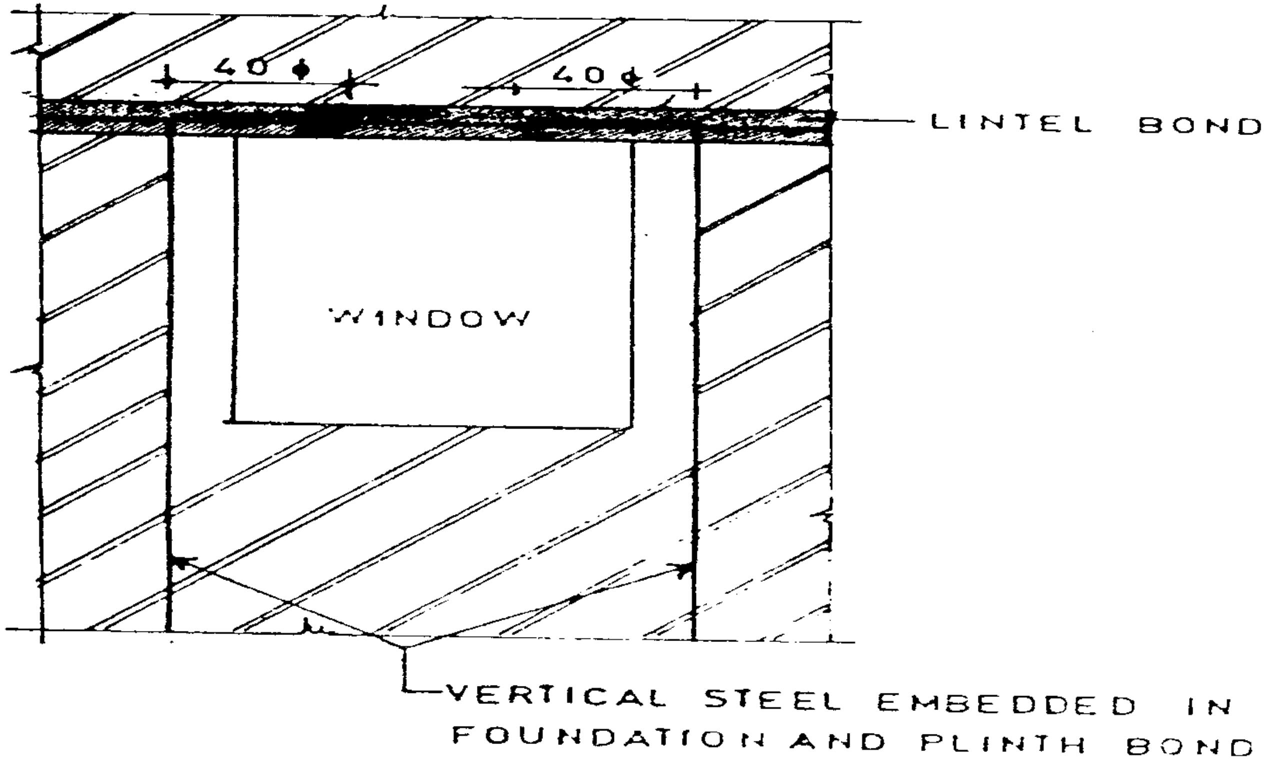

Fig.3 STRENGTHENING OF MASONRY AROUND OPENINGS

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Recommendations of mitigation measures for ameliorating the performance of constructed facilities during strong earthquake

- Institute deem-to-comply provisions in codes.
- Revise and update the codes of practices regularly. An International Code of Practice shall be formulated in coordination with different countries.

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- Provide code requirements for appropriate reinforcement, anchorage, bracing and also connections in steel and timber structures.
- Inspect ongoing construction to ensure compliance with code requirements.
- Include code requirements for effective sections of the structural elements.

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- Adequately strengthen the unreinforced masonry structures vulnerable to earthquake as per the provisions of codes.
- Try to keep symmetry of the structures with the centre of gravity as near the ground as possible and as centrally as possible in plans. If the symmetry is not achieved due to functional requirements, the different parts of the same structure should be separated from one another with crumple portions.

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- **Assess the workmanship and materials incorporated in the structure. The locally available building materials should be evaluated properly for the type of construction most suited for the local conditions.**
- **Develop guidelines for the inspection, checking and improvement of existing buildings with regards to earthquake by retrofitting.**
- **Either bury or design all future life-line installations to resist earthquake forces.**

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- Initiate review of all schools and other public buildings as evacuation centres.
- Keep trees and shrubs along the right-of-way utility distribution system trimmed.
- Offer proper training to engineers, architects, building officials and builders with regards to the effects of the intense to moderate earthquakes.

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- The implementation of these recommendations will better ensure earthquake resistant structures that facilitate mitigation of damage to constructed facilities.
- Some of these provisions in one form or another should be addressed by the authorities responsible for the development of housing and building technology.

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CONCLUSION

- Natural Disaster such as EARTHQUAKE has been occurring since the history of the civilization.
- Earthquake is the only natural disaster which is unpredictable.
- Earthquake cannot be prevented but their effects can certainly be mitigated.

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- Construction and maintenance of constructed facilities falling in the earthquake zones need investigation, planning, provisions and manning of special facilities for timely mitigation of such disasters, their nature, degree of severity and exact location.
- A knowledge of the design and construction methods for structures to withstand seismic forces is available but its IMPLEMENTATION needs to be made more effective.

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- If the structures are built adequately to withstand the fatal forces created by the disasters, the damages could be minimized.
- Great benefits could be derived by improving public awareness and organising disaster preparedness and management.

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- **Last but not the least**,

the accountability

should be devolved on every citizen

to adopt earthquake mitigation

measures such that

constructed facilities will not be subjected to undue danger

as far as human and material safety are concerned.

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THANK YOU

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