बिहार सरकार

बिहार राज्य आपदा प्रबंधन प्राधिकरण

(आपदा प्रबंधन विभाग)

पंत भवन, द्वितीय तल, पटना–1

बिहार सरकार

# Training of

# Engineer in Chief, Chief Engineer and Superintending Engineer

## On

# Earthquake Resistant Buildings

# Reading Material

# (Presentations)

# INDEX

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# (1)

# Disaster Management

## Disaster Damage Scenario

**50 min**

## आइये अब हम कुछ प्रश्नों पर विचार करें

- **आपदा प्रबंधन के शब्द Hazard, Vulnerability, Risk & and Disaster का क्या अर्थ हैं ?**
- **आपदा प्रबंधन क्या है ?**
- **आपदा जोखिम को कम कैसे करें ?**
- **आपदा प्रबंधन की चार मुख्य अवस्थाएं ?**
- **आपदा प्रबन्धन में चारों अवस्थाओं में अभियन्ताओं की क्या भूमिका है?**

## खतरा, संवेदनशीलता, जोखिम और आपदा
## (Hazard, Vulnerability, Risk & Disaster)

**Hazard** प्राकृतिक / मानव जनित घटना हैं। यह हानि पहुँचा सकती हैं।

**RISK**

अशिक्षा, गरीबी एवं संरचना असुरक्षा के कारण, लोग खतरों से **Vulnerable** बन जाते हैं।

खतरा घटित होने पर, जीवन और आधारभूत ढाँचे के विनाश के कारण, **Disaster** आ जाता हैं। क्षतिपूर्ति के लिये बाहरी सहायता की आवश्यकता पड़ती है।

## खतरा (Hazard)

खतरा किसी समय की एवं किसी क्षेत्र की वस्तुस्थिति या घटना है। यह हानि पहुँचा सकता हैं। खतरा आपदा में परिवर्तित हो सकता है। यह प्राकृतिक या मानव जनित हो सकता है।





**प्राकृतिक खतरे**








**मानवजनित खतरे**




## प्राकृतिक खतरों में वृद्धि







## प्राकृतिक खतरों में वृद्धि के कारण






## किसी व्यक्ति या समुदाय की भेद्यता (Vulnerability)

खतरा के दुष्परिणाम का पूर्वानुमान नहीं कर पाना, अथवा बचने या सामना करने में असमर्थ होना, और इसके आघात से संभलने की क्षमता नहीं होना।

भेद्यता का आकलन ➡ सम्भावित नुकसान

## भेद्यता (Vulnerability)

अशिक्षा, गरीबी, स्वीकार्य जीवन पद्धति

- खतरनाक क्षेत्र में सघन आबादी
- नरम मिट्टी पर मकान एवं संरचनाएं
- आपदाओं में असुरक्षित घर
- शहरों में अनियोजित एवं सघन वास
- अपर्याप्त चिकित्सा एवं स्वच्छता
- सामाजिक वातावरण में नाजुकता
- खतरों की जानकारी का अभाव
- समुदायिक सहयोग का अभाव
- आपदारोधी बजट पर दबाव

## क्षमता (Capacity)

- जोखिम न्यूनीकरण में सहायक उपलब्ध संसाधन
- पर्याप्त क्षमता भेद्यता को कम कर देती है।

- नीतिनिर्धारण, सक्रिय संस्थान, एवं साधन।
- भौतिक, तकनीकी एवं आर्थिक संसाधन।
- प्रशिक्षित मानव संसाधन तथा प्रौद्योगिक विकास।
- सामुदायिक जागरूकता, सहयोग व भागीदारी।
- आजीविका के वैकल्पिक उपाय।
- पूर्व चेतावनी हेतु प्रशिक्षित हितधारक।

## आपदा जोखिम (Risk)
## संभावित क्षति एवं नुकसान

- जीवनों का संभावित नुकसान
- संभावित घायलों की संख्या
- संरचनाओं/सम्पत्ति के संभावित क्षति की मात्रा
- आर्थिक काम–काज, सामाजिक व्यवस्था एवं पर्यावरण में संभावित विघटन का परिमाण

## आपदा जोखिम (Disaster Risk)

**खतरों को आपदा में परिवर्तित होकर क्षति पहुँचाने की सम्भावना।**

आपदा जोखिम = खतरा (Intensity, Extent, Timing) X संवेदनशीलत (Weak Buildings, Vulnerable area, Poverty) / क्षमता (Available & Potential resources)

**Evaluation of DR**

- Number of Deaths and Injured
- Loss on Damaged buildings and Property
- Loss of Economic Activities

प्राकृतिक खतरों में वृद्धि

सामाजिक वातावरण में बदलाव

→ जोखिम (Risk) में वृद्धि

## आपदा जोखिम न्यूनीकरण (DRR)

**खतरों की समझ**
खतरा मानचित्र, भूकम्प जोन मैप

**संवेदनशीलता विश्लेषण**
उम्र, विकलांग, गरीबी, कमज़ोर मकान

**क्षमता–बर्द्धन**
आपदा से निपटने/उबरने के साधन/शक्ति
संरचनात्मक एवं सामाजिक संसाधनों का सूची
समुदाय की जागरूकता व भागीदारी

## आपदा

- किसी क्षेत्र में या किसी जगह पर, जोखिम अथवा दुर्घटना या लापरवाही से, आपदा प्रकट हो सकती है।
- यह महाविपत्ति एव गहरे संकट की स्थिति है।
- आपदा में जान का भारी नुकसान या अतिशय मानवीय पीड़ा या सम्पत्ति की क्षति एवं नुकसान या पर्यावरण की क्षति एवं क्षरण हो सकता है।
- आपदा का सामना करने एवं संभलने के लिये बाहरी सहायता की आवश्यकता पड़ती है।

## आपदा प्रबन्धन : समाज के विभिन्न समूहों द्वारा

**आपदा से पहले**

- ✓ जोखिम न्यूनीकरण
- ✓ रोकथाम, तैयारी

**आपदा के बाद**

- ✓ राहत, बचाव
- ✓ पुनर्वास, पुनरूद्धार

आपदा क्षति से पूर्णतया बचा नहीं जा सकता; परन्तु उपयुक्त प्रबन्धन तकनीकि द्वारा, इसके आघात को काफी दुर्बल बनाया जा सकता है।

## आपदा प्रबंधन की चार मुख्य अवस्थाएं

**Mitigation :** जोखिम का आकलन, रोकथाम संरचात्मक एवं गैर–संरचनात्मक शमन, क्षमतावर्द्धन।

**Preparedness :** आपदा पूर्व तैयारी, चेतावनी।

**Response :** राहत और बचाव, क्षति मूल्यांकन।

**Recovery :** पुनर्वास, पुनर्निर्माण, पुनरुत्थान, सामान्य जीवन की प्राप्ति। (BBB)


## आपदा प्रबन्धन में अभियन्ताओं की भूमिका

प्राकृतिक आपदा ↕ अभियन्ता

आपदा बिगाड़ती है; अभियंता बनाते हैं।

सरकारों में आपदा प्रबन्धन की स्पष्ट नीति है, जबकि, उपयुक्त तकनीकि के द्वारा, क्रियान्वयन की कामयाबी अभियंताओं के हाथ मे है।

बचाव प्रक्रिया का संचालन


सामुदायिक आश्रय एवं टायलेट का निर्माण

पीने का पानी

**Normally, engineers are field workers.**

## Response:

राहत एवं जबाबी कार्रवाई के दौरान

अनिवार्य सेवाओं की पुनः शुरूआत


सुरक्षित/ असुरक्षित संरचनाओं को छॉटना

## Recovery :

पुनर्वास और सामान्य जीवन प्राप्ति के दौरान

संरचनाओं का पुनर्निर्माण / सुदृढ़ीकरण

स्थायी आवास निर्माण

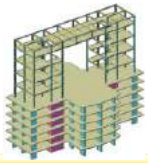
क्षतिग्रस्त आधारभूत संरचनाओं का पुनर्निर्माण / सुदृढ़ीकरण

आश्रय पुनर्निर्माण / सुदृढ़ीकरण में तकनीकी सहायता।

आजीविका पुनरुत्थान में सहायता

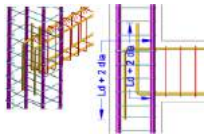
## Mitigation :

आपदा न्यूनीकरण के दौरान



नवीनतम इंजीनियरी तकनीकि का ज्ञानअर्जन एवं उपयोग

सुरक्षित संरचनाओ का निर्माण



संरचनाओं में **Ductility** प्राप्त करने में सक्रिय होना

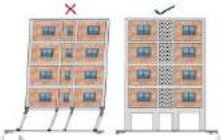
जोखिम क्षेत्रों की पहचान, भूमि उपयोग की योजना

सुरक्षित इंजीनियरिंग तकनीकि को फैलाना

## Preparedness :

वर्तमान संरचनाओं का मूल्यांकन एवं सुदृढ़ीकरण

**DAMAGE GRADE G1, G2, G3, G4,G5**



वर्तमान संरचनाओं का फोरेंसिक आकलन।

वर्तमान संरचनाओ का सुदृढ़ीकरण।

असुरक्षित संरचना पर चेतावनी देना।

असुरक्षित बसावट पर जागरूक करना।

आपदा पूर्व तैयारी की गतिविधियों में शरीक होना।

सभी प्रकार के निर्माण आपदारोधी बने, यह सुनिश्चित करना, अभियंताओं की प्राथमिक जिम्मेवारी है।

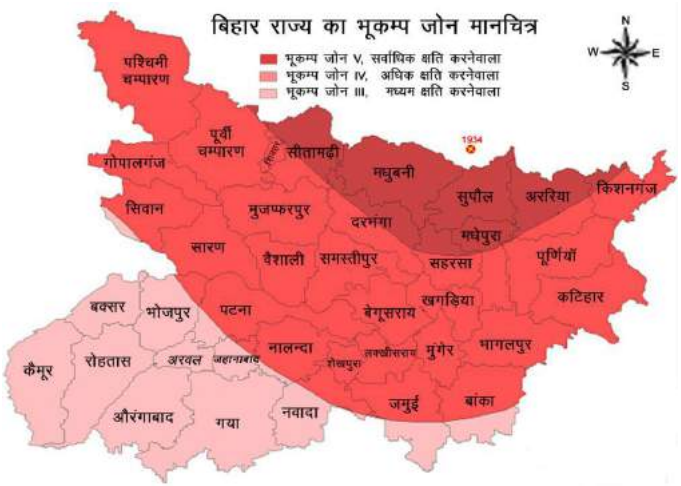
आपदा प्रबन्धन में, उपयुक्त तकनीक के उपयोग की विशिष्ट जानकारी वाले, कुशल अभियन्ता की माँग हमेशा बनी रहेगी।

हमें सशक्त होकर और मिलकर आगे बढ़ना है।

# Damage Scenario under Re-occurrence of Major Earthquake at Bihar-Nepal Border

## हम कुछ प्रश्नों पर विचार करें

- बिहार के कौन से जिले किस भूकंप जोन में हैं ?
- बिहार को प्रभावित करनेवाले विगत बड़े भूकम्प ?
- विगत भूकंपों में हुई क्षति का परिदृश्य ?
- बिहार में सम्भावित भूकम्प के प्रभाव क्या होंगे ?
- भूकम्प प्रबंधन में क्या–क्या त्रुटियां हैं ?



बिहार को प्रभावित करनेवाले विगत बड़े भूकम्प

26 अक्टूबर 1833, शाम 5.30 से 8 बजे, M 7.5 - 8

- भूकम्प केन्द्र : नेपाल में, सीमा से 100 कि.मी. पर
- नेपाल में 414 लोग मारे गये
- मुजफ्फरपुर, मुंगेर एवं अन्य जगहों पर भवन ढ़हे / क्षतिग्रस्त हुए

15 जनवरी 1934, दोपहर 2.13 बजे, M8.4

- भूकम्प केन्द्र : नेपाल में, सीमा के पास
- नेपाल में 8519 लोग एवं भारत में 7,153 लोग मारे गये
- मुंगेर एवं भटगॉव बर्बाद, नेपाल सीमा से सटे जिलों में भीषण क्षति

21 अगस्त 1988, सुबह 4.39 बजे, M6.6

- भूकम्प केन्द्र की दूरी : नेपाल में, सीमा के पास
- बिहार में 282 लोग मारे गये एवं 3,766 लोग आहत हुए
- बिहार में 25,093 भवन ध्वस्त एवं 1,24,241 भवन क्षतिग्रस्त

25 अप्रील 2015, सुबह 11.41 बजे, M 7.8

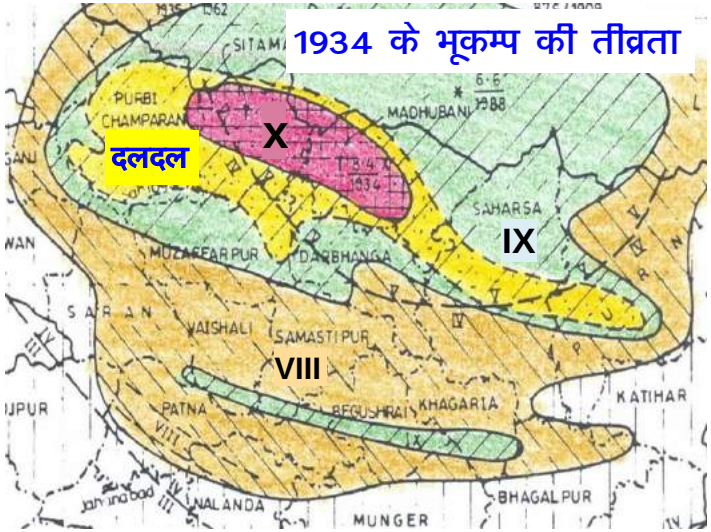
- भूकम्प केन्द्र : नेपाल में, काठमाण्डू से 80 कि.मी. उत्तर पश्चिम
- नेपाल में करीब 7000 लोग मारे गये और भारत में 78
- नेपाल में लाखों भवन ध्वस्त हो गये।
- नेपाल में भरतपुर, काठमाण्डू में सभी मुख्य धरोहर संरचना बर्बाद हो गया।

## 1833 Bihar-Nepal earthquake

- **A violent Earthquake which shaked Eastern India and Nepal.**
- **Epicenter was 100 km north of Indian border, inside Nepal.**
- **Widespread damage occurred in Nepal.**
- **1.2 m deep water was thrown out of tanks, at Muzaffarpur**
- **A Chasm of considerable size was formed in the earth at Chapra.**
- **No loss of life was reported in India.**

## 1934 Bihar-Nepal earthquake

- **One of the most violent earthquakes.**
- **Large parts of the cities of Motihari, Muzaffarpur and Darbhanga and, Patan and Kathmandu the numerous villages in between were destroyed.**
- **In Sitamarhi, Madhubani and Purnia houses had greatly tilted and sank into the ground.**
- **In Purnia 95 percent houses became uninhabitable including 50 percent destroyed.**
- **The towns of Patna, Barh and Jamalpur were severely damaged including damage to roads.**
- **Severe damage was seen along river banks and low lying water logged areas near river banks.**



1934 के भूकम्प में मुंगेर में क्षति

1934 के भूकम्प में क्षतिग्रस्त पुल

1934 के भूकम्प में क्षतिग्रस्त रेल–लाईन

## 1988 Bihar-Nepal earthquake

- **Earthquake occurred in monsoon season when the areas in north Bihar were under floods.**
- **Most of the damaged houses were of unburnt or burnt brick masonry in Bihar.**
- **The worst affected Districts in Bihar were Darbhanga, Madhubani, Saharsa and Munger.**
- **Large scale liquefaction took place but to a much smaller extent than that in 1934.**
- **Energy released in M 8.4 of 1934 was about 750 times of the energy released in M 6.6 of 1988.**

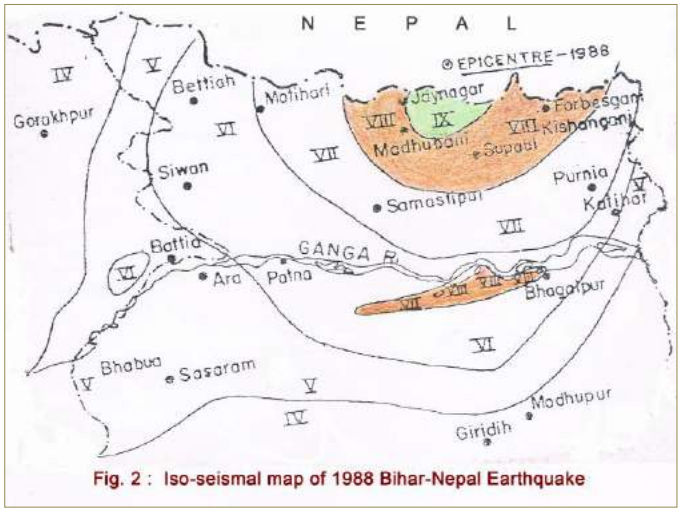


Fig. 2 : Iso-seismal map of 1988 Bihar-Nepal Earthquake

## 25 APRIL 2015 NEPAL EARTHQUAKE

- **Main shock: 20 seconds, 7.8 M, depth around 15 km, 80 km northwest of Kathmandu.**
- **Tremors were felt from Assam to New Delhi and to Andhra Pradesh, Gujarat and Karnataka in south.**
- **A 2nd EQ 6.6 M occurred 65 km east of Kathmandu at 10 km depth, after 33 minutes of the main quake.**
- **Over thirty-five aftershocks of magnitude 4.5 M or greater occurred in the following days.**
- **Scientists think that earthquakes of 7.8 M can't release all of the strain between India and Asia plates. History suggests that most of the stored energy gets uncorked only by a handful of 8 M quakes, or one 9 M quake.**

## 25 APRIL 2015 NEPAL EARTHQUAKE

- **The earthquake was caused by a slip along the Main Frontal Thrust.**
- **Kathmandu, situated on a block of crust approximately 120 km wide and 60 km long, shifted 3 m to the south in just 30 seconds.**
- **The earthquake's effects were amplified in Kathmandu which sits on 600 m of sedimentary rocks infilling of a lake.**
- **In Nepal, Many Heritage structures collapsed, Hundreds and Thousands of buildings destroyed.**
- **Many buildings were brought down in Bihar. The intensity in Patna was V.**

**A Remote hill town of Barpak**

**Ground Failure**

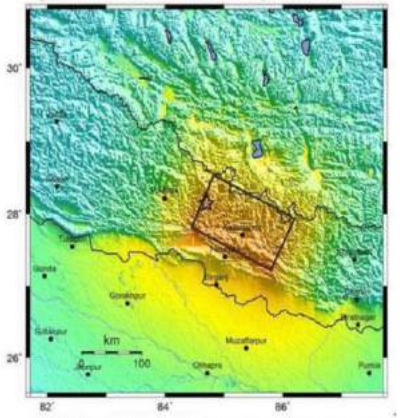
**Collapsed houses in Madhubani, Bihar**

**Shaking Intensity**

The Modified Mercalli Intensity (MMI) scale depicts shaking severity. The area nearest Katmandu experienced very strong to severe shaking.

| Modified Mercalli Intensity | Perceived Shaking |
|---|---|
| X | Extreme |
| IX | Violent |
| VIII | Severe |
| VII | Very Strong |
| VI | Strong |
| V | Moderate |
| IV | Light |
| II-III | Weak |
| I | Not Felt |

*Image courtesy of the US Geological Survey*




*USGS Estimated shaking Intensity from M 7.8 Earthquake*

## बिहार में भूकम्प के सम्भावित प्रभाव

- **Ground Failure and Liquefaction**
- **Ground Shaking: Damage in Buildings; Bridges, Flyovers, Railways, Water Towers and Treatment facilities, Pipelines, Electric Generating Facilities and Transformer Stations**
- **Secondary Effects: Fires, Chemical Spills, Communication facilities, Loss of Economic production etc.**

## भारी भूकम्प में हताहत

**HIGH RATE**

- घनी आबादी के इलाके
- कच्चे ईंट या मिट्टी से बने घर
- मिट्टी के मसाला वाले ईंट के घर (रात के भूकम्प में)
- स्कूल एवं सभास्थल (दिन के भूकम्प में)

बरबाद मकानों में, 6 से 18 प्रतिशत आवासी मारे जा सकते हैं और तीन गुने तक घायल हो सकते हैं।

**LOW RATE**

बाँस या लकड़ी के बने हल्के मकान

## 1934 भूकम्प तीव्रता की काल्पनिक पुनरावृति

**(As per publication of BSDMA)**

- मानव जीवन की हानि की सम्भावित संख्या
  - मध्य रात्रि में भूकम्पनः 2 लाख से ज्यादा
  - दोपहर में भूकम्पनः 70 हजार से ज्यादा
- सम्भावित पुनर्निमाण : 45 लाख से ज्यादा
  (जनगणना घरों का 20 प्रतिशत)
- सम्भावित मरम्मति : 1 करोड़ से ज्यादा
  (जनगणना घरों का 45 प्रतिशत)

## Gaps in the Management of Earthquakes

- **Lack of adequate skilled knowledge** on seismic risk, vulnerability and structural mitigation activities among various stakeholders;
- **Lack of adequate preparedness and response capacity** among various stakeholder groups;
- **Inadequate attention to structural mitigation measures in the education syllabi** of professional and vocational education;
- **Inadequate monitoring and enforcement** of earthquake-resistant building codes and town planning bye-laws;
- **Absence of systems of licensing** of engineers and masons;
- **Low public awareness** on the need for incorporating earthquake-resistant features in non-engineered construction in suburban and rural areas;
- **BIS Codes** are not in the Public Domain.

# धन्यवाद

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

# (2a)

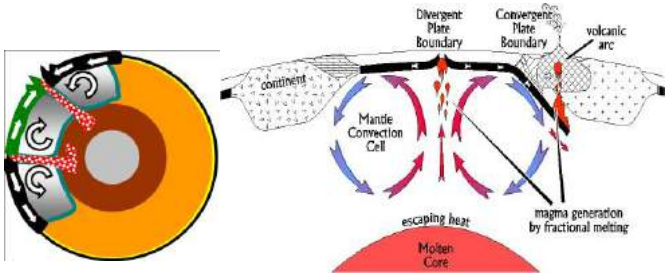
# ENGINEERING SEISMOLOGY

# SEISMIC HAZARDS

40 min

## CONVECTION CURRENTS IN VISCOUS MANTLE

- **Radioactive Elements Decay in Core.**
- **Enormous heat is generated.**
- **गर्म लावा का उपर उठना एवं चट्टानों का नीचे जाकर गलना।**
- **Convection currents in Mantle.**
- **Movement of Crust & Mantle plates (Tectonic Plate)**




## TECTONIC PLATES

**Mantle** के **convection currents** के कारण, **Crust** एवं **Mantle** का कुछ भाग **(lithosphere)**, धीमी गति से सरकते रहते हैं, इसे **Tectonic Plate** कहते हैं।

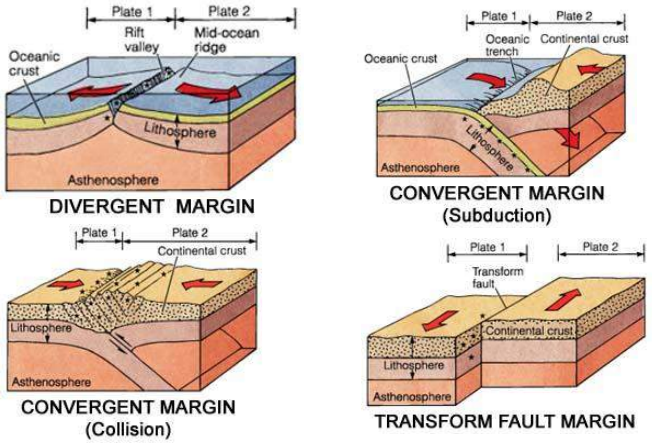
धरती का सतह करीब 70 कि.मी. मोटे सात विशाल **Tectonic Plate** एवं कुछ छोटे प्लेटों से बना है।

ये प्लेट विभिन्न दिशाओं में विभिन्न स्पीड से चलायमान हैं। औसतन एक वर्ष में **10 cm** के आसपास विचलन होता है।

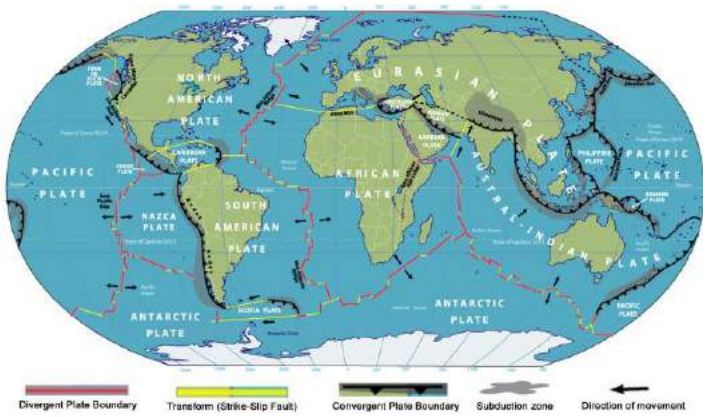
ज्यादातर, **Tectonic Plate** की सीमा पर भूकम्प आता है।

जब दो प्लेट ढ़केलती है, तो पहाड़ बनता है; जब एक दूसरे से दूर जाती है, तो दरार बनता है; जब अगल–बगल चलती है, तो सतह परिवर्तित हो जाता है।

## टेक्टोनिक प्लेट का विचलन

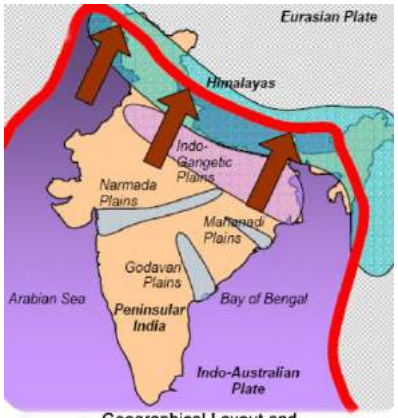


## TECTONIC PLATES




## हिमालय में भूकम्प

**Main Central Thrust, Main Boundary Thrust एवं Main Frontal Thrust जैसे विशाल faults के चलते हिमालय में विनाशकारी भूकम्प आते हैं।**



Geographical Layout and Tectonic Plate Boundaries in India

## ELASTIC REBOUND THEORY

**Brittle चट्टान elastic material से बने है।**

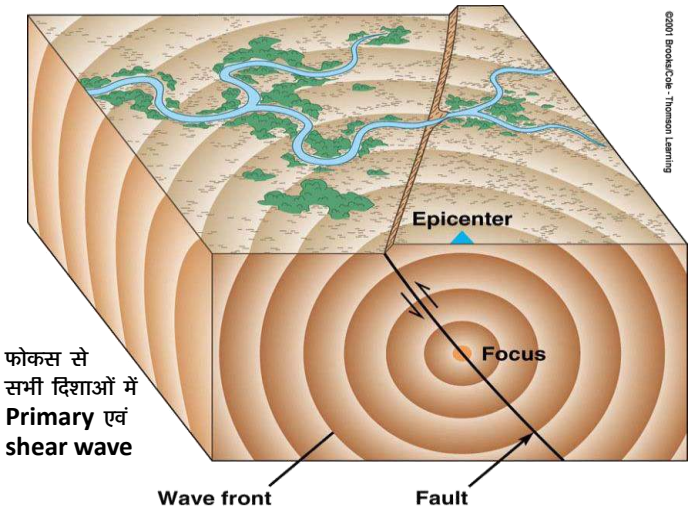
**Tectonic plate** के चलन से **Lithosphere** के चट्टान में **stain energy** का संचयन

भूकम्प तरंग **/ shock wave** के रूप में, सभी दिशाओं में, उर्जा का **radiation**

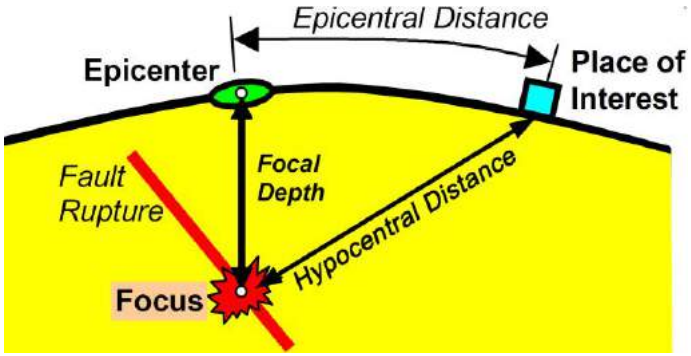
**Crushing strength** तक **stain** पहुचने पर अचानक चट्टान का टूटना

**Fault** के दोनों सतह विपरीत दिशा में विचलन एवं संचयित **srain** उर्जा की मुक्ति

हम सदा दो भूकम्पों के बीच हैं।




फोकस से सभी दिशाओं में **Primary** एवं **shear wave**



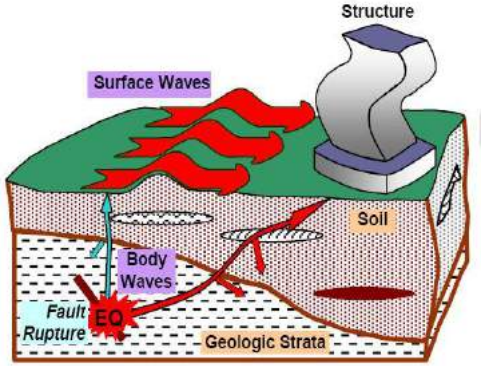

**FOCUS / HYPOCENTER**

धरती के अंदर, जहाँ चट्टान में विस्फोट के कारण भूकंप उत्पन्न हुआ।

**EPICENTER:**

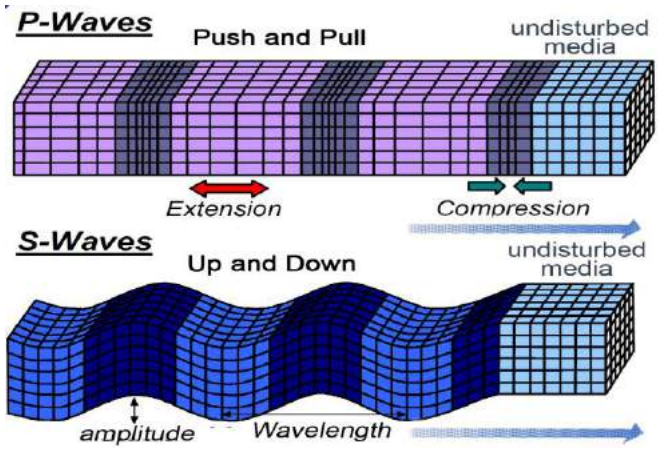
फोकस के सीधे उपर, धरती के सतह पर का भौगोलिक स्थल।

- **Body Waves are generated by Fault rapture.**
  - **P-Wave (Longiludinal wave) : 3-8 km/sec**
  - **S-wave (Transverse wave) : 2-5 km/sec**

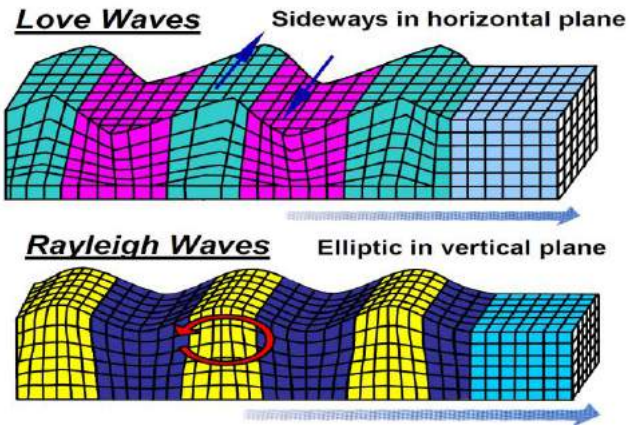



- **Surface waves are generated in epicentre area.**

## SEISMIC WAVES : BODY WAVES




## SEISMIC WAVES : SURFACE WAVES



सबसे पहले, **P-Wave** Vertically झटका देता है। वायुमंडल के संम्पर्क से, भूकम्प ध्वनि प्रकट होता है।

उसके बाद, **S-Wave** horizontal दिशा में भारी झटका देता है और भवनों का दोलन होने लगता है।

**Surface Waves** से, horizontal एवं Vertical दोलन होता है।

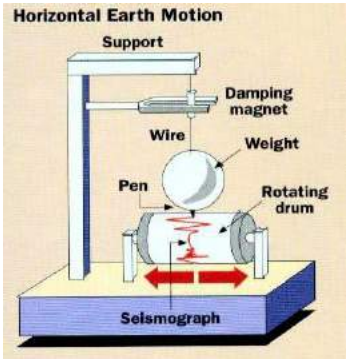
**S-Waves** एवं **Surface Waves** मिलकर सर्वाधिक क्षति पहुँचाती है।

धरती के अंदर की अपेक्षा सतह पर ज्यादा कम्पन होता है।

1956 में चीन में भूकम्प से 8 लाख लोग मर गये।

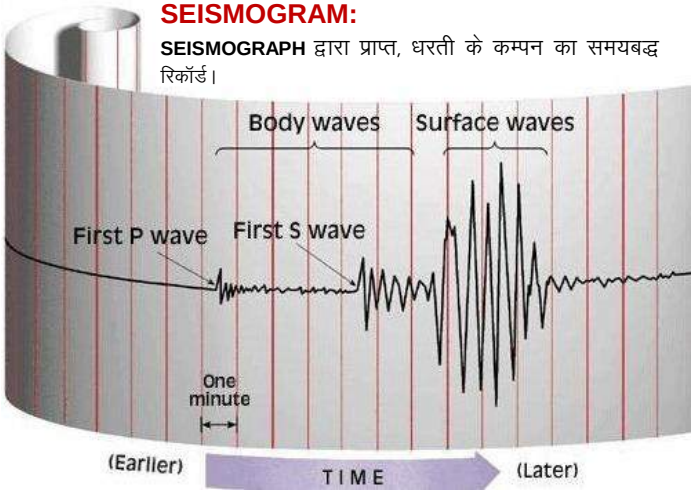
## Seismometer

भूकम्प के दौरान, किसी स्थल पर, धरती के सभी सम्भावित कम्पन वेग रिकॉर्ड करने वाला यंत्र। कागज से लपेटा हुआ ड्रम 15 मिनट में एक बार धुम जाता है और चौबीसों घंटे डाटा रिकॉर्ड करता है।




## SEISMOGRAM:

**SEISMOGRAPH** द्वारा प्राप्त, धरती के कम्पन का समयबद्ध रिकॉर्ड।




## MAGNITUDE SCALE

भूकम्प विस्फोट का आकार; उत्सर्जित **energy** का परिमाण।
**seismograph** के उपयोग द्वारा निर्धारित।

- **Charles Richter** द्वारा विकसित **magnitude scale 1** से **10** तक है। M3 से कम का भूकम्प हम महसूस नहीं करते।
- परिमाण स्केल **logrithmic** है। परिमाण में **1** की बढ़ोतरी से उत्सर्जित उर्जा 31 गुना तथा **wave amplitude** 10 गुना बढ़ जाती है।
- इस स्केल पर चिली में 1960 में M9.5 तक भूकम्प रिकॉर्ड किये गये हैं। 30.9.1993 को, महाराट्र के लातूर में, M6 के भूकम्प से 10000 मारे गये।
- बिहार के 1934 के भूकम्प M8.4 द्वारा उत्सर्जित उर्जा हिरोशीमा पर गिराये बम 4000 गुणा था।

| भूकम्प ग्रुप | Magnitude | औसत संख्या प्रति वर्ष |
|---|---|---|
| Great | 8 and higher | 0-1 |
| Major | 7 – 7.9 | 18 |
| Strong | 6 – 6.9 | 120 |
| Moderate | 5 – 5.9 | 800 |
| Light | 4 – 4.9 | 6,200 (estimated) |
| Minor | 3 – 3.9 | 49,000 (estimated) |
| Very Minor | < 3.0<br>M2-3:;<br>M1-2: | <br>~1,000/day<br>~8,000/day |

## INTENSITY SCALE

भवनों, स्थल आकृति एवं मानव पर भूकम्प झटकों के प्रभाव के आधार पर, किसी स्थल विशेष की भूकम्प तीव्रता का आकलन किया जाता है।

**Epicentre** क्षेत्र में अधिकतम तीव्रता रहती है और सभी दिशाओं में कम होती जाती है।

नियमानुसार, **MSK-scale** *(Medvedev-Sponheuer-Karnik)* पर रोमन अंक में, **I** से **XII** तक भूकम्प तीव्रता दर्शायी जाती है।

## MODIFIED MERCALLI SCALE OF INTENSITY

**I** Barely felt
**II** Felt by only few people
**III** Felt noticeably, standing autos rock slightly
**IV** Felt by many, windows and walls creak
**V** Felt by nearly everyone, some dished and windows broken
**VI** Felt by all, damaged plaster and chimneys
**VII** Damage to poorly constructed buildings
**VIII** Collapse of poorly constructed buildings, slight damage to well built structures
**IX** Considerable damage to well constructed buildings, buildings shifted off foundations
**X** Damage to well built wooden structures, some masonry buildings destroyed, train rails bent, landslides
**XI** Few masonry structure remain standing, bridges destroyed, ground fissures
**XII** Damage total

## INTENSITY OF SHAKING DEPENDS ON

- **Ground motion characteristics**
  - Magnitude of earthquake
  - Focal depth, mostly 10-100 km
  - Direction of fault rupture
  - Propagation path
  - Epicentral distance
  - Shear-wave velocity
  - Frequency of shaking
  - Aftershocks
- **Characteristics of soil**
  - Surface topography
  - Thickness of soil above the base rock
  - Soft sedimentary sites amplify
  - Density and elastic properties of soil
  - Liquefaction/ subsidence
  - Slope instabilities (landslides)
- **Characteristic of structures**
  - Type of building
  - Strong lateral discontinuity

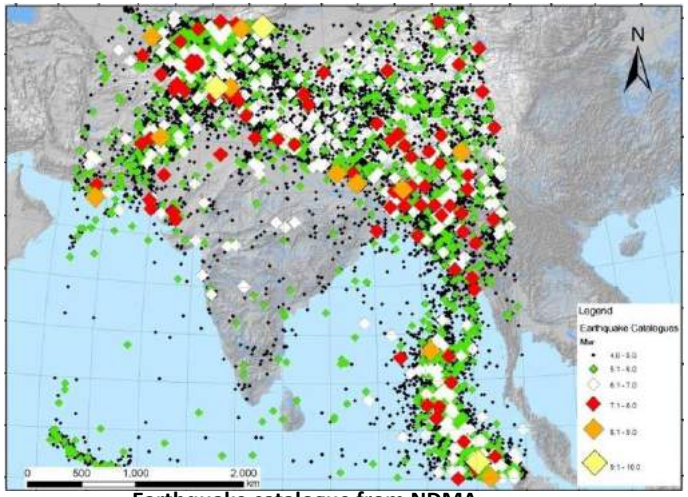
## SEISMIC HAZARDS

**PRIMARY HAZARDS**
- Fault displacement
- अचानक भूकम्पन

**SECONDARY HAZARDS**
- Ground failure
- Liquefaction
- भूस्खलन
- बाढ़, सुनामी
- आग लगना
- Chemical spills

**EARTHQUAKE DAMAGE**
- मानव निर्मित संरचनाऐं
- यातायात/संचार
- जीवनोपयोगी सेवाऐं
- भोजन सामग्री

**EEFFECTS**
- House collapse
- Inaccessibility
- Loss of property
- Casualties



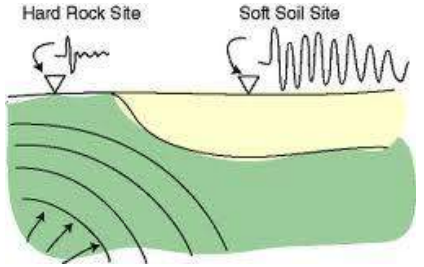
Earthquake catalogue from NDMA

## ENGINEERING SEISMOLOGY

**To estimate the parameters, seismologists need:**

- Catalogues of past Earthquakes
- Structure and properties of soil at the site
- Structure and properties of path between epicentre and the site
- Records of earthquakes near epicentral region
- Results of geological surveys

## SITE EFFECTS



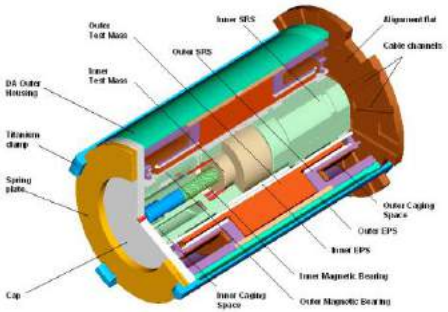

- Surface topography
- Thickness of soil above the base rock
- Soft sedimentary sites amplify
- Density and elastic properties of soil
- Liquefaction/ subsidence
- Slope instabilities (landslides)

## STRONG MOTION ACCELEROGRAPH

भारी भूकम्प के दौरान, **epicentral** क्षेत्र में, भूकम्पन द्वारा उत्पन्न भूत्वरण का **Time-History** रिकॉर्ड करने वाला यंत्र।

**Accelerograph is accelerometer & accelerogram**

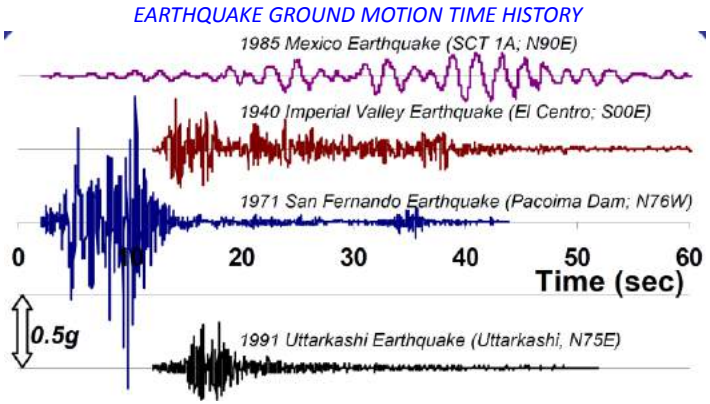
- भारी भूकम्प के **acceleration** के तीनों **component** को रिकॉर्ड करता है।
- भूकम्प के दौरान स्वचालित हो जाता है
- **Analog / digital** यंत्र लगाया जाता है।

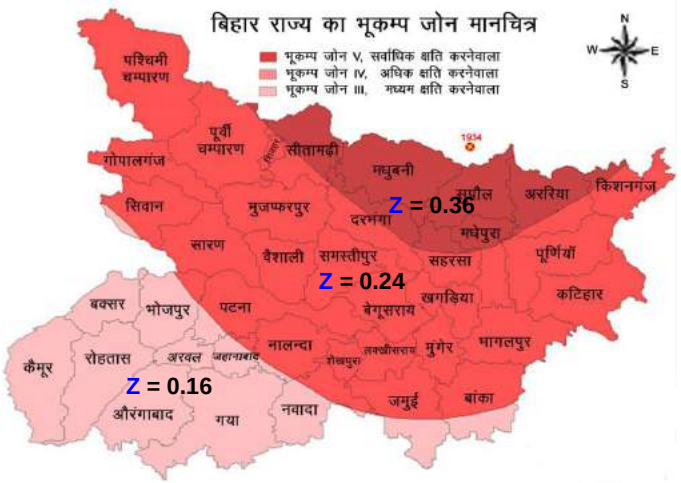


**ACCELEROGRAPH**

## ACCELEROGRAM:

**ACCELEROOGRAPH** द्वारा प्राप्त, भूकम्पन के **acceleration** का रिकॉर्ड।




**SEISMIC HAZARD INTENSITIES**

## SEISMIC MICROZONATION

**Estimates local site specific hazards likely to be caused by**

- **Local soil condition**
- **Topography**
- **Proximity to fault etc.**

***The quantifies of 'Ground Shaking' may be used for Seismic Regulation (Land use planning and design of critical facilities)***

## भूकम्प की भविष्यवाणी : कब? कहाँ? कितना?

सही समय, स्थान या विस्तार के लिहाज से (कब?),
अचानक fault के विचलन एवं भूकम्प की भविष्यवाणी,
अब तक सम्भव नहीं है।

- भूकम्प जोन मैप सापेक्षिक तीव्रता (कहाँ? कितना?) की जानकारी देता है।
- आनेवाले भूकम्प के आकार की जानकारी, ज्यादातर, विगत भूकम्प से मिलती है।
- **Seismologists** चट्टानों में दबाब का स्तर एवं नन्हें आघात के तरंग का अध्ययन करते रहते हैं।
- कुओं में जलस्तर, पॉक एवं बेतरतीब गैस निस्सरण के ठोस समुदायिक वैज्ञानिक अवलोकन का उपयोग सम्भव है।

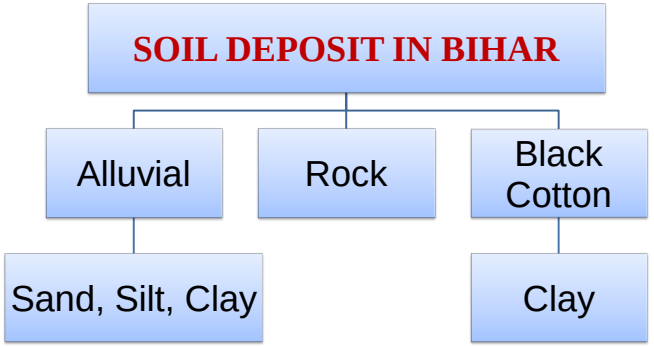
भूकम्प–आपदा न्यूनीकरण बेहतर विकल्प है।

# Thank You

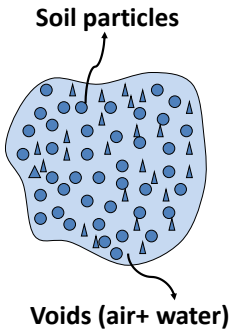
बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

# 2 (b)
# Ground failure, Soil liquefaction, Site Selection, Sub surface Investigations

40 min




## Property of soil as load bearing strata for foundations structures:




- Size of soil particles and their proportion
- Loose, medium, dense).
- dry, partial saturation, fully saturated
- Position of water table

## IS 1498:1970 Classification

| Classification | Symbol | Grain size |
|---|---|---|
| Gravel | G | 75mm – 4.75mm |
| Sand | S | 4.75mm – .075mm |
| Silt | M | .075mm-0.002mm |
| Clay | C | <0.002mm |

## Engineering Classification of Soils

**COHESIONLESS SOIL**

- GW – well graded gravel
- GP – poorly graded gravel
- GC – clayey gravel
- GM – silty gravel
- SW – well graded sand
- SP – poorly graded sand
- SM – silty sand
- SC – clayey sand

**COHESIVE SOILS**

- ML – silt with low plasticity
- CL – clay with low plasticity
- OL – organic silt & clay with low plasticity
- MI – silt with medium plasticity
- CI – clay with medium plasticity
- OI – organic silt/clay with medium plasticity
- MH – high plastic silt
- CH – high plastic clay
- OH – organic silt & clay of high plasticity

| Classification VS Strength | |
|---|---|
| SW | Good Bearing capacity |
| SP,SM,SC | Good to Poor Bearing capacity, susceptible to Liquefaction |
| CL,CI | Good to Poor Bearing capacity |
| MI,ML | Very poor ,susceptible to Liquefaction |
| MH,CH | Not suitable For Foundation |

## SOIL FAILURES due to GROUND SHAKING

Liquefaction

Ground Settlement

Surface fault rupture

Landslide

## PROBLEM : Why does building fail?

**Soil fails due to liquefaction**

Settlement about 1 m,

bulge in the road.

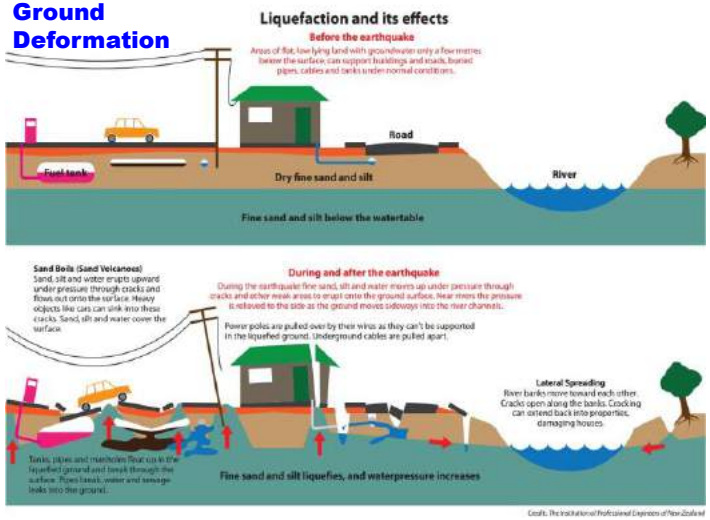
LIQUEFACTION NEAR A BUILDING AT KANDLA PORT;
ONLY MINOR CRACKS IN THE WALLS,
BUT SETTLED DOWN BY ABOUT 70MM.

## LOSS OF SOIL BEARING CAPACITY DUE TO LIQUEFACTION

**Liquefaction is the phenomenon of instantaneous transformation of soil mass of solid consistency into a liquefied state due to earthquake vibrations.**

Soil liquefaction induced tilting and sinking of a residential building during Missouri earthquake.

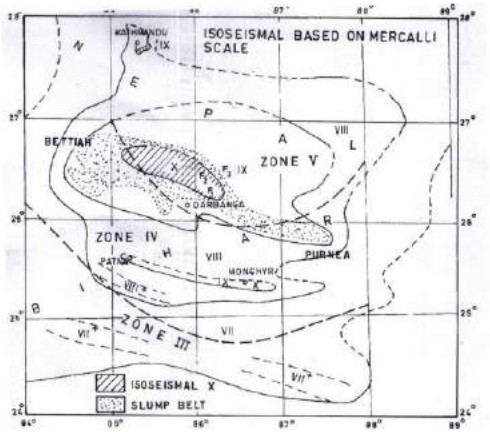
**Ground Deformation**




## FACTORS AFFECTING LIQUEFACTION

- **Fine & uniform size sand contracts under shear**
  - **SP – poorly graded sand**
  - **SM – silty sand**
  - **SC – clayey sand**
- **Water saturated Soil mass below foundation**
- **No drainage can occur during shaking**
- **Greater Intensity & duration of earthquake**
- **Relative density < 50%, for PGA = 0.1g**

## Slump Belt in 1934 Earthquake




Affected area and Iso-seismals of Nepal-Bihar Earthquake of Jan15,1934

**POTENTIAL SITES FOR LIQUEFACTION**

- River deposited sediments
- Reclaimed lands over ponds, lakes.
- Flood plains

## PROBLEM : Why does Foundation fail?

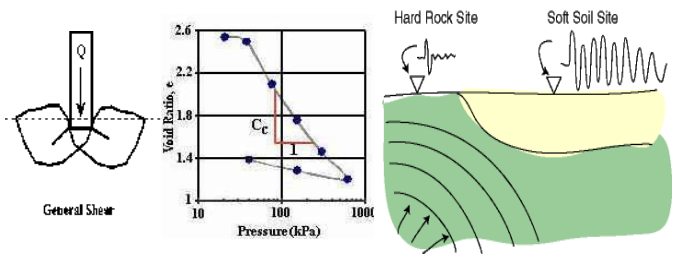
**Damages due to differential settlement**

FAILURE OF STRUCTURE


TILTING

CRACKING

## Soil Investigation : Why?




*C, Φ. Settlement*
**IS:1892– 1979**

***Hard, Medium or Soft*** **(IS 1893 PART 1)**

## Soil Investigation : Depth of Exploration

### IS 1892 Guidelines

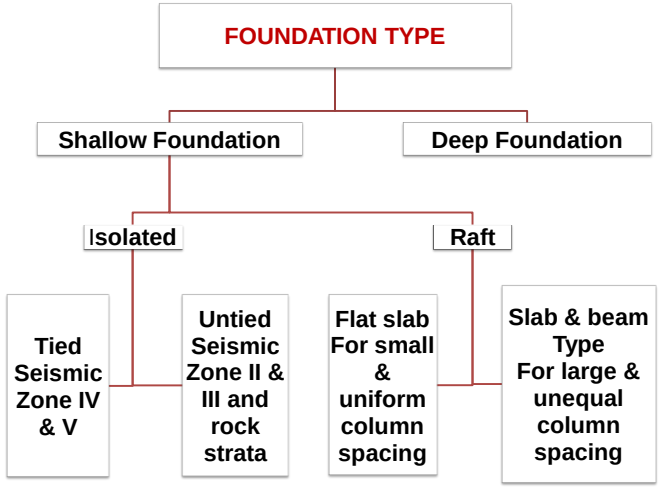
- **Depth of Exploration should be 1.5 x width of foundation (B) below foundation level.**
- **If foundations of adjacent column are closer, then Depth of Exploration should be 1.5 x width of building below foundation level.**
- **In weak soil, exploration should be continued to depth at which loads can be carried by the stratum without undesirable settlement and shear failure.**

### IS 2911 (Part 1/Sec2)

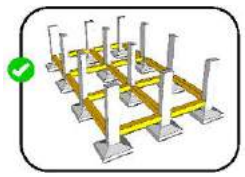
- **For pile foundation Depth of Exploration should be equal to pile depth + 10.0m**

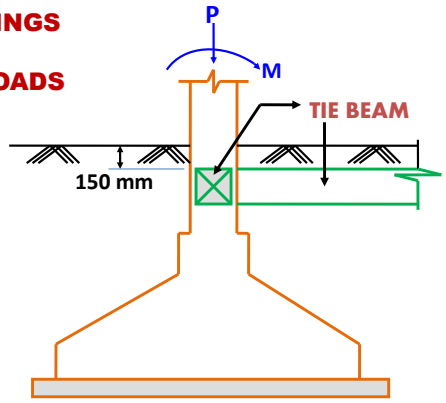
## SOIL EXPLORATION

- Position of water table
- SPT or CPT
- Soil classification in various layers
- grain size distribution
- Unit Weight, Specific Gravity
- Plastic and liquid limits
- angle of internal friction and cohesion
- coefficient of consolidation of cohesive soils
- Chemical Tests




## ISOLATED FOOTINGS UNDER EARTHQUAKE LOADS



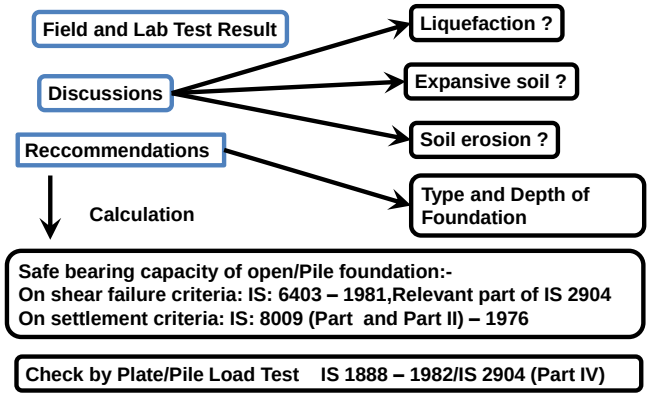


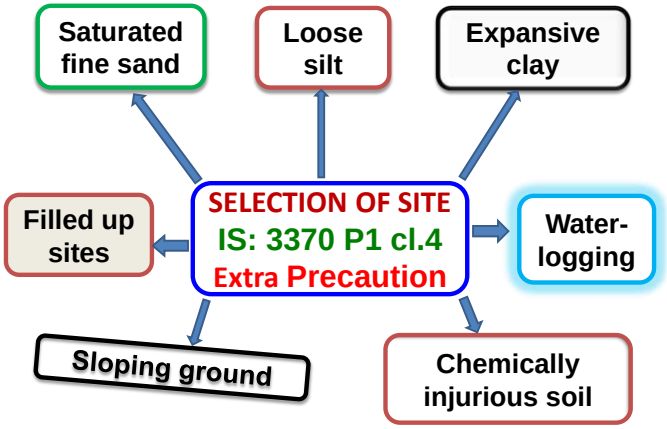

All tie shall be designed for additional axial force
= Ah/4 x Larger Column load

| Foundation type in different sub soil | |
|---|---|
| **Soil Profile** | **Foundation type** |
| Dense sand up to great depth | Spread Footing,<br>Pile if uplift |
| Stiff clay or stiff silt and clay up to great depth | Spread Footing.<br>Pile if special condition |
| Upper firm clay followed by soft clay | Spread Footing for low load otherwise Pile foundation |
| Upper layer soft clay followed by firm or rock | Pile Foundation |
| Upper layer soft clay followed by deep layer of dense sand | Pile Foundation |

| FOUNDATION TYPE IN DIFFERENT SUB SOIL | |
|---|---|
| **Soil Profile** | **Foundation type** |
| Loose sand up to great depth | Raft, driven pile |
| Soft clay with incraesing stiffness with depth | Raft, pile |
| Compact sand followed by medium soft clay followed by hard clay | Deep pile |
| Upper layer poor soil followed by loose sand followed by dense soil | Driven or cast in situ Pile Foundation |
| Fill followed dense sand followed by clay | Remove top layer or provide pile |
| Soft clay, followed by dense sand followed by soft clay | Pile driven / cast in situ or raft |
| Fill followed by rock | Pile /shallow foundation placed on rock |

## SOIL TEST REPORT




**THANK YOU**

**THANK YOU**

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

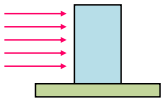
# (3)
# Principles of Earthquake Resistant Buildings and Architectural Considerations

80 min

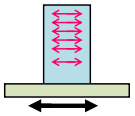
## BIS CODES FOR STRUCTURAL SAFETY

| | |
|---|---|
| IS: 456 - 2000 | "Code for PCC & RCC" |
| IS: 875 Part 1 | "Unit weights of materials" |
| IS: 875 Part 2 | "Imposed Loads" |
| IS: 875 Part 3 | "Wind Loads" |
| IS: 1904-1987 | "Safety of Foundation" |
| IS: 1905-1987 | "Masonry Buildings" |
| NBC | "National Building Code of India" |
| IS : 1893 (P 1-5) | EQ resistant design of structures |
| IS : 4326 | EQ resistant Masonry buildings |
| IS : 13920 | Ductile detailing of RCC structures |
| IS : 13935 | RVS & Retrofitting of Masonry buildings |
| IS 15988 | Evaluation & Retrofitting of RC buildings |

## EARTHQUAKE & WIND EFFECTS ON BUILDINGS



**Wind**
- Intensity of wind (Increase With t)
- Area Of Exposure
- Surrounding Structure



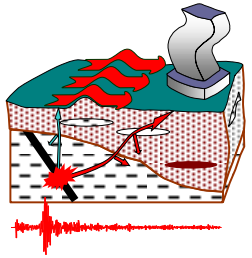
**Earthquake**
- Magnitude and Duration
- Properties of the Structure;
  a. Stiffness Distribution
  b. Mass Distribution

## EARTHQUAKE

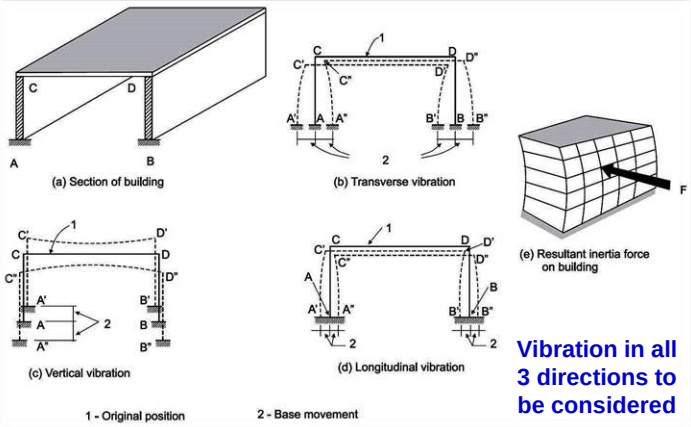
a **sudden, rapid shaking of** the Earth caused by the **release of strain energy** stored in rocks

**Ground vibrations at any location depends on:**

1. magnitude of earthquake
2. depth of focus
3. distance from epicentre
4. characteristics of path travelled by seismic waves
5. soil strata beneath the structure

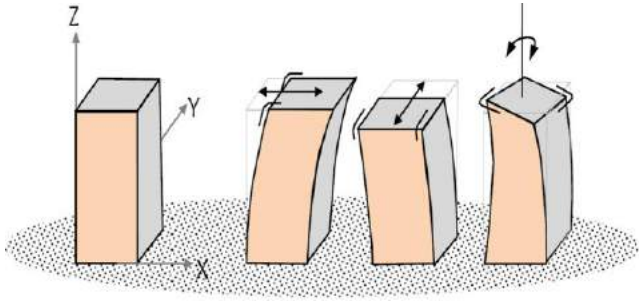


## SEISMIC VIBRATION




**Vibration in all 3 directions to be considered**

## SEISMIC VIBRATION OF BUILDING





## POOR PERFORMANCE OF MASONRY BUILDINGS

- Non adherence to building codes and byelaws
- Very long walls, unsupported cross walls
- Weak connection between two walls or between roof and wall
- Inadequate structural system
- Deficiencies in design/detailing
- Heavy dead weight and very stiff buildings
- **Irregular plan and configuration**
- **Lack of symmetry in plan and elevation**
- **Inappropriate sizes and positions of openings**
- **Stress concentration at corners of doors and windows**
- **Large openings close to corners**
- Foundation: Improper site/design/construction
- Sub-standard materials, lack of skill & workmanship
- Very low tensile and low shear strength mortars
- Lack of maintenance: deterioration aging, corrosion & cracking

## RETURN PERIOD OF EARTHQUAKES
**for given magnitude of earthquake**

**Maximum Considered Earthquake: MCE**

**Return period 2500 years,**
**Probable to exceed by 2% in 50 years**

**Design Basis Earthquake: DBE**

**Return period 475 years,**
**Probable to exceed by 10% in 50 years**

## EQ RESISTANT DESIGN PHILOSOPHY

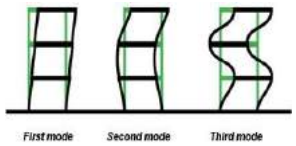
- बारबार आनेवाले गौण भूकम्प **(< DBE)** के दौरानः
  संरचना क्षति : नहीं
  गैर–संरचना क्षति : न्यून

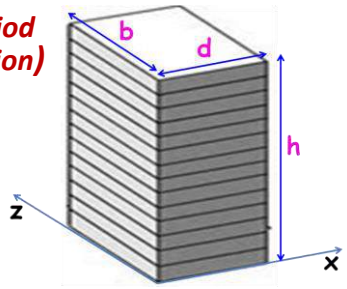
- यदा–कदा आनेवाले मध्यम भूकम्प **(= DBE)** के दौरानः
  संरचना क्षति : न्यून, मरम्मति योग्य
  गैर–संरचना क्षति : काफी, हटाने योग्य

- आसाधारण शक्तिशाली भूकम्प **( MCE)** के दौरानः
  संरचना क्षति : काफी,
  परन्तु, भवन ढ़हना नहीं चाहिए।

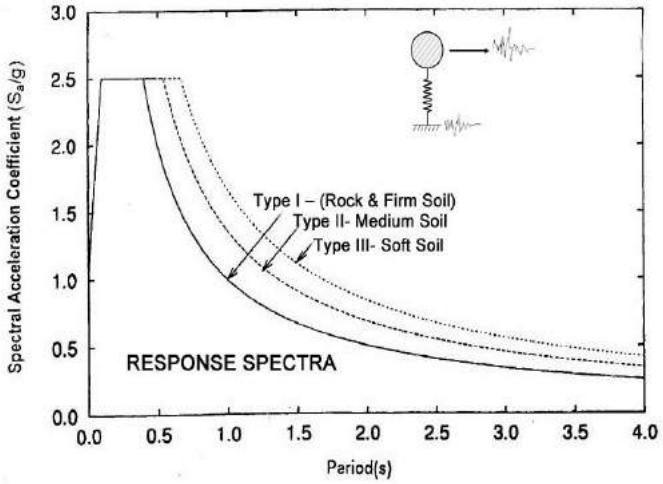
***Fundamental Time Period (un-damped free vibration)***

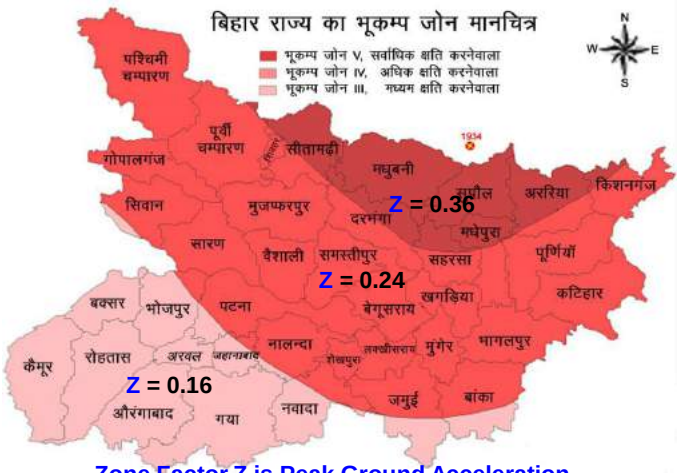
**IS 1893 Clause.7.6**




$T_a = 0.075\ h^{3/4}$, दोनों दिशाओं में, अनावृत RCC फ्रेम के लिये,
$T_{ax} = 0.09h/\sqrt{d}$, x दिशा में, पर्याप्त दीवारवाले फ्रेम के लिये,
$T_{az} = 0.09h/\sqrt{b}$, z दिशा में, पर्याप्त दीवारवाले फ्रेम के लिये






**Zone Factor,Z is Peak Ground Acceleration at Maximum Considered Earthquake**

| **Importance Factor, I** *(IS 1893 part 1, Clause 6.4.2)* | |
|---|---|
| Importance services and community Buildings | 1.5 |
| All other Buildings. | 1.0 |

| **Response Reduction Factor, R** *(IS 1893 Table 7)* | | |
|---|---|---|
| S.N. | Lateral loading Resisting System | R |
| 1. | Ordinary RCC Moment Resisting Frames (OMRC) | 3.0 |
| 2. | Special RCC Moment Resisting Frames (SMRF) | 5.0 |
| 3. | Load Bearing Masonry Walls Buildings | |
| | (a) Unreinforced | 1.5 |
| | (b) Reinforced with RC Band and vertical reinforced ends and joints. | 3.0 |
| 4. | Ductile Shear walls with SMRF | 5.0 |

## Design Horizontal Seismic Coefficient, $A_h$

$$Ah = \frac{Z}{2} \cdot \frac{I}{R} \cdot \frac{Sa}{g}$$ *(IS 1893* Clause 6.4.2)

**For SMRF R=5 and Ah is only 10 % of MCE**

**All possible safety margins have already been used by IS code during earthquake-resistant design**

**Violation of any analysis, design, detailing or construction specifications may result in catastrophic consequences since the building does not have "hidden" margins, now**

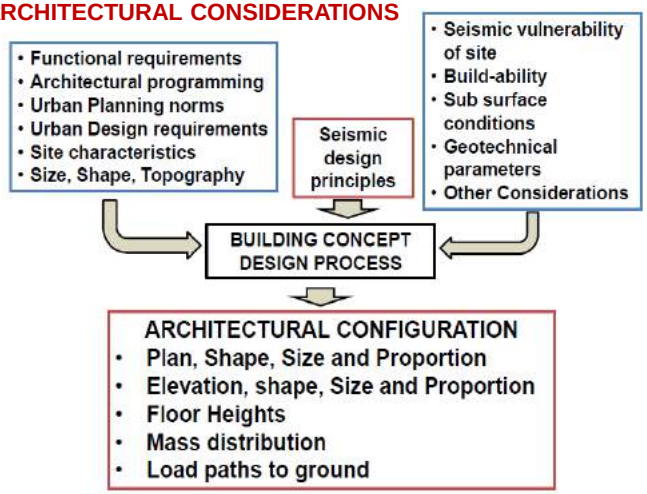
**The gap between the actual forces and the Design forces is to be filled up by the *provisions of Ductile detailing as per IS:13920***

**बहुमंजिली आर.सी.सी. फ्रेम संरचना पर भूकम्पीय प्रभाव के विश्लेषण की विधियाँ**

- **STATIC ANALYSIS**
- **DYNAMIC ANALYSIS**
  - Time History Analysis
  - Response Spectrum Analysis
    - Free vibration analysis
    - Modal Analysis

| LIMIT OF STATIC ANALYSIS | | | |
|---|---|---|---|
| संरचना | Zone III | Zone IV | Zone V |
| नियमित भवन | 90 m | 40 m | 40 m |
| अनियमित भवन | 40 m | 12 m | 12 m |

## ARCHITECTURAL CONSIDERATIONS




# SEISMIC RESISTANCE

**Four aspects**

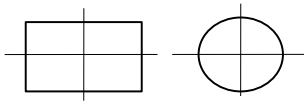
1. **Structural configuration**
2. **Lateral stiffness**
   **(stiff: less deflection)**
3. **Lateral strength**
   **(strong: more load carrying capacity**
4. **Ductility**
   **(ductile: capacity to deflect without breaking)**

**Good Structural configuration is** ensured by:

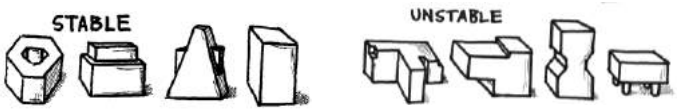
- **Simple regular geometry &**
- **Uniformly distributed mass & stiffness**

in both **plan and elevation**

**Compact symmetrical Plan**
**good seismic performance**



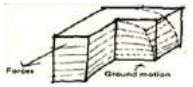
- **Undergoes predominantly bending deformation under Earthquake loads**
- **Less torsion or twisting behavior about vertical axis.**




## IRREGULAR FORM AND CONFIGURATION
## PLAN IRREGULARITIES

**1. TORSION IRREGULARITY**
Eccentricity between centers of mass and stiffness increase effects of torsion

**2. RE-ENTRANT CORNERS**
projections beyond the re-entrant corner are >15% of plan dimension



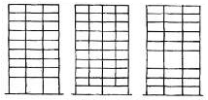
**3. DIAPHRAGM DISCONTINUITY**
Diaphragms with cut-out or open areas > 50 % of the gross enclosed diaphragm area

**4. NON-PARALLEL SYSTEMS**
Vertical elements resisting lateral force are **not parallel to** the **major orthogonal axes or the lateral force resisting elements**

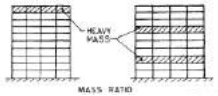
## IRREGULAR FORM AND CONFIGURATION
### VERTICAL IRREGULARITIES

**1. STIFFNESS IRREGULARITY**

Soft Storey
Intermediate sift storey
Extreme Soft Storey

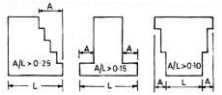


**2. MASS IRREGULARITY**




**3. VERTICAL GEOMETRIC IRREGULARITY**

When the horizontal dimension of the lateral force resisting system in any storey is >15% of that in its adjacent storey




**4. IN-PLANE DISCONTINUITY OF VERTICAL ELEMENTS**

Interruption of vertical members, Abrupt changes in stiffness ratio

## *LOAD PATH* FROM ROOF FOUNDATION

**Such Configuration induces large vertical earthquake forces even under horizontal earthquake ground motions due to overturning effects**

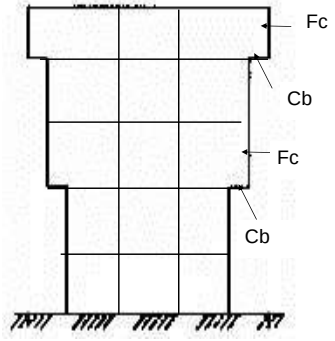


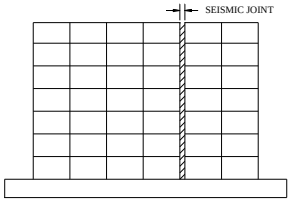

**Fig.:-Floating columns**
**Fc= Floating Columns**
**Cb= Cantilever Beams**

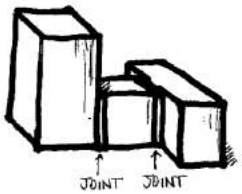
## IMPORTANCE OF URBAN PLANNING IN DISASTER RESILIENCE

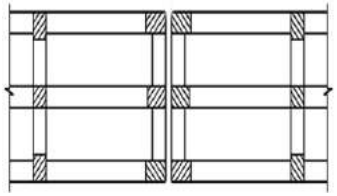
- **Electricity:** damage in supply network
- **Information and Communication services**:
- **Transportation systems:**
  - **Streets, Roads, Bridges & Flyover, Railway & Metro**
- **Water supply lines:** leakage and contamination
- **Dams:** may cause subsequent disaster
- **Drainage systems:** waterlogging on streets
- **Sewage systems:** contaminate ground water
- **Buildings**
  - **slum houses/unauthorized:** maximum damage
  - **Masonry buildings**
  - **Framed structures**
  - **Heritage Buildings:** restoration & retrofitting
- **Open spaces**: Key to safety during earthquakes

## SEPARATION JOINTS

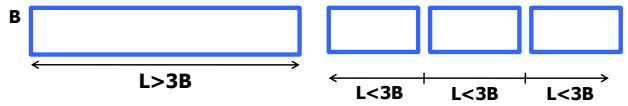
**Pounding Damage**



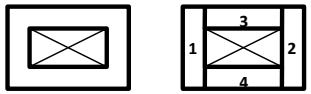



## SEPARATION JOINTS

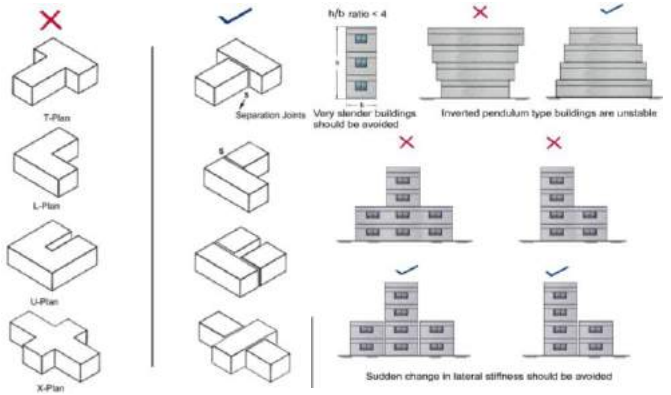



Long rectangular blocks




Floor with large opening

## SEPARATION JOINTS

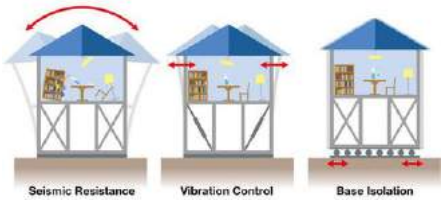



## MUD MASONRY

**AVOID masonry, particularly mud masonry and mud mortar in highly seismic areas**

## EARTHQUAKE RESISTANT BUILDINGS

1. Seismic strengthening
2. Energy absorbing devices
3. Base isolation technique




## SELECTION OF APPROPRIATE STRUCTURAL SYSTEM

1. Load Bearing wall systems (Brick or Concrete Masonry)
   - Small span low rise residential buildings
   - Up to 2 storey (High Seismic Zones)
   - Upt o 4 storey (Moderate Seismic Zones)
2. R.C.C Framed Buildings
   - More suitable for Seismic zones
3. Steel Buildings
   - Large span Industrial Structures
   - Large span Roofs
4. Composite Buildings
   - Steel & in situ concrete
   - In-situ concrete & Pre-stressed concrete
   - Steel & Precast elements

## Selection of appropriate structural system

moment resisting frame

braced frame

shear wall

## SELECTION OF STRUCTURAL SYSTEM

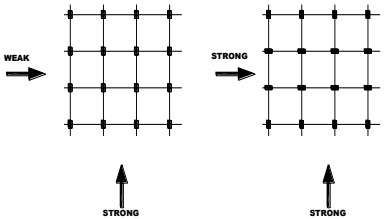
**R.C.C Framed Construction**

| FLOOR SYSTEM | FRAMING SYSTEM | FOUNDATION SYSTEM |
|---|---|---|
| Flat Plate<br>Flat Slab<br>Beam & Slab<br>Waffle Slab<br>Grid Floors<br>Ribbed Slab<br>Shallow wide beam | Shear wall-slab system<br>Moment resisting Frames (Beam-Column)<br>Braced Structures<br>Staggered wall system<br>Framed Tube Structures<br>Hybrid Structures | Isolated/ Combined footings<br>Raft<br>Piles<br>Piled-Raft |

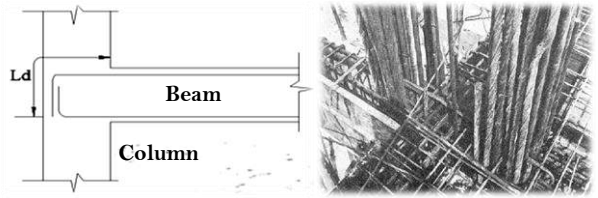
## Desirable Structural framing arrangements

- Square Grids with Square columns
- Beams Concentric to columns
- No Abrupt Changes in Columns sizes
- Column Orientations Planned to Provide Adequate Stiffness in Both Directions

All the upper floors weak in long direction (Izmit, Turkey 1999)




## ADEQUATE MEMBER SIZES

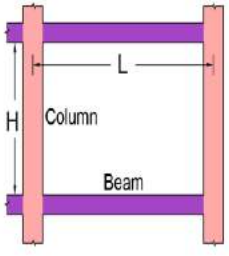



Structural member sizes usually depends upon
- Moments / Shear considerations
- Deflection (Stiffness consideration)

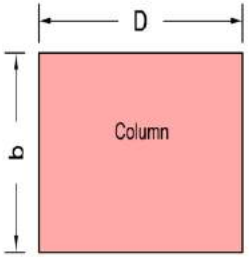
Sizes important for
- Beam - column joint design
- Reinforcement anchorage
- Confinement of joints
- Reduce reinforcement congestion

## COLUMN AND BEAM SIZES IN RCC FRAME

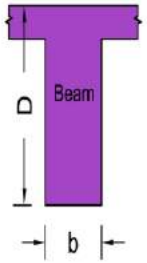
### sizes in preliminary design




ELEVATION
BEAM - COLUMN FRAMING




- b > 200 mm
- b > 0.4 D
- If L > 5 m, or, H > 4 m; then b > 300 mm

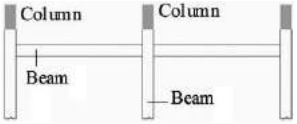



- b > 200 mm
- b > 0.3 D

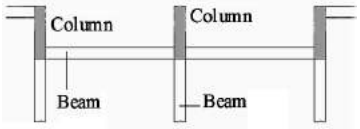
## RIGID BEAM-COLUMN JOINTS

- **Adequate beam-column sizes**
- **Proper confinement of concrete at joints**
- **Dense concreting in joint zone**
- **Stirrups within the joint (Diagonal Tension)**
- **Sufficient anchorage of beam reinforcement**

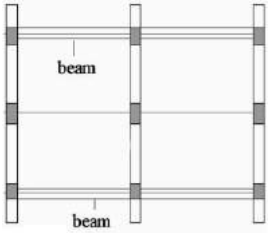
## PROBLEMATIC FRAMING ARRANGEMENT



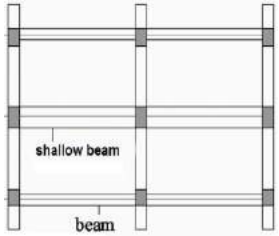

**Eccentric Beam (Torsion)**




**Increased column size to connect Beam**

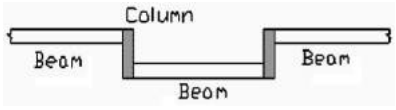



**Untied Column**

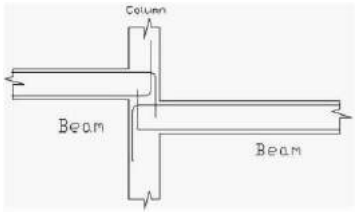



**Tied Column**

## PROBLEMATIC FRAMING ARRANGEMENT




**Non-concentric Discontinuous Beam (Reinforcement Congestion in columns)**

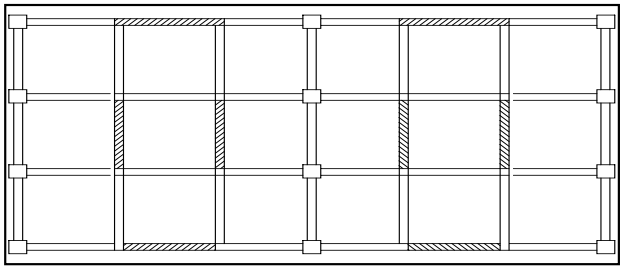



**Discontinuity and change in beam level (reinforcement congestion in column)**

## BEAM-COLUMN SYSTEM: (CHECK LIST)

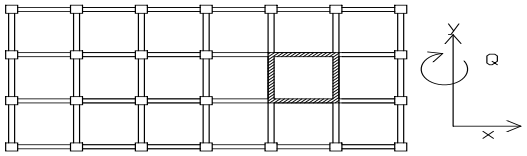
- ✓ Column orientations in both directions
- ✓ Completeness of frames
- ✓ Adequate Beam-column sizes
- ✓ Concentric beam alignment
- ✓ Avoid abrupt change in column sizes
- ✓ Avoid floating columns
- ✓ Avoid strong beam-weak column
- ✓ Square / circular column (most preferred)
- ✓ Well tied free standing staircase cores

## FRAME-SHEAR WALL COMBINATION

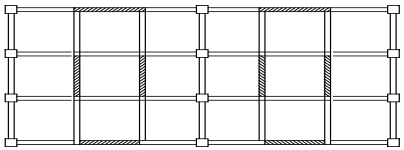


- Height range 30-35 Storey.
- Shear walls provides lateral stiffness
- Shear walls predominantly carry earthquake loads.
- Frames require to carry 25% of earthquake forces.

## SHEAR WALL LOCATION




Unsymmetrical placement causes torsion

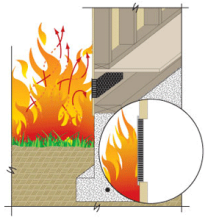


Place Symmetrical along both axes

## GENERAL PRINCIPLES:

## FIRE SAFETY

**Earthquakes** are frequently followed by **fire**



**Buildings** shall be made **fire resistant**

Provisions of Indian Standards for fire safety:

IS 1641 : 1988
IS 1642 : 1989
IS 1643 : 1988
IS 1644 : 1988 and
IS 1646 : 1986.

**THANKS**

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

# (4)
# EQ Resistant Design of Masonry Buildings, RVS, Seismic Retrofitting

30 min

## FAILURE OF WALLS

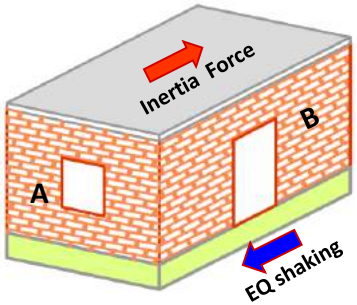
In-plane Shear Failure

In-plane bending

Out-of-plane overturning

failure at corner

## RIGID R.C. ROOF ON COMPLETE WALL ENCLOSURE



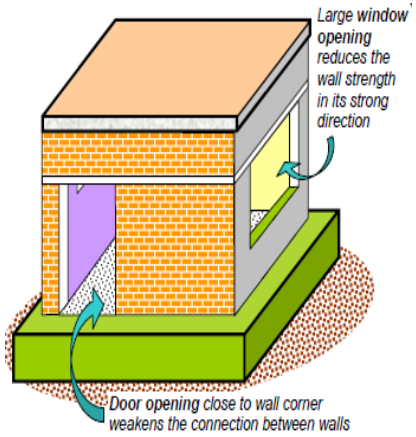

***Enclosure will act as a box for resisting the lateral loads***

**The Horizontal Rigid Diaphragm distributes Roof Inertia Force to the four walls in proportion to their stiffness**

**Inertia will almost entirely shared by walls B.**

**The bending of walls A will reduce.**

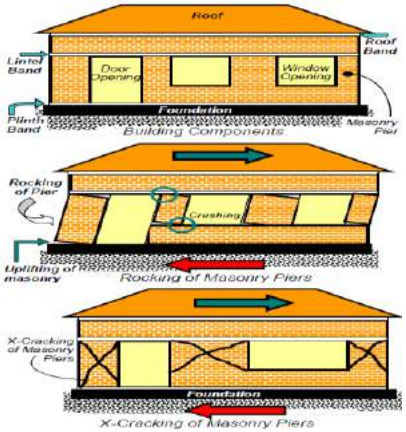
## LOCATION AND SIZE OF OPENINGS




***Openings near the wall corners hamper the flow of forces from one wall to another.***

***Large openings weaken walls from carrying the in-plane inertia forces***

**REASON STRUCTURAL - LACK OF VERTICAL INTEGRITY AT WINDOW SILL & JAMB**

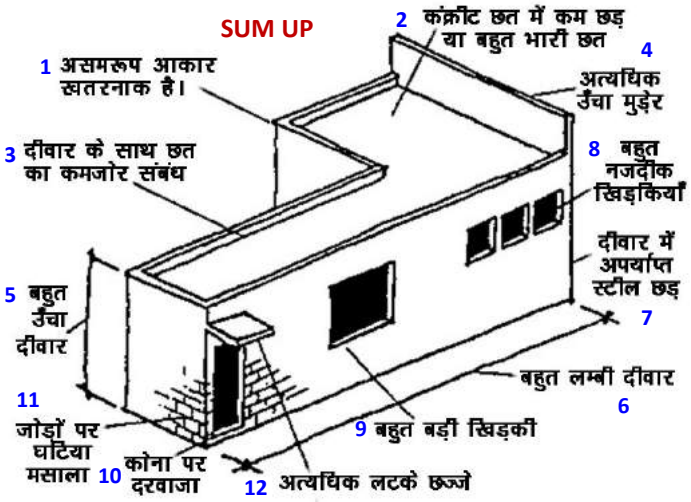



**ROCKING & CRACKING OF MASONRY PIERS**

***The wall piers disconnects from the masonry at the opposite diagonals***

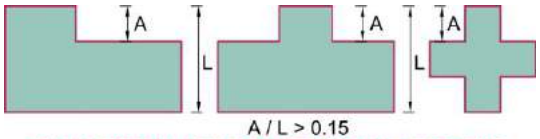
***The masonry piers develop diagonal shear cracks.***

**SUM UP**

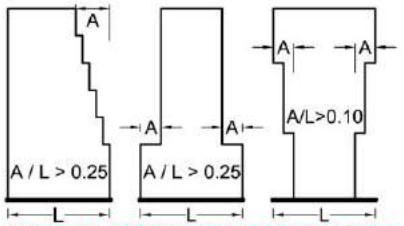



**EARTHQUAKE RESISTANT DESIGN**
**of**
**MASONRY BUILDINGS**
**(IS 4326)**

## CONFIGURATION AND SHAPE IRREGULARITIES

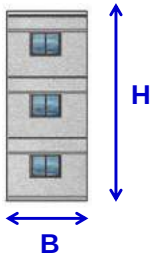



PLAN IRREGULARITIES : RE-ENTRANT CORNERS

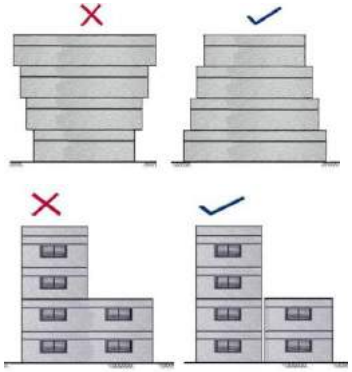



VERTICAL GEOMETRIC IRREGULARITIES

## ADOPT SIMPLE RECTANGULAR SHAPES

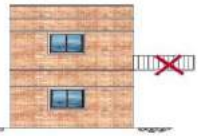



H < 4xB



## DANGEROURS SHAPE AND CONFIGURATION

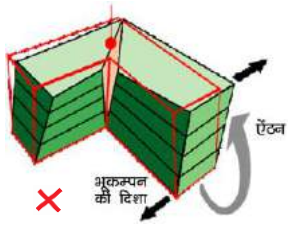
बाहर निकला उपरी मंजिल

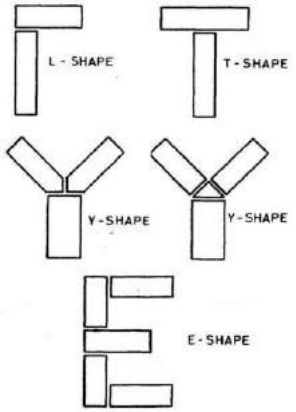


लम्बा निकला बालकोनी

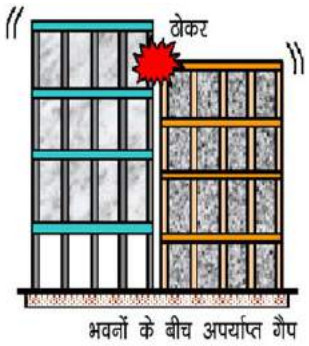
उपरी मंजिल पर लटकता पीलर

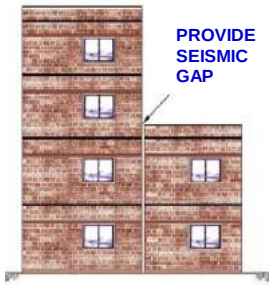
## UNSYMMETRICAL PLANS ARE DANGEROUS
## PROVIDE SEISMIC GAPS



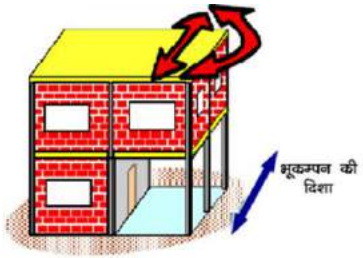



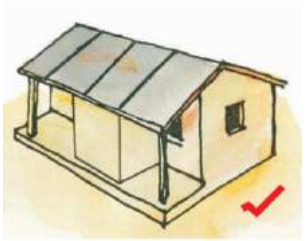
## ADJACENT BUILDINGS



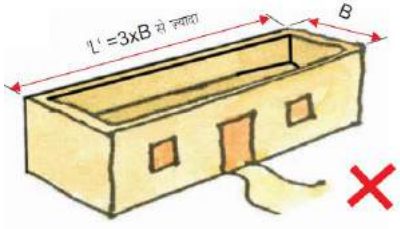



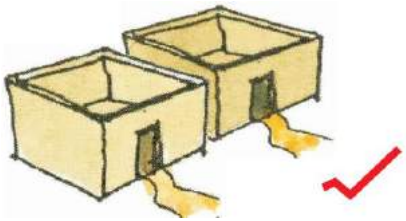

## UNSYMMETRICAL LOADS MAY PRODUCE TORSION



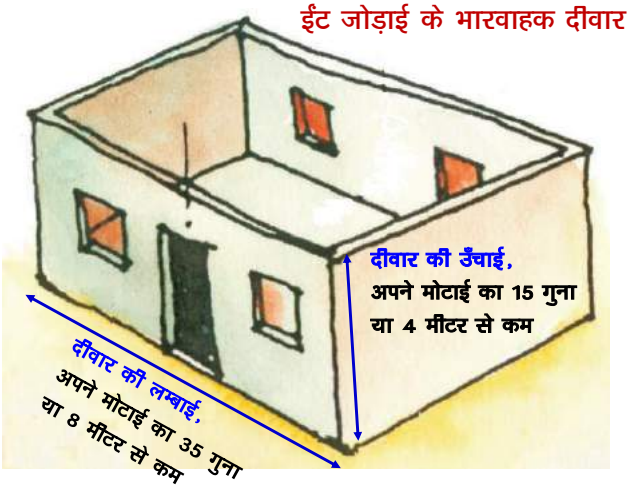
## LENGTH SHOULD BE LESS THAN 3xWIDTH



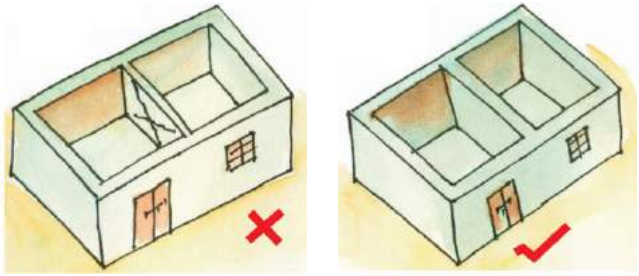



PROVIDE SEISMIC GAP

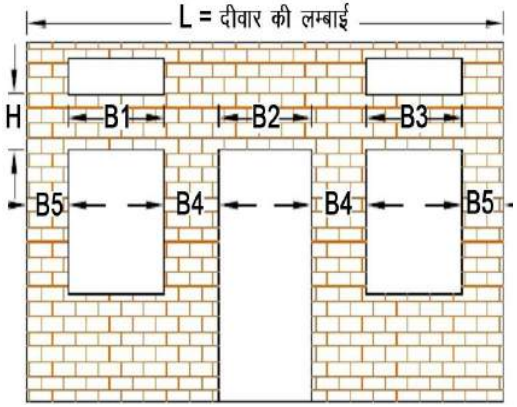
## ईंट जोड़ाई के भारवाहक दीवार



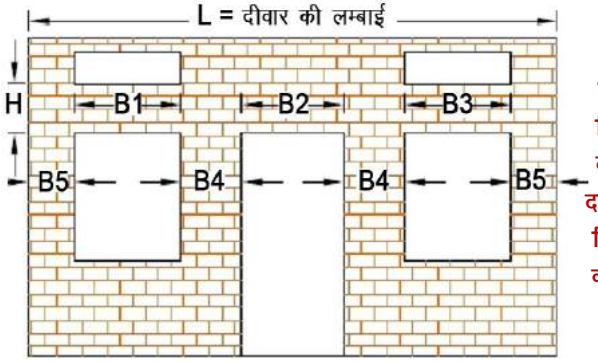
**THIN PARTITIONS MAY GET DAMAGE**
**PROVIDE THICK PARTITIONS**



## दरवाजों एवं खिड़कियों के आकार




**B4 : दो ईंट की लम्बाई से ज्यादा**
**B5 : एक ईंट की लम्बाई से ज्यादा**
**H : 450 मिलीमीटर से ज्यादा**




कमरा के किसी भी दीवार में, दरवाजों एवं खिड़कियों के आकार

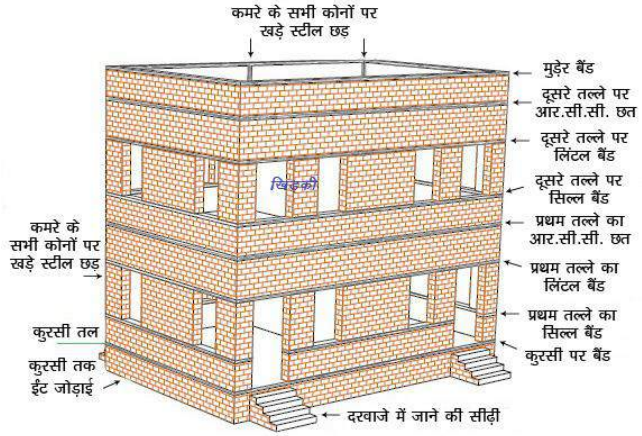
B1+B2+B3,
एकमंजिले मकान में : L के **50 %** से कम
दो मंजिले मकान में : L के **42 %** से कम
तीनमंजिले मकान में :L के **33 %** से कम

## भूकम्परोधी भवनों के आवश्यक अंग

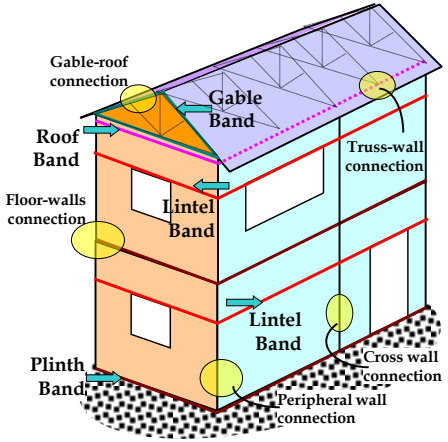
क्षैतिज भूकम्परोधी बैंड तथा दीवार के कोनों पर कंक्रीट में छड़ खड़ा करने से, कुर्सी से लेकर छत तक, सभी दीवारें बक्से की तरह बँध जाती है।

| भूकम्प जोन | मकान की अधिकतम उँचाई | ईंट जोड़ाई मसाला का अनुपात | क्षैतिज भूकम्परोधी आर.सी.सी. बैंड | दीवार के कोनों एवं किनारों पर खड़े स्टील के छड़ |
|---|---|---|---|---|
| V | तीन मंजिल (12 मीटर से कम) | सिमेंट:बालू – 1:4 | कुरसी बैंड<br>लिंटेल बैंड<br>सिल्ल बैंड<br>छत बैंड | कमरों के सभी कोनों पर तथा एक मीटर से बड़े दरवाजों एवं खिड़कियों के दोनों तरफ |
| IV | चार मंजिल (15 मीटर से कम) | सिमेंट:बालू – 1:6 | कुरसी बैंड<br>लिंटेल बैंड<br>छत बैंड | कमरों के सभी कोनों पर तथा 2.5 मीटर बड़े से द्वारों के दोनों तरफ |
| III | चार मंजिल (15 मीटर से कम) | सिमेंट:बालू – 1:6 | कुरसी बैंड<br>लिंटेल बैंड<br>छत बैंड | दो मंजिल से उँचे मकान के कमरों के सभी कोनों पर |

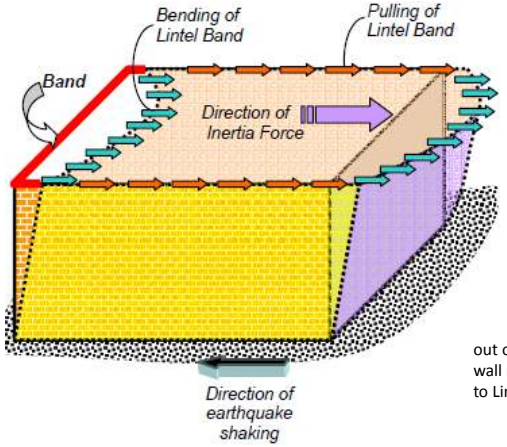
## भूकम्परोधी भवनों के आवश्यक अंग




## BANDS IN SLOPED ROOF BUILDINGS



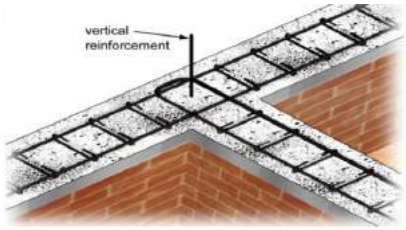

## LINTEL BANDS UNDER EARTHQUAKE SHAKING




**During earthquake shaking, the lintel band undergoes bending and pulling actions**

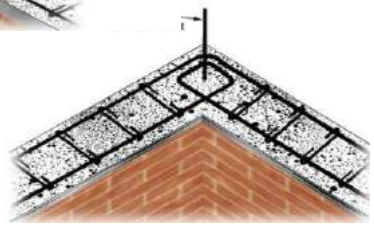
out of plain deflection of wall reduces to 1/5$^{th}$ due to Lintel bands. IS 4326

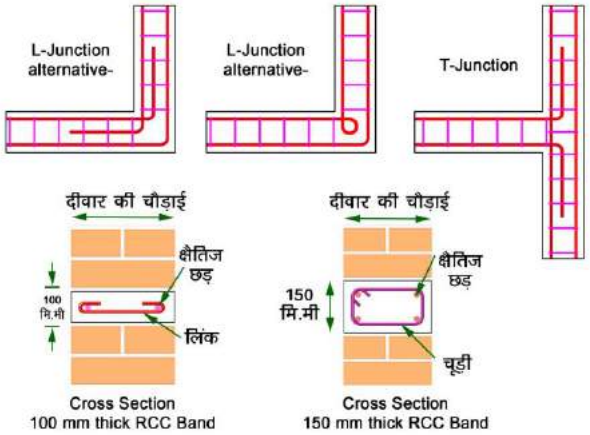
## RCC BAND AT WALL CORNERS




**T - JUNCTION**

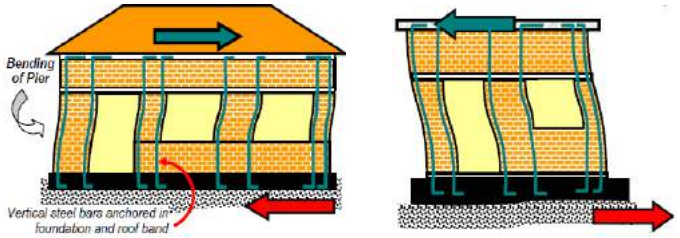
**L - JUNCTION**






दो दीवारों के जोड़ पर, बैंड में छड़ बाँधने का सही तरीका

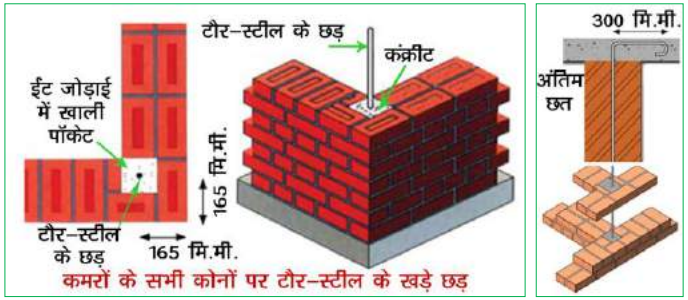
## VERTICAL REINFORCEMENT IN MASONRY




***Vertical reinforcement properly anchored into foundation and into roof:***

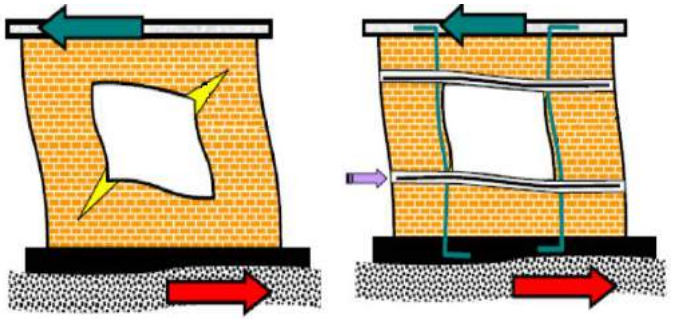
- ✓ ***Causes bending of wall in place of sliding or rocking***
- ✓ ***Delays the shear-cracking***
- ✓ ***Protect from sliding***
- ✓ ***Supports in cross direction***
- ✓ ***Adequate vertical bars prevents it's yielding in tension***

## सभी कमरों के कोनों पर, कंक्रीट में खड़ा छड़

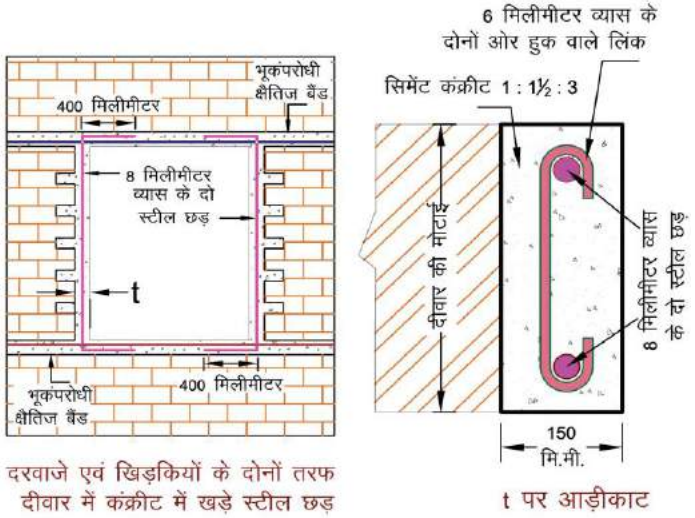



- सभी कमरों के कोनों पर, कंक्रीट डालने के लिये, ईंट जोड़ाई में खाली पॉकेट बनायें।
- पॉकेट में छड़ खड़ा करके कंक्रीट ढ़ालें।
- ये खड़े छड़ नींव से प्रारम्भ होकर, सभी आर.सी.सी. बैंड होकर, अंतिम छत की ढ़लाई के अंदर 300 मिलीमीटर मुड़ जानी है।

## बड़ी खिड़कियों का बचाव



- लिंटल बैंड
- सिल्ल बैंड
- खड़ा छड़

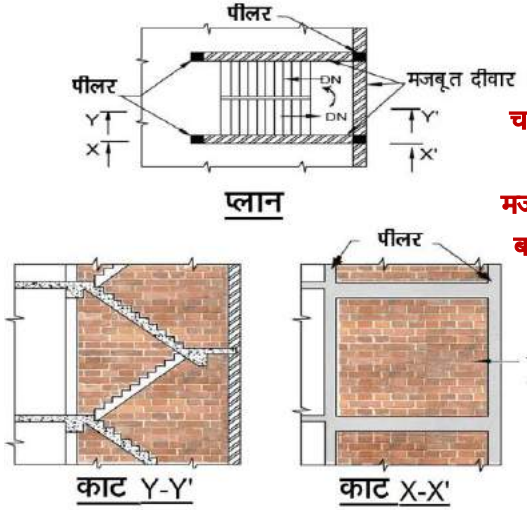



दरवाजे एवं खिड़कियों के दोनों तरफ
दीवार में कंक्रीट में खड़े स्टील छड़

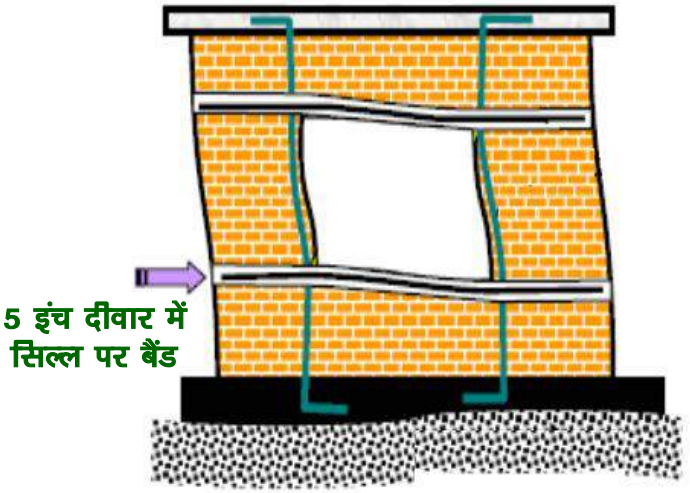
t पर आड़ीकाट

## HEAVY WATER TANK ON THE ROOF


CONNECT
PROPERLY TO THE
STRUCTURE

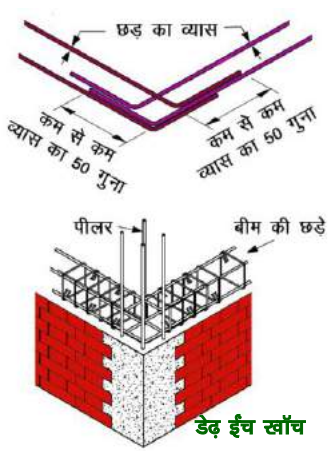


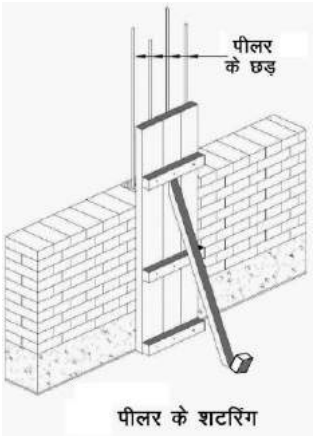

चारों कोना पर
पीलर तथा
मजबूत दीवार से
बना सीढ़ी घर



5 इंच दीवार में
सिल्ल पर बैंड

## ईंट जोड़ाई दीवार में पीलर

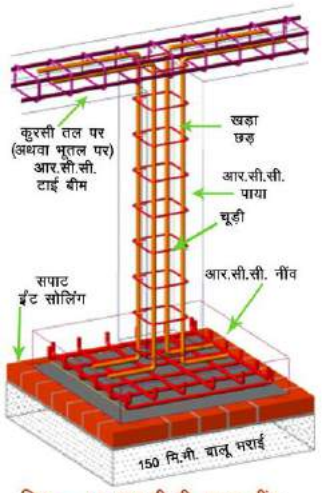



FOUNDATION FOR MASONRY BUILDING

**cohesive soils (clayey, silty clayey or clayey silty)**

- **Safe bearing capacity of 7 to 9 t/m².**
- **Foundation depth of 1.5 m**
- **if scouring depth is more, increase depth till clay soil is reached.**



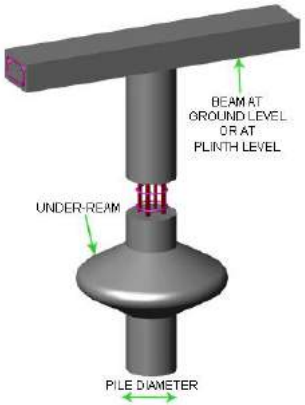

चित्र – 18 आर.सी.सी. पाया नींव

FOUNDATION FOR MASONRY BUILDING

**Non-cohesive soft alluvial soils saturated with water and possibility of deeper scour or liquefaction**

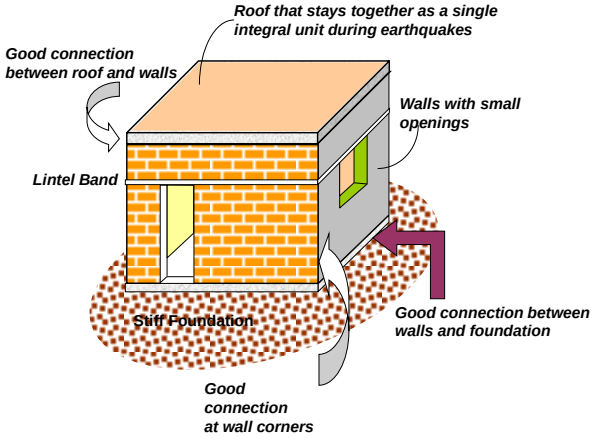
**Provide deep RC pile foundation with bulb at the bottom for desired load capacity**

- **3 to 8 m depth based on liquefaction of the soil strata.**
- **minimum depth of 3 m for the single storey houses**



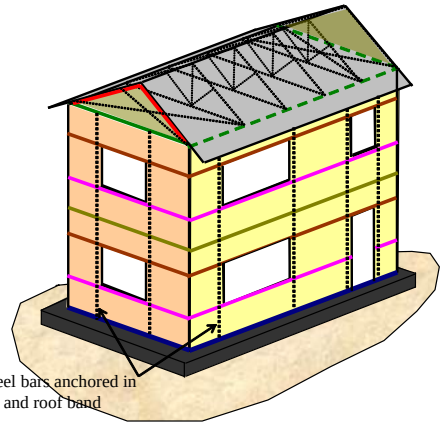

UNDER-REAMED PILE FOUNDATION

## BOX ACTION IN MASONRY BUILDINGS



## CONFINED MASONRY

Provision of Horizontal bands and Vertical Steel




# Rapid Visual Screening and Seismic Retrofitting

**IS: 13935**

**50 min**

## RVS PROCEDURE

- ✓ शीघ्रता से वर्तमान भवन का निरीक्षण कर, भूकम्परोध से संम्बंधित संरचना अंगों का डाटा एवं संरचना निर्माण का रिकॉर्ड एकत्र करना
- ✓ **Maximum Considered Earthquake** में, कमजोर संरचनात्मक अंगों के कारण, भूकम्पीय क्षतिग्रस्तता का आकलन एवं संभावित उन्नयन की पहचान करना

## *GRADES OF DAMAGE TO MASONRY BUILDINGS*

**Classification of damage**

**G1 :** ***Structural Damage :*** **(Nil)**

***Non-Structural Damage :*** **(slight)**

- **Hair-line cracks in very few walls**
- **Fall of small pieces of plaster only**

**[Restoration]**

**G2 :** ***Structural Damage : (Slight)***

- **Hair-line Cracks in many walls**

***Non-Structural Damage : (moderate)***

- **Fall of fairly large pieces of plaster**

**[Restoration]**

**G3 :** ***Structural Damage : (moderate)***

- **Large & extensive cracks in most walls**
- **Roof tiles detach**

***Non-Structural Damage : (heavy)***

- **Chimneys fracture at the roof line;**
- **Failure of individual partitions, gable walls**

**[Restoration & Retrofitting]**

**G4 :** ***Structural Damage : (heavy)***

- **Gaps in walls, Inner walls collapse;**
- **Partial structural failure of roofs & floors**

***Non-Structural Damage : (very heavy)***

- **Non-Structural elements collapse.**

**[Reconstruction & Restoration with partial Rebuilding / Retrofitting]**

**G5 :** **Structural Damage : (very heavy)**

- **Total or near total collapse of the building.**

**[Debris removal & Reconstruction]**

**DAMAGE GRADE :**
**Directly observed after an EQ**

**DAMAGEABILITY GRADE**

**Assess Vulnerability of existing building**

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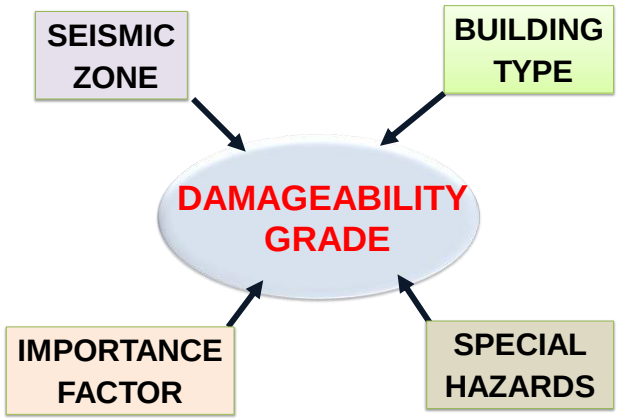



**LOAD BEARING MASONRY भवनों के प्रकार**

| प्रकार | भवन का विवरण |
|---|---|
| A | जमीन पर उथला नीव के साथ मिट्टी गारे में निर्मित दीवारें |
| A+ | गोल पत्थरों के साथ चिनाई; मिट्टी गारे में कच्ची ईंट की दीवारें |
| B | परम्परागत लकड़ी की छतों के साथ, अप्रबलित ईंट की दीवारें |
| B+ | चूना के मसाले में, UN-REINFORCED BRICK MASONRY WALLS |
| C | (क) HORIZONTAL RCC ROOF अथवा HORIZONTAL SEISMIC EAVES BAND वाले ढालवाँ छत के साथ; अच्छे सिमेंट मसाले में, पकी ईंट से निर्मित UN-REINFORCED BRICK MASONRY WALLS<br>(ख) B+ की तरह, HORIZONTAL SEISMIC BANDS के साथ |
| C+ | C (क) की तरह, परन्तु HORIZONTAL SEISMIC LINTEL BAND के साथ |
| D | C (क) की तरह, परंतु HORIZONTAL SEISMIC BANDS एवं VERTICAL REINFORCEMENT के साथ अथवा REINFORCED CONFINED MASONRY |
| D+ | पकी ईंटों से चिनाई की गयी REINFORCED MASONRY WALLS |

## SPECIAL HAZARDS

इनकी उपस्थिति से भवनों के भूकम्पीय जोखिम बढ़ जाते हैं।

1. LIQUEFIABLE CONDITION
2. LAND SLIDE PRONE AREA
3. IRREGULAR BUILDINGS

### RVS प्रक्रिया में सर्वेक्षक को क्या करना है :–

- ✓ प्रत्येक भूकम्प जोन के लिए, अलग सर्वेक्षण फॉर्म
- ✓ शीघ्रता से भवन का निरीक्षण
- ✓ क्षैतिज बल प्रतिरोधी अंगों की पहचान
- ✓ विशेष खतरों की पहचान
- ✓ निर्माण दस्तावेजों की समीक्षा
- ✓ RVS Forums पर आँकड़ा अंकित करना
- ✓ निरूपण गणना आवश्यक नहीं
- ✓ क्षतिग्रस्तता ग्रेड का निर्धारण
- ✓ RVS Forums पर अनुशंसा अंकित करना

### सर्वेक्षक के साथ उपकरण:

- डिजिटल कैमरा
- मापी हेतु टेप
- क्लिप के साथ सख्त पाटी
- पेन, पेंसिल, रबड़
- पर्याप्त संख्या में RVS फॉर्म
- RVS मार्गदर्शिका की प्रति
- मजदूर, छेनी, हथौड़ी, कुदाल

### चिनाई भवनों के प्रकार एवं क्षतिग्रस्तता ग्रेड में सम्बंध

| प्रकार | मध्यम भूकम्पीय तीव्रता (MSK VII) Zone III | उच्च भूकम्पीय तीव्रता (MSK VIII) Zone IV | बहुत उच्च तीव्रता (MSK IX या अधिक) |
|---|---|---|---|
| A एवं A+ | G4 : few<br>G3 : most<br>Rest G2 / G1 | G5 : few<br>G4 : most<br>Rest G3 / G2 | G5 : few<br>Rest G4 / G3 |
| B एवं B+ | G3 : few<br>G2 : many<br>Rest G1 | G4 : few<br>G3 : most<br>Rest G2 | G5 : few<br>G4 : many<br>Rest G3 |
| C एवं C+ | G2 : few<br>G1 : many<br>Rest G1 / G0 | G3 : few<br>G2 : most<br>Rest G1 | G4 : few<br>G3 : many<br>Rest G2 |
| D एवं D+ | G1 : few | G2 : few | G3 : few<br>G2 : many<br>Rest G1 |

few = (5 ± 5)%, many = (50 ± 5)%, , most= (75 ± 5)%

## VULNERABILITY ASSESSMENT and SEISMIC RETROFITTING

**RAPID VISUAL SCREENING**
शीघ्रता से भवन की असुरक्षितता की पहचान

DAMAGE G4, G5 → **DETAILED EVALUATION** By Professional Engineer

DAMAGE G1, G2 Restoration

DAMAGE G3

Cost permits → Other Options

**Seismically Safe for MCE**

**Seismic Retrofitting**
भूकम्प के दृष्टिकोण से सुदृढ़ीकरण

## SEISMIC RETROFITTING OF MASONRY BUILDINGS

Cement mortar

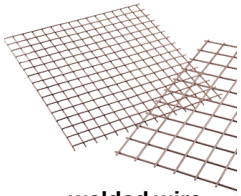
Cement Concrete

### SELECTION OF MATERIALS

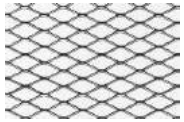

Admixture for Non-shrinkage / Bond

## SELECTION OF MATERIALS …contd

rods, angles, beams, channels



welded wire fabric



expanded metal

bolts

**VARIOUS FORMS OF STEEL**

Chicken Mesh

## SELECTION OF MATERIALS & TECHNIQUES


**Non-shrink Grouts:** Repair small / medium cracks

**Micro Concrete (dry powder bagged) + water** for repairs to all kinds of concrete structures

**Polymer concrete** Polymer binder + Aggregates (silica, quartz, granite, limestone)

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## SELECTION OF MATERIALS ...contd

Epoxy Glue Gun Dispenser

Epoxy Resins

Gluing steel plates to RCC

**Epoxy mortar**: Repair large void spaces in concrete, forcing mortar up to the end of the crack.

Epoxy mortar: Repair of medium cracks

## SELECTION OF MATERIALS ...contd

Mechanical Anchors: To Add / Connect new members

Chemical Anchors: To Add / Connect new members
Bonded in drilled holes through polymer adhesives

## SELECTION OF MATERIALS ...contd

Strengthening RCC Beams

FRP bars being used in a bridge deck

Strengthening RCC Columns

Fibre Reinforced Plastics (FRP)

| sl | Code Requirement are not Satisfied | Action for Retrofitting |
|---|---|---|
| i) | Weak Mortar | Ferro-cement plating / fiber-wrapping |
| ii) | Door, Window openings are more | Close / narrow the opening or reinforce by seismic belting |
| iii) | Length of wall between cross walls are more | provide pilaster or buttress |
| iv) | Height of wall from floor to ceiling are more | add pilaster to increase thickness by Ferro-cement plating |
| v) | Horizontal seismic Bands are not provided | Provide Seismic Belt on both sides of walls |
| vi) | Vertical bar at each corner and T-junction of wall are not provided | Install Vertical Belts on both sides of walls |
| vii) | Vertical bar at jambs of windows and doors | Install seismic belts around the opening |

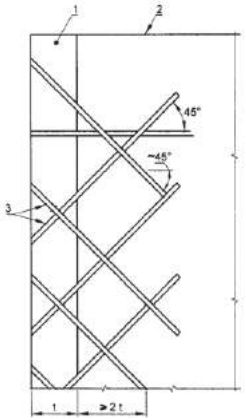
## STRENGTHENING OF EXISTING WALLS

### Connection between existing thick walls

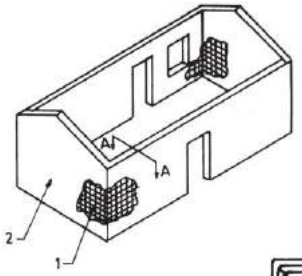
**Stone buildings of historic importance, having wall masonry in good mortar**

**Sewing Transverse Walls with Inclined Bars**

- Drilling inclined holes
- Inserting steel rods and
- Injecting cement grout

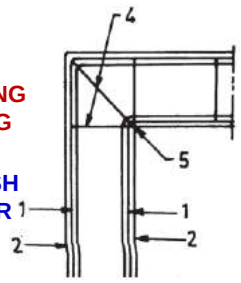



1 Transverse wall
2 Longitudinal wall
3 Holes drilled through the junction of the two walls

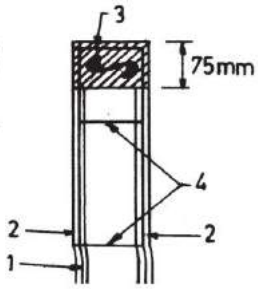



1 50 x 50 mm Welded wire mesh
2 Mortar or micro-concrete
3 Concrete roof hand
4 Cross ties @ 300-400 mm c/c
5 Corner bar dia 8 mm

**STRENGTHENING OF EXISTING WALLS with WIRE MESH and MORTAR**

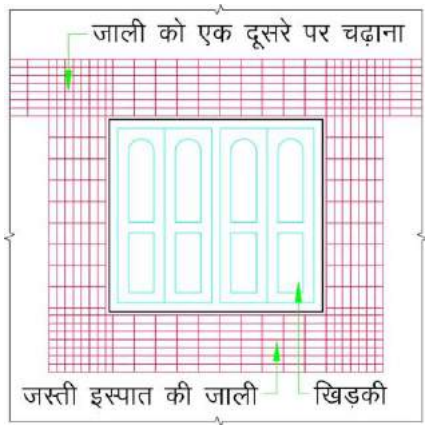


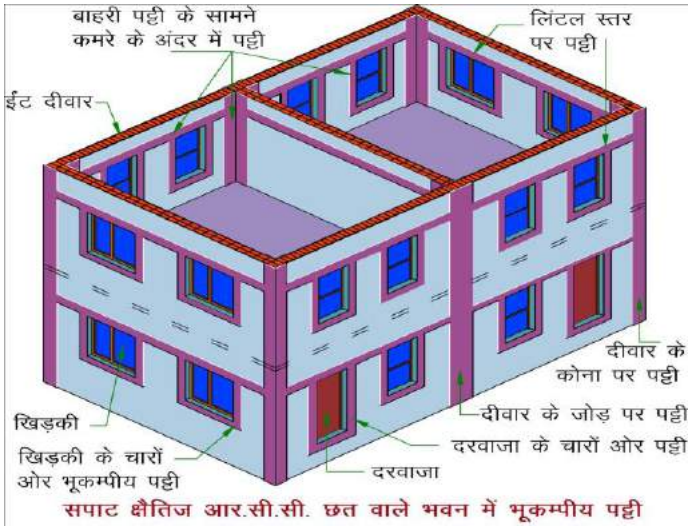

SEC A-A



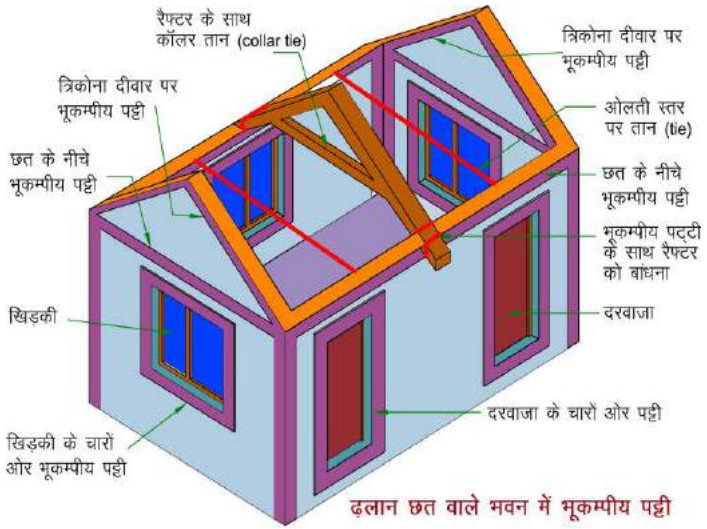

CORNER REINFORCEMENT

## REINFORCING AROUND OPENING



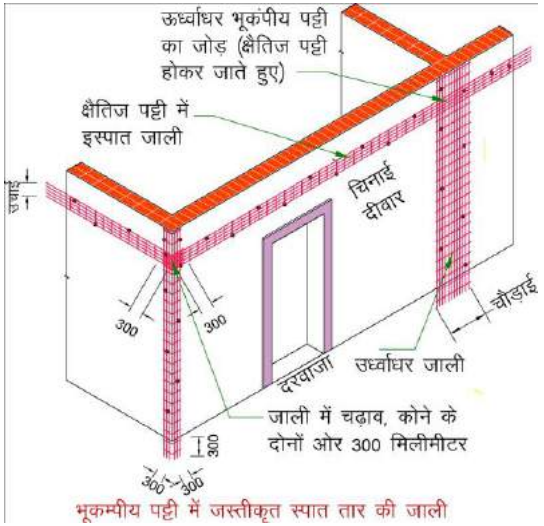




सपाट क्षैतिज आर.सी.सी. छत वाले भवन में भूकम्पीय पट्टी

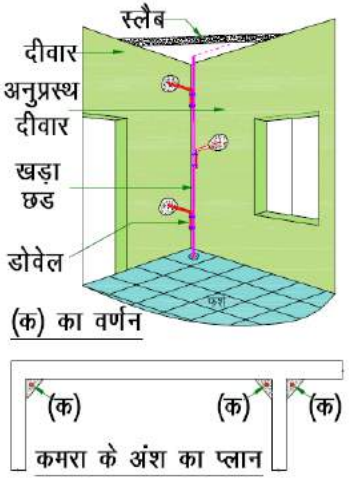


ढ़लान छत वाले भवन में भूकम्पीय पट्टी

**Vertical Seismic Band at Corner & Junctions**



भूकम्पीय पट्टी में जस्तीकृत स्पात तार की जाली




**कमरा के अंदर कोनों पर, छड़ खड़ा करना**

**Vertical Bar at Inside Corner**

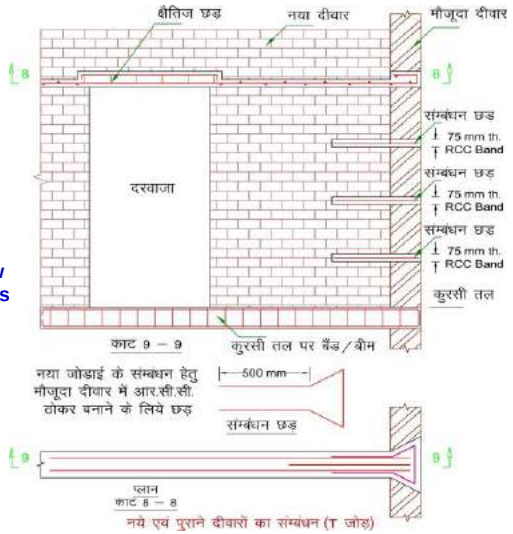

छड़ों से परिबंधित ईंट पीलर


**CONNECTION OF JACKETTING WITH FOUNDATION**

**SEISMIC STRENGTHENING TECHNIQUES**

**Connection of new walls with old walls**

**T-junction**



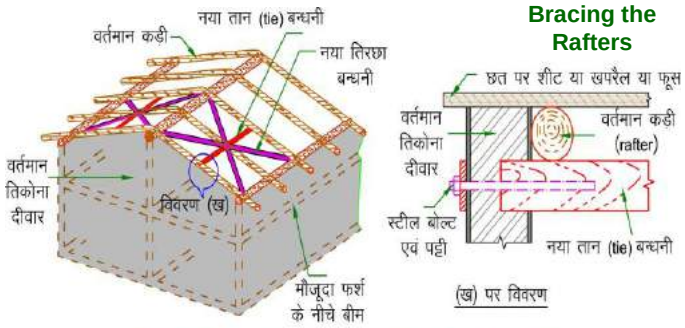
नये एवं पुराने दीवारों का संबंधन (T जोड़)

## SEISMIC STRENGTHENING TECHNIQUES

**Modification of Roofs or Floors**

**Pitched roofs without trusses**

**Details of New Roof Bracing**

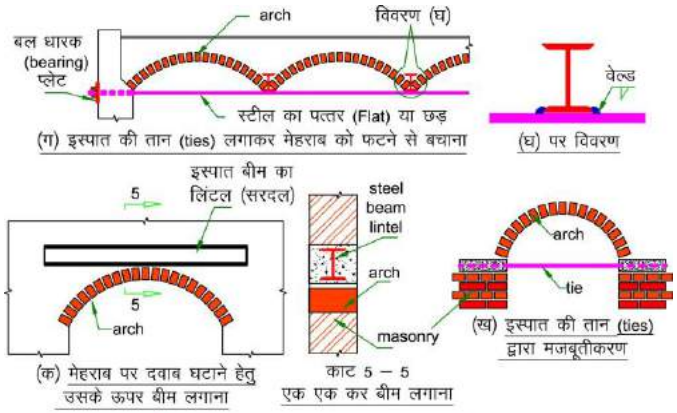



**Bracing the Rafters**




कड़ी पर आधारित ढलान वाले छत का मजबूतीकरण, छत में नया बन्धनी

## MASONRY ARCHES




चिनाई मेहराब (Masonry Arches) का मजबूतीकरण

*Thank You*

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

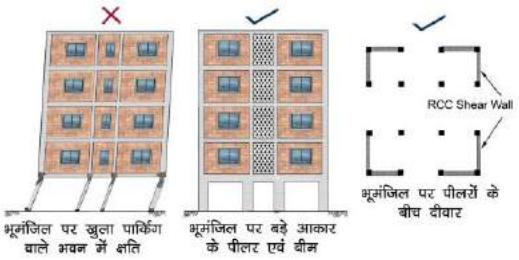
# (5)
# Seismic Safety of RC Buildings
## *Precautions in Construction, Quality Assurance, Structural Audit*

40 min

**SOFT GROUND STOREY FAILURE**

**SOFT STOREY (OPEN PLINTH),**
**VERTICAL SPLIT BETWEEN TWO BLOCKS (BHUJ)**

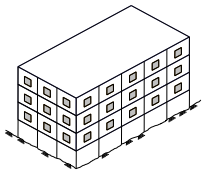
- **In-filled brick walls at upper floors increase the lateral stiffness of the frame.**
- **Sudden change of stiffness' between the ground storey and upper storey**
- **Dynamic ductility demand during earthquake gets concentrated in the soft storey and the upper storey tend to remain elastic.**



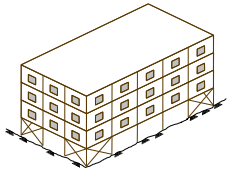

**IS: 1893-2002 (Part 1) Cl, 7.10**

1) **The dynamic analysis of the building is to be carried out which should include the strength and stiffness effects of infills as well as the *inelastic deformations* under the design earthquake force disregarding the Reduction Factor R.**
2) **The building is analysed as a bare frame neglecting the effect of infills and, the dynamic forces so determined in columns and beams of the soft (stilt) storey are to be designed for 2.5 times the storey shears and moments:**
   **OR,**
   **the shear walls are introduced in the stilt storey in both directions of the building which should be designed for 1.5 times the calculated storey shear forces.**

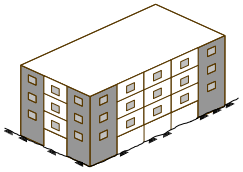
## REMEDIAL MEASURES FOR SOFT GROUND STOREY



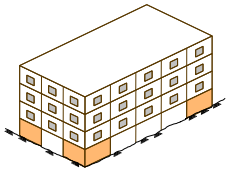
*Largest size stilt columns*



*Bracings in the columns of open ground storey*



*Providing R.C. Shear Wall*



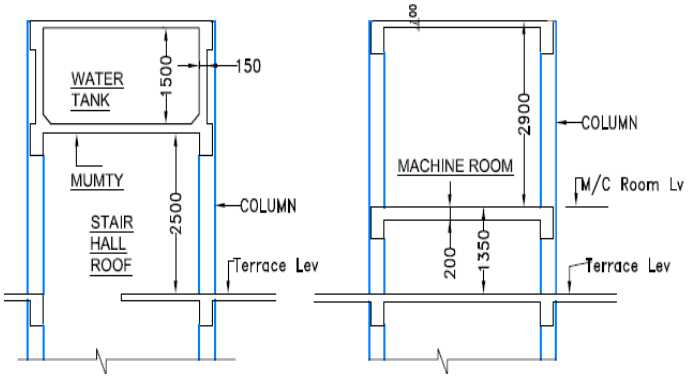
*Providing Brick infills between columns*

## INTERMEDIATE SOFT STOREY


**Large variation in stiffness of floors**

**COLLAPSE OF SOFT MIDDLE STOREY IN A BUILDING AT BHUJ**

## VERTICAL PROJECTIONS ABOVE ROOF




**Columns From Foundation to Top**

**Horizontal seismic co-efficient = 5x Ah**

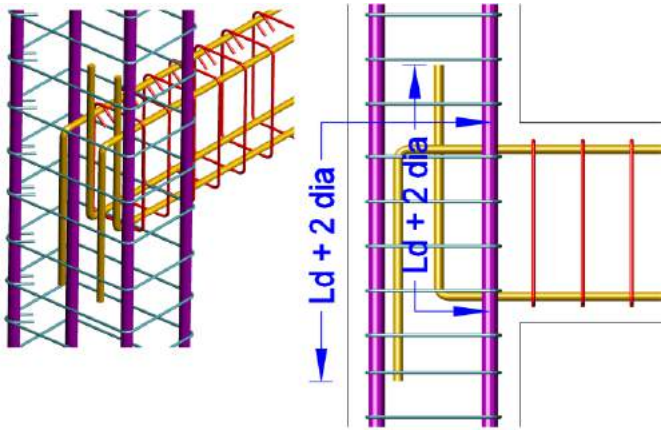
## HORIZONTAL PROJECTION

**Counterbalanced & Stable Projection**

**Vertical seismic co-efficient = 3.33x Ah**

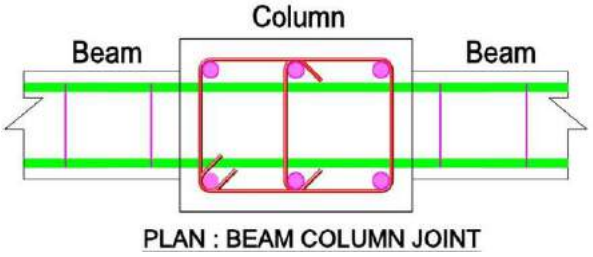
## DUCTILE DETAILING

### Anchorage of beam bars at an external joint




Ductility of Flexural Members

### Beam bars through column




**In the internal joint, both face bars of the beam shall be taken continuously through the column.**

**Insufficient lap length in R.C. columns, upper columns simply pulled out**

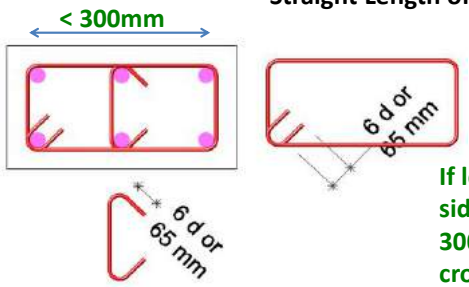
**Widely spaced hoops with 90° (instead of 135°) hooks.**

**Without the unfavorable effect of the infill walls it could however have behaved much better.**

**(Izmit, Turkey 1999)**

## HOOK IN TRANSVERSE TIES

Straight Length of HOOK = 6d




PLAN : COLUMN TRANSVERSE REINFORCEMENT

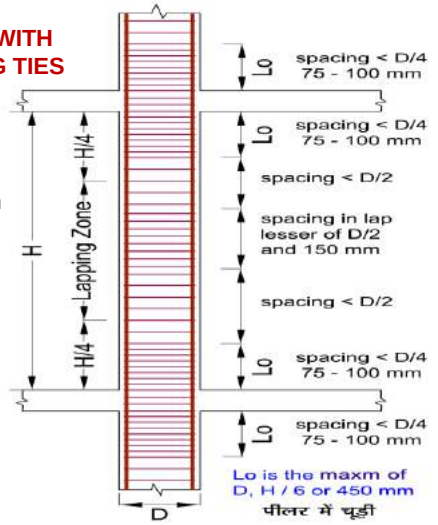
If length of any side of a stirrup > 300 mm; a crosstie shall be provided

## COLUMN DETAILS WITH SPECIAL CONFINING TIES

**Column**
b = lesser dimension
D = Larger dimension

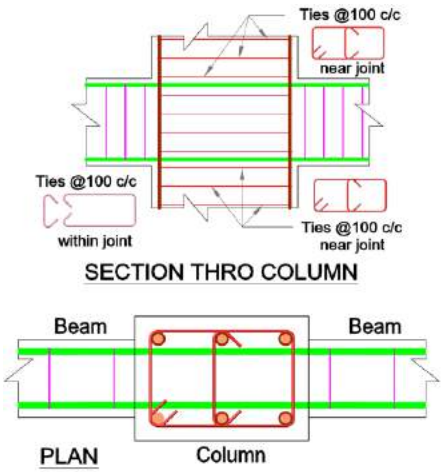
**Links spacing**
least of
@ b/2 c/c or 300 mm

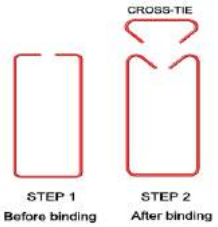
**Long bar Laps**
At entral half height,
Maxm 50% bars to be
Lapped at a section




## BEAM – COLUMN JUNCTION

SPECIAL CONFINING TIES WITHIN JOINT

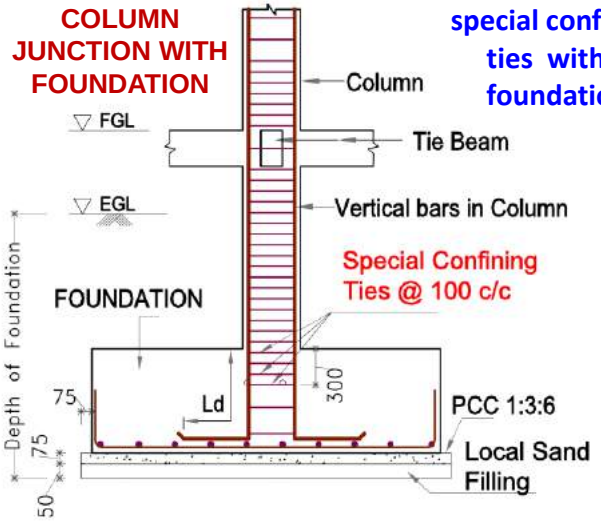



STEPS TO ENSURE 135° HOOK WITHIN THE JOINTS

## COLUMN JUNCTION WITH FOUNDATION

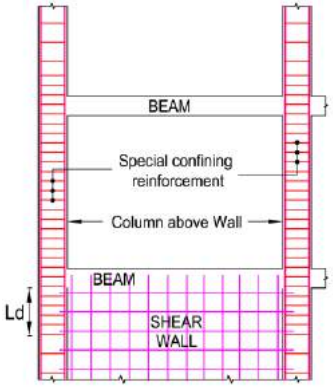
special confining ties within foundation



## SHORT COLUMN BEHAVIOR

Short Column behavior

Short Column: Inadequate ties




## TORSIONAL FAILURE

Front columns failed after twisting due to continuous wall at the right & rear back. (Kobe, Japan 1995)

- Buildings should be planned preferably symmetrical in space & shape, it may be split by providing separation Joints, if needed.
- Eccentricity of the centre of mass and centre of stiffness should be dealt with IS:1893, by taking torsion into account.

## VERTICAL CANTILEVER ELEMENTS

Elements projecting above the roof and attached to the building:-

- Parapets,
- Water tanks,
- Smoke chimneys, and
- Light weight fortifications

These elements and their connections with the roof structure have to be designed for the imposed load, the wind loading or the earthquake loading

## HORIZONTAL EARTHQUAKE LOAD ON VERTICAL CANTILEVER PROJECTIONS

(IS: 1893 (Part 1) -2002 - 7.12.2.1)

Horizontal Earthquake Load, $Feq = 5 \times A_h . W$
Where $A_h$ is design horizontal seismic coefficient

- Check the stability of water tanks, parapets, smoke chimneys attached to buildings and projecting above the roof for Feq
- Design of connections with the main structures for Feq
- The horizontal earthquake load will be assumed to be reversible in direction.
- The parapet wall will be reinforced on both faces of the wall and anchored into the doubly reinforced concrete slab for transfer of moments.

## EARTHQUAKE LOAD ON HORIZONTAL CANTILEVER ELEMENTS

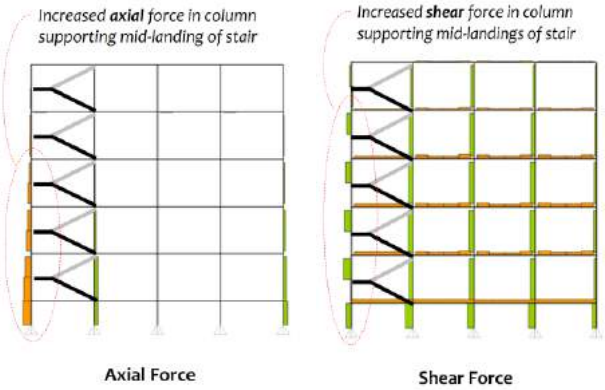
**like balconies** **IS: 1893 (Part-I)-2002**

Vertical Earthquake load,
$Feq = W \times 3.33 \times A_h$

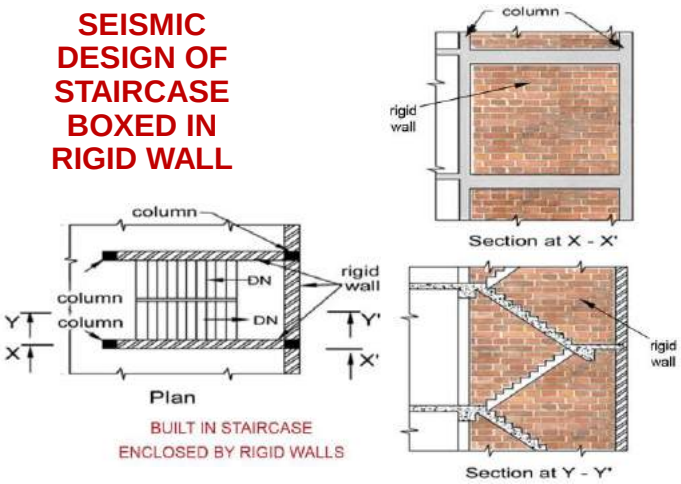

- If the balcony is anchored in a wall, stability should be checked by taking the seismic force downwards and the stabilizing weight should be assumed to have the seismic force upward.
- If the balcony slab is made continuous with the floor / roof slab, the reinforcement of the balcony should be anchored in the slab for sufficient length to engage the appropriate weight of the slab.

## STAIRCASES

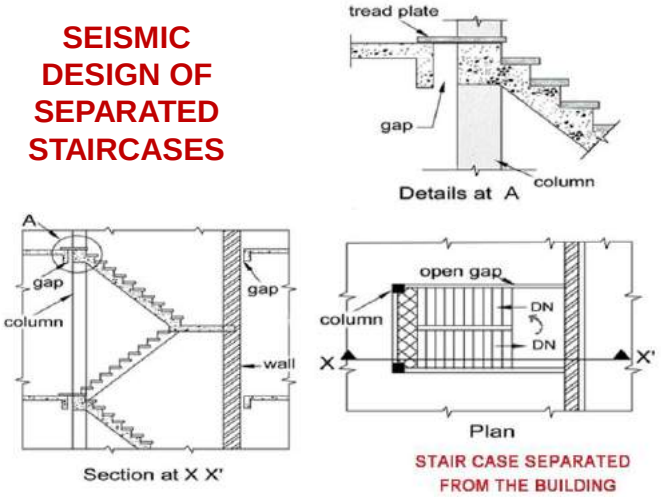
**Cracking and damage due to bracing effect**




## SEISMIC DESIGN OF STAIRCASE BOXED IN RIGID WALL




## SEISMIC DESIGN OF SEPARATED STAIRCASES



## MASONRY PARTITION WALLS

- **Materials:** burnt clay bricks, solid and hollow concrete blocks and hollow tiles

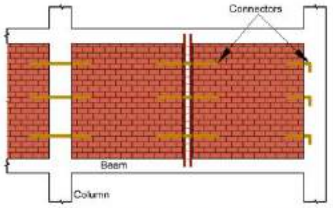
### ISSUES

- **Bare frame analysis and effect of infilled wall**
- **Distribution of infill walls in building**
- **Continuity of infill walls at all floors**
- **Isolation of infill in ductile RC frames**
- **Behaviour thin unreinforced masonry partition walls**

## STABILITY OF INFILL WALLS

## DESIGN OF PARTITION WALLS

- **Increase in seismic forces towards top**
- **Anchoring brick partition walls**
- **Fibre-reinforced polymer or micro concrete integrated overlay**
- **Thin RC seismic band at lintel level connected with RC columns**



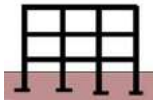
SHEAR CONNECTORS FOR FILL-IN BRICKWORK

***Precautions in Construction, Quality Assurance, Structural Audit***

40 min

## WEAK STRUCTURE : why ?

Design ?
Checking ?
Details ?



weak soil ?

Material ?

Trained ?

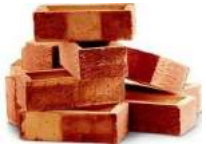
Supervision ?

Inspection ?

## DEFECTS IN BRICWORK

- POOR QUALITY OF MATERIALS
- POOR QUALITY OF CONSTRUCTION

## SOAKING OF BRICKS



(IS 2212-1991 Clause 10)

**Water to penetrate whole depth of bricks**
**Normally 4 to 6 hour is sufficient**

- It assists in removing the dirt and dust
- It reduces chances of efflorescence
- It prevents suction of water from wet mortar

- Brick joints to be packed with mortar
- Uniform layers
- Bed joint thickness < 12 mm

Cement Mortar
1:4, 1:6

Minimum 7 days curing

## MATERIALS & RCC PROCESS

- Cement
- Aggregates
- Water
- Chemical admixtures
- Formwork
- Mix design
- Batching

- ➢ Mixing
- ➢ Transporting
- ➢ Placing
- ➢ Compaction
- ➢ Finishing
- ➢ Curing
- ➢ Supervision
- ➢ Inspection

## MATERIALS

**CEMENT**

Use 43 grade OPC, Slag cement or PPC
Use within initial setting after adding water
Procure fresh, Protect from moisture

**SAND** FM > 2,
**AGGREGATES**
Clean and Fresh,
Protect from dust

**WATER**

If you can drink, you can use, OK

**WELL GRADED AGGREGATES**

*Range in aggregate size to fit together well*
*Gives a denser and stronger concrete*

## MATERIALS

**SUPER PLASTICISER : IS 9103-1999**

- ❖ Improves workability
- ❖ About 10 to 15 % less water

- ➢ Approve with past experience & mix design
- ➢ Establish slump with & without admixtures
- ➢ Maximum weight, 2 % by weight of cement

**STEEL REINFORCING BARS**

Standard manufacturer (Tata, SAIL, etc)

X Bars made from re-rolled steel

**Good quality of all materials**

**ENVIRONMENTAL EXPOSURE CONDITIONS**
**IS:456-2000 Table 3**

| Environment | Exposure Conditions |
|---|---|
| Mild | Concrete surfaces protected against weather or aggressive conditions |
| Moderate | Concrete exposed to condensation and rain, Concrete in contact or buried under non-aggressive soil / ground water |
| Severe | Concrete surfaces exposed to severe rain, alternate wetting and drying |
| Very Severe | Concrete surfaces exposed to corrosive fumes Concrete in contact with or buried under aggressive sub-soil / ground water. |
| Extreme | Members in direct contact with liquid / solid aggressive chemicals |

## CONCRETE COVER REQUIREMENT

(IS 456 2000 Clause 26.4)

| Nominal cover : Depth of concrete cover to any steel bar, to meet durability requirements | |
|---|---|
| **Exposure** | **Nominal cover** |
| Mild | 20 mm |
| Moderate | 30 mm |
| Severe | 45 mm |
| Very severe | 50 mm |
| Extreme | 75 mm |
| Nominal cover >= diameter of main bar | |

| Table 5 of IS 456-2000 | | | |
|---|---|---|---|
| Exposure conditions | RCC with 20 mm maximum size aggregate | | |
| | Min. Cement kg/m$^3$ | Max. W/C ratio | Min. Grade |
| Mild | 300 | 0.55 | M 20 |
| Moderate | 300 | 0.50 | M 25 |
| Severe | 320 | 0.45 | M 30 |
| Very severe | 340 | 0.45 | M 35 |
| Extreme | 360 | 0.40 | M 40 |

# QUALITY ASSURANCE

- SUPERVISION
- INSPECTION
- SIEVE ANALYSIS
- TESTS FOR TORSTEEL BARS
- TESTS FOR CEMENT
- CONCRETE CUBE TEST

## SUPERVISION (IS 456 2000 Clause 13.6)

**CONSTANT & STRICT SUPERVISION :**

- Formwork: sizes of elements, Levels
- Proportioning and mixing of the concrete
- Reinforcement and its placing
- Compaction, Curing, Stripping of the formwork

**RECORD**

- Test reports of materials
- Concrete mix design details
- Concrete mix test reports
- Record in Site order book:
  - ✓ Checks: Geometry, Reinforcement
  - ✓ Concrete placement Clearance
  - ✓ Non-conformance reports

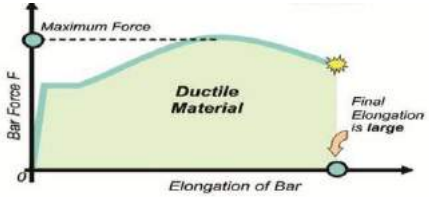
## INSPECTION

(IS 456 2000 Clause 17.1, 17.2)

- Setup inspection procedure
- Ensure compliance of design
- Verify quality of individual parts
- Tests and Records of materials
- Clear instructions on inspection & deviations
- Identify Workmanship , Durability & Appearance

## STEEL REINFORCEMENTS

### TEST FOR ELONGATION




Length of test piece = 5.65 √A,

where A is the cross-sectional area of the test piece

**as per IS 13920:1993 cl. 5.3:**

High strength deformed steel bars produced by thermo-mechanical treatment process of grade Fe 500 or Fe 550, having elongation more than 14.5% and conforming to other requirements of IS 1786 may also be used for reinforcement.

## TESTS FOR CEMENT

Test as per IS: 4031 Part V 1988

Initial setting time > 30 min
Final setting time < 600 min

| Compressive strength of 70.6 mm size cube<br>Test as per IS: 4031 Part 6 | | | | |
|---|---|---|---|---|
| Cement | IS code | 3 days | 7 days | 28 days |
| 33 Grade OPC | IS 269 | 16 mpa | 22 mpa | 33 mpa |
| Portland Slag Cement | IS 455 | 16 mpa | 22 mpa | 33 mpa |
| PPC | IS 1489 P1 | 16 mpa | 22 mpa | 33 mpa |
| 43 Grade OPC | IS 8112 | 23 mpa | 33 mpa | 43 mpa |
| 53 Grade OPC | IS 12269 | 27 mpa | 37 mpa | 53 mpa |

## CONCRETE CUBE : SAMPLE & TEST RESULT

IS: 456-2000 Clause 15

- *1 sample = 3 test specimens*
- Sample Result = av. of 3 specimens
- Specimen variation< ±15 % of av.
- Test Result = 28 days strength
- For quicker idea, 7 days tests

| Concrete in $m^3$ | No of Samples |
|---|---|
| Any shift < 5 | 1 |
| *6 - 15* | *2* |
| 16 - 30 | 3 |
| 31 - 50 | 4 |
| 51 – 100 | 5 |
| 100 - 150 | 6 ..... |

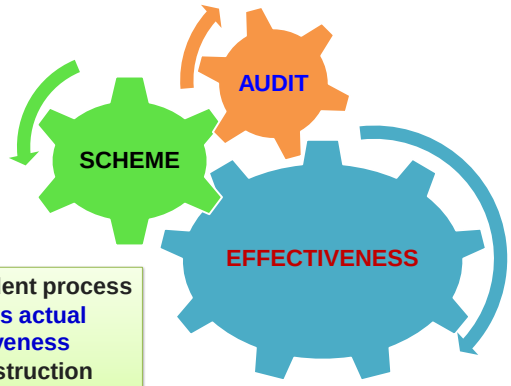
### ACCEPTANCE CRITERIA

IS 456 2000 Clause 16.1

- ✓ Mean of 4 consecutive results > fck + 0.825 x SD, and > fck + 4 mpa
- ✓ Individual result > fck - 4 mpa

| INSPECTION CHECK LIST | | | |
|---|---|---|---|
| Name of Project, Location | | | |
| Date of inspection ? | | | |
| Structural members inspected | | | |
| Concrete Cube Test results | PASSED | FAIL | |
| Tests of construction materials conform to IS Codes. | YES | NO | |
| Tests of construction materials conform to IS Codes. | YES | NO | |
| Construction has been done as per drawing. | YES | NO | |
| Workmanship & appearance are satisfactory. | YES | NO | |
| Segregation or honeycombing on the concrete surface. | SEEN | NO | |
| | | | |
| Photograph: taken properly and docketed | YES | NO | |
| *Note : Fill in the blanks or tick as appropriate.* | | | |
| Engineer | Name | Signature | Date |
| EE / SE / CE | | | |

## QUALITY AUDIT




An Independent process **to assess actual effectiveness** of a Construction scheme

## QUALITY AUDIT PROCESS

- **Verification and evaluation of** activities, records, processes
- Performed at **predefined time intervals**

## Quality Audit Management

- Variety of prescribed self-assessment forms
- Variety of software and tools

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

**(6)**

# NON-STRUCTURAL RISK MITIGATION

# BUILDING SERVICES, FIRE SAFETY

# BIHAR BUILDING BYE LAWS 2014

# STRUCTURAL DESIGN BASIS REPORT

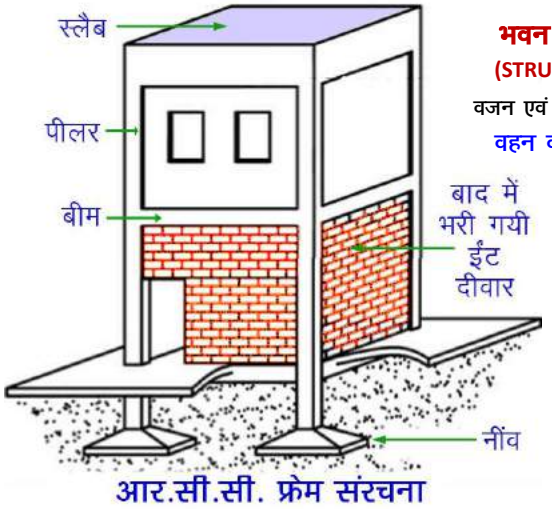


20 min

## STRUCTURAL ELEMENTS

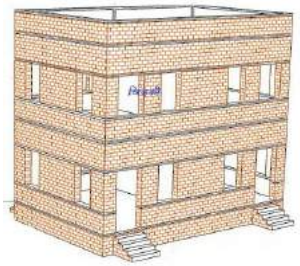
**The structural elements differ in each type of building, but generally they include:**

- **Foundation,**
- **Columns,**
- **Slabs,**
- **Beams, and**
- **Load-bearing walls.**

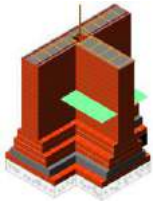



आर.सी.सी. फ्रेम संरचना

**भवन संरचना**
**(STRUCTURE)**
वजन एवं क्षैतिज बल
वहन करता है

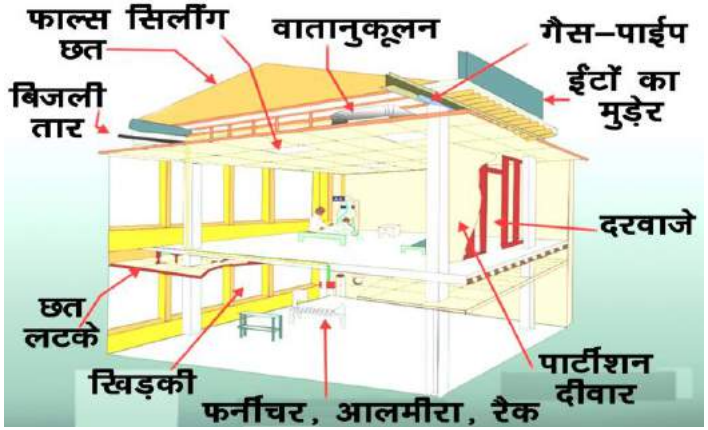


भारवाहक दीवार वाली भवन संरचना



## गैर–संरचना अवयव (NON-STRUCTURE ELEMENTS)

### संरचना पर लटके या स्थापित




## NON-STRUCTURAL ELEMENTS

Chhajja

Parapets

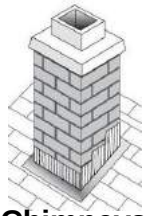
Wall cladding

Partitions

## NON-STRUCTURAL ELEMENTS

Stairways

Balcony



Chimneys

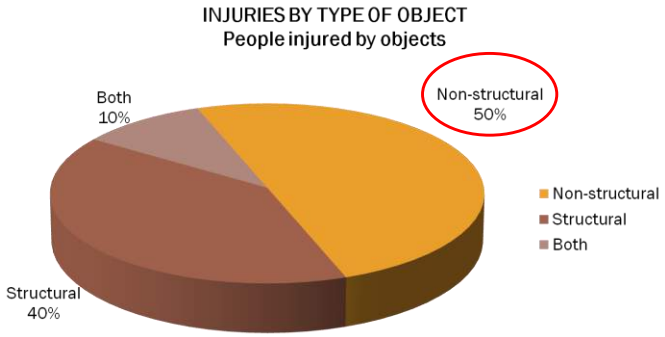
Water Tank

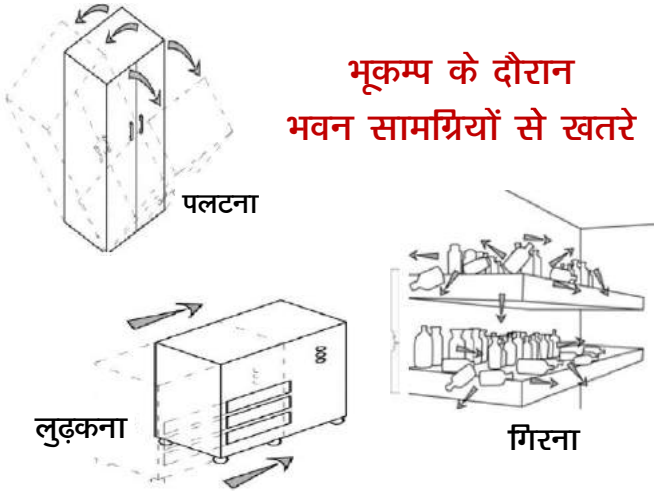
**During earthquakes**
**NON-STRUCTURAL ELEMENTS**
**may cause :-**

- ***Some of the deaths***
- ***Many or most of the injuries***
- ***A large proportion of economic damage, destruction and disruption***
- ***Loss of building contents***

## Falling Hazards (Non-Structural) mitigation

### RESEARCH FINDINGS




भूकम्प के दौरान
भवन सामग्रियों से खतरे

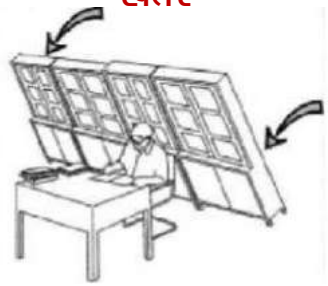
फोटो फ्रेम गिरने से चोट लग सकता है।

## भूकम्प के दौरान भवन सामग्रियों से खतरे

आलमीरा गिरने से दरवाजा बंद हो सकता है; निकल नहीं सकते।

## भूकम्प के दौरान भवन सामग्रियों से खतरे

आलमीरा गिरने से चोट लग सकता है।

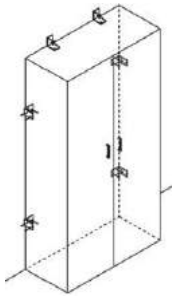


## SAFETY FROM BUILDING CONTENTS

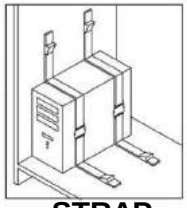
अगर भूकम्प दोलन के समय अस्थिर हो सकने वाले भवन सामग्री मौजूद हैं, तो,

- उन्हें संरचना के साथ मजबूती से बॉधना होगा, अथवा,
- उन्हें हटा देना चाहिए।

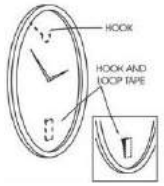
## भवन संरचना के साथ बॉधने की सामग्री



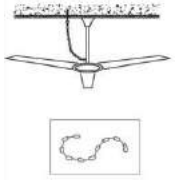
ANGLES



STRAP




HOOK



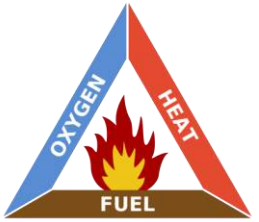
CHAIN

## BUILDING SERVICES, FIRE SAFETY

20 min

## COMMON CAUSES OF FIRE

- Kitchen Cooking
- Burning lamp
- Children playing with fire
- Excessive load over electric wiring
- Faulty Electric Heaters
- Fireworks, crackers
- Lighting
- Flammable materials




FIRE TRIANGLE

## REQUIREMENTS OF EXITS

**EXITS TO PROVIDE**
**SAFE ESCAPE OF OCCUPANTS**
**IN CASE OF FIRE / OTHER EMERGENCIES**

1) **Lifts and escalators are not exits.**
2) **Exits :**
   - **obstruction Free, clearly visible**
   - **lead to exterior open space of building**
   - **lead to exterior leading to the street**
   - **reached without passing through other occupied exits**
3) **Routes : signposted and Illuminated.**
4) **Fire Fighting Equipments: clearly located / marked**
5) **Alarm devices : to ensure prompt evacuation**


## EXITS : TRAVEL DISTANCE

A) **max. 20 meters for residential/ educational / institutional / hazardous occupancies.**

B) **max. 30 meters for assembly / business/ mercantile / industrial / storage occupancies**

1) **Travel distance to any exit is measured along the way out path.**
2) **In case of the subdivision of the floor into rooms, served by corridors/ passages, travel distance can be measured from the corridor entrance of such rooms/ suites.**
3) **For the portions of homes for the aged/ orphanages/ mental hospitals/ etc, double the provisions of these shall be taken.**

## OTHER REQUIREMENTS OF EXITS

1) Exit doorways to open into a stairway / horizontal exits/ corridor / passageway.
2) min. width = 1 m, min ht. = 2 m.
3) Exit doorways shall open outwards, but not obstruct travel.
4) Exit door, when opened, shall not reduce the width of the stairway/ landing to less than 0.9 m.
5) Exit doors shall open into a landing- and not directly into a flight of stairs.
6) Exits doors shall be operable from the inside without the use of a key.
7) Revolving doors can be used in residential / business/ mercantile occupancies subject to special conditions.

## FIRE DOOR

Rating 20-minutes to 3 hours

Maintain fire doors and shutters in good operating condition


## STAIRWAYS- INTERIOR STAIRS


1) No combustible material
2) Self contained, with at least one wall adjacent to an external wall.
1) Generally, shall not be arranged around a lift shaft.
2) min. width = 100 cm, min. tread = 25 cm for residential buildings;
3) min. tread= 30 cm for other buildings.
4) Treads design + construction + maintenance shall be done to prevent slipping

## STAIRWAYS- FIRE SCAPES/ EXTERNAL STAIRS

1) Shall be connected to the ground.
2) Entrance shall be separated/ remote from the main staircase
3) min. width = 75 cm,
4) min. tread = 20 cm
5) max. riser = 19 cm
6) max. riser/ flight = 16 nos.

## SPIRAL STAIRCASE

1) Limited to low occupant load / building heights of up to 9 m only unless connected to platforms/ balconies/ terraces; which allow evacuees to pause.
2) min. diameter = 150 cm
3) sufficient head room to be given.

## RAMPS

1) maximum slope of 1:10 (can substitute for / comply with all requirement of staircase).
2) in no case slope be greater than 1:8.
3) slopes of 1:10 to 1:8 allowed for height up to 2.40 m.
4) for heights more than 2.40 meters, these slopes shall not be greater than 1:20.
5) for slopes greater than 1:10, non skid materials to be used Should not be within minimum setbacks.
6) Permitted in the basement within the minimum setback provided it does not obstruct the movement of the fire engine.
7) Hospital ramps should not have slopes greater than 1:20.

**Entrance gate in high rise building campus**
**Width greater than 5 m**
**Height clearance 5m**

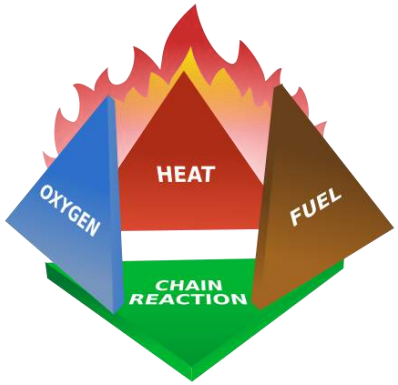
OBSTRUCTED
FIRE ESCAPE STAIR

## FIRE SIGNAGE




## FIRE FIGHTING

**skilful combination of removing fuel, heat, and oxygen**




fire tetrahedron

**Reducing Oxygen**
Water, dirt, foam and retardants

**Reducing heat**
water, foam, dirt, or scattering the fuels

**Removing Fuel**
Removing the fuel source

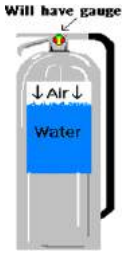
## FIRE EXTINGUISHERS

| | |
|---|---|
| Class A fire (A - Ash) | paper, wood, cloth, some rubber and plastic |
| Class B fire (B - Barrel) | combustible liquids, flammable gases, greases, some rubber and plastic materials |
| Class C fire (C - Circuit) | energized electrical equipment where safety requires the use nonconductive extinguishing media |
| Class D fire | combustible metals such as magnesium, titanium, zirconium, sodium, lithium and potassium |
| Class K fire (K-Kitchen) | grease |

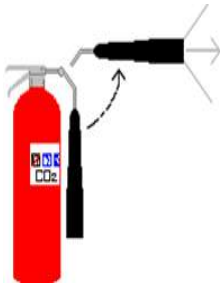
## PORTABLE FIRE EXTINGUISHERS

- Selection based on classes of anticipated fires, size and degree of hazard
- keep at readily accessible designated place, 15-25 m
- maintain in a fully charged and operable condition
- Record annual maintenance check date
- Instruction and hands-on practice

## FIRE EXTINGUISHER MATERIALS



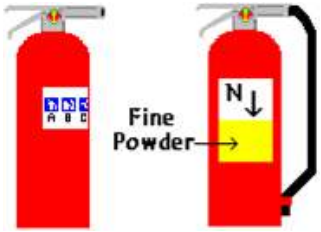

Pressurized Water
Class A fires
Pressure gauge




Carbon Dioxide
Class B & C fires
Hard nozzle
No pressure gauge

Dry Powder
Class D fires
fire causes powder to "cake" and form a barrier

## FIRE EXTINGUISHERS



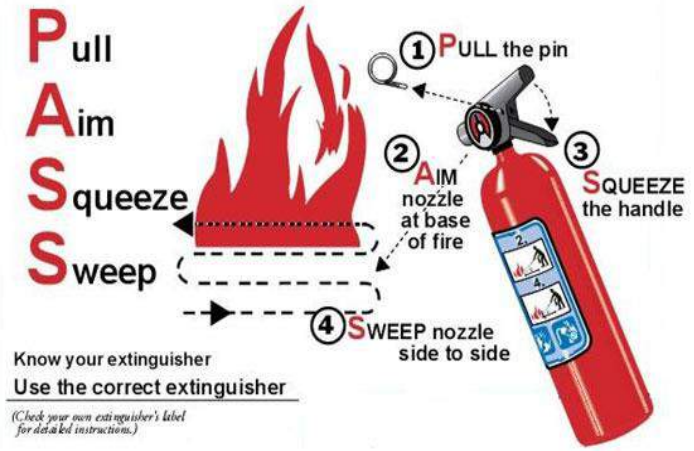

Multi-Purpose Dry Chemical
Use on Class A, Class B, and Class C fires
Fine powder under pressure
Pressure gauge present

Class K fires
Extinguisher liquid quickly cools down the grease, reduces the flames forms a vapor blanket

## Fire Extinguisher Chart

| Extinguisher | | Type of Fire | | | | | |
|---|---|---|---|---|---|---|---|
| Colour | Type | Solids (wood, paper, cloth, etc) | Flamable Liquids | Flamable Gasses | Electrical Equipment | Cooking Oils & Fats | Special Notes |
| | Water | ✓ Yes | ✗ No | ✗ No | ✗ No | ✗ No | Dangerous if used on 'liquid fires' or live electricity. |
| | Foam | ✓ Yes | ✓ Yes | ✗ No | ✗ No | ✓ Yes | Not practical for home use. |
| | Dry Powder | ✓ Yes | ✓ Yes | ✓ Yes | ✓ Yes | ✗ No | Safe use up to 1000v. |
| | Carbon Dioxide ($CO_2$) | ✗ No | ✓ Yes | ✗ No | ✓ Yes | ✓ Yes | Safe on high and low voltages. |

## To operate an extinguisher:




Know your extinguisher

Use the correct extinguisher

*(Check your own extinguisher's label for detailed instructions.)*

## FIRE FIGHTING SYSTEMS


FIRE ALARM SYSTEM

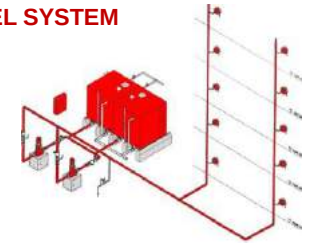
SMOKE DETECTOR

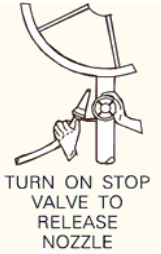
HEAT DETECTOR

**AUTOMATIC SPRINKLER SYSTEMS**

**Check periodically the control valves, water and air pressure**

## HOSE REEL SYSTEM





TURN ON STOP VALVE TO RELEASE NOZZLE

RUN OUT THE HOSE

TURN ON WATER AT NOZZLE AND DIRECT THE STREAM AT THE BASE OF FIRE

## BIHAR BUILDING BYE LAWS 2014

30 min

## INSTITUTIONAL PROVISIONS

- **BIHAR MUNICIPALITY ACT 2007**
  - **Establishment and maintenance of shelters, in times of disasters, and relief works**
  - **Empowers the State Government to make building rules for protection against natural disasters**
- **BIHAR URBAN PLANNING ACT AND RULE 2012, 2014**
  - **Identify and map the facilities and human resources at the level of village, block, city and district;**
  - **Mapping of vulnerable areas which are disaster prone and plan for pre-disaster, disaster mitigation and post-disaster**

## BIHAR BUILDING BYELAWS 2014

***Applicable to places:***

- **All Municipal Corporations**
- **All Municipal Councils**
- **All Nagar Panchayats**
- **All Metropolitan areas**
- **All Planning areas under Planning Authorities**
- **Gram Panchayat areas covered under various Development Plan**

***Applicable to activities:***

- **Planning, Design and Construction of building**
- **Removal / Demolition / Alteration of building**
- **Change of occupancy of a building**
- **Sub-division of land**
- **Change in use of land or building**

## BYE-LAWS DISASTER MITIGATION PROVISIONS

**1. Flood affected area demarcation during site plan preparation. {Section (5)(3)(ii)(d)}**

***All major physical characteristics size of water body, flood-affected areas and 0.5 m contours at in case of the site which has a slope of more than 1 in 20.***

**2. Compliance with Guideline on Earthquake safety requirements during plan sanctioning process. {Section (6)(vii).}**

***A certificate from the registered Engineer that the building plan and the design complies with the Earthquake Safety requirements as stipulated in the*** *(बिहार राज्य आपदा प्रबंधन प्राधिकरण, बिहार में, भूकम्पीय खतरों से न्यूनीकरण के लिये, भवनों के निरूपण एवं निर्माण का परिपत्र)* ***as in Appendix A.***

## BYE-LAWS DISASTER MITIGATION PROVISIONS

**3. Warning to Structural engineer for fault in design {Section (6)(2)(2)}**

***Empanelled Structural Engineer, who has prepared the structural design, shall put his seal, and address on all the documents signed by him and shall also furnish a certificate to the effect that he shall supervise the structural part of the construction and shall be responsible for any structural failure and except if the owner intimates that his services have been terminated.***

**4. Provision for preparedness before any hazard *{Section (6)(2)(3)}***

***All structural design,, plumbing, electrical installation, sanitary arrangements, fire protection shall adhere to the specification, standards and code of practice recommended in the National Building Code of India, 2005.***

## BYE-LAWS DISASTER MITIGATION PROVISIONS

**5. Before issuing occupancy certificate, the competent authority shall verify that the building complies with the provisions of life safety as mentioned in National Building Code 2005 . {Article (16)(4)}**

**In case of multi storied building (residential buildings greater than 15m in height) and other special building covered area more than 500 sq.mtr., periodic inspection shall be made by the authority**

**6. No construction or re-construction of any building, within a strip of land of 200 m from the outer boundary of the river of Ganges except for repair and renovation work of heritage buildings. {Article (22)(1)}; other rivers 100 m {Section (22)(2)}**

## BYE-LAWS DISASTER MITIGATION PROVISIONS

**7. Structural safety of building in areas of flood plain *{Section (29)(G)}***

***no permission to construct a building on a site shall be granted: In case of areas which get flooded if the Structural Plans are not prepared taking this into account.***

**8. Demarcation of unsafe building . *{Article (23)}***

***All unsafe buildings shall be considered to constitute danger to public safety and shall be restored by repairs or demolished as directed by the Authority.***

**9. Prohibition of Hazardous activities in Public Areas (Residential , Commercial, Public-Semi Public spaces, Agricultural, Forest, and Along Water Bodies) *{Section (28)(1)}***

## BYE-LAWS DISASTER MITIGATION PROVISIONS

**10. Provision of setback and exit way for the time of emergency**

**Minimum setbacks for high rise buildings.- For high-rise/ multi-storied buildings, the open spaces around the building unless or otherwise specified shall be as given in the Table 14. *{Section (36)(1)***

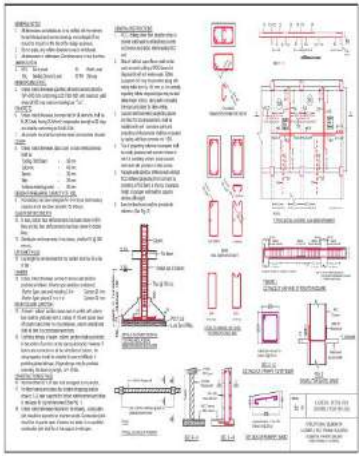
**In case of multi storied buildings the exterior open space around a building shall be of hard surface capable of taking load of fire engine weighting up to 45 tonnes. *{Section (36)(3)}***

**Every building meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants, in case of fire or other emergency. *{Section (42)(1)}***

**11. Life Safety provisions as per National Building Code**

**The building design shall comply to the provisions of life safety as mentioned in National Building Code 2005(Group-1 Part-IV Fire and Life Safety-4). *{Section (56)}***

## BIHAR BUILDING BYELAWS 2014 : APPENDIX A

## BYE-LAWS DISASTER MITIGATION PROVISIONS

12. **Compliance with standards of Structural safety issued by Bureau of Indian Standards in building.** ***Section (59)(1)}***

**All buildings shall comply with the standards as mentioned below :**

**For General Structural Safety**

| | | |
|---|---|---|
| IS: 456:2000 | IS: 800-1984 | IS: 801-1975 |
| IS 875 (Part 2) | IS 875 (Part 3) | IS 875 (Part 4) |
| IS 875 (Part 5) | IS: 883:1966 | IS: 1904:1987 |
| IS 1905:1987 | IS 2911 (Part 1) | |

**For Earthquake Protection**

| | | |
|---|---|---|
| IS: 1893-2002 | IS: 13920-1993 | IS:4326-1993 |
| IS:13828-1993 | IS:13827-1993 | |
| IS:13935-1993 | | |

## REFERENCE TO BIS CODES IN BYELAWS 2014

**National Building Code 2005**

| | |
|---|---|
| **IS 456-2000** | Plain and Reinforced Concrete - Code of Practice |
| **IS SP I6-1980** | Design Aids to IS 456-1978 |
| **IS 800-2006** | Code of Practice for Genera Construction in steel |
| **IS 875(part 1)-1987** | Unit weights of building material and stored materials: Code |
| **IS 875 (part 2) - 1987** | Imposed (live) loads for Buildings and Structures: Code |
| **IS 875 (part 3) - 1887** | Wind Loads for Buildings and Structures: Code of Practice |
| **IS 1905-1987** | Standard use of Unreinforced Masonry Code of Practice |
| | **FOR FOUNDATION SAFETY** |
| **IS 1892—1979** | Subsurface investigation for foundations Code of Practice |
| **IS 2131-1981** | Method of Standard Penetration Test for soil (First Revision) |
| **IS 1498-1970** | Classification and identification of soil for engineering purposes |
| **IS 1904-1986** | Foundations In Soil Code for General Requirements |
| **IS 6403—1981** | Determination of Bearing Capacity of Shallow foundation: Code |
| **IS 2950 Part 1-1981** | Design and Construction of Raft foundation Code of Practice |
| **IS 2911(Part 1/Sec 2)** | Bored cast in situ Plain Concrete Pile Foundation: Code |
| **IS 2911(Part 3).1980** | Bored cast in situ Under reamed Pile Foundation Code |
| **IS 2911(Part 4).1985** | Load Test on Pile Foundation Code of Practice |
| | **FOR BUILDING MATERIAL** |
| **IS 383-1970** | Specification for coarse and fine aggregates for concrete |
| **IS 1199-1959** | Methods of sampling arid analysis of concrete |
| **IS 516-1959** | Methods of tests for strength of concrete |
| | **FOR EARTH QUAKE SAFETY DESIGN** |
| **IS 1893 (Part 1)-2002** | Criteria for Earthquake Resistant Design **of** Structures(5th revision) |
| **IS 13920-1993** | Ductile detailing of RCC structures against EQ forces: Code |
| **IS 4326-1993** | Earthquake Resistant Design and Construction of Buildings Code |

## FORMS TO BE SUBMITTED FOR ENSURING SEISMIC SAFETY

1. **Necessary Environmental clearance from the appropriate authority wherever applicable.**
2. **Compliance Certificate (Form III) from the registered Engineer that the building plan and the design complies with the Earthquake Safety requirements**
3. **Structural Stability Certificate in the prescribed Form-IV with Design Basis Report, signed by the engineer /structural engineer**
4. **Supervision Certificate in Form-V**
5. **A check list in Form-VI**
6. **Certificate of Occupancy Form-XIII**
7. **Indemnity Bond for Basement Form- XV**
8. **Certificate of Undertaking for Hazard Safety Requirement. Form-XVI**

## CONCLUSION

**FOR SAFE AND SUSTAINABLE DEVELOPMENT** AND **SEISMIC SAFETY IN BUILDINGS**, **ENFORCEMENT OF BUPD ACT (2012), BUPD RULE(2014) AND BIHAR BUILDING BYELAWS (2014) IS MANDATORY.**

## STRUCTURAL DESIGN BASIS REPORT
# SDBR

10 min

## STRUCTURE DESIGN BASIS REPORT (SDBR)

**"For buildings more 15m in height, structural stability certificate in the prescribed Form-IV with Design Basis Report, signed by the engineer /structural engineer and the owner jointly shall be furnished."**

- **By the structural designer**
- **While initiating structure analysis**
- ***Prior to Structural Design***

**for**

- **Permission from Statutory Body**
- **Approval from Senior Officer in Dept.**
- **Ask from Design Consultants**

## TO FURNISH INFORMATIONS in SDBR

**Fill up the relevant information in prescribed DBR Format with**

- ✓ **Calculated Design parameters / values**
- ✓ **Reference BIS Code with relevant Clauses**
- ✓ **Plan & Sections of buildings**

## DESIGN DATA

- TYPE OF STRUCTURE
  - Load Bearing
  - RCC Frame
  - RCC Frame and Shear Wall
- SOIL DATA : IS 1893 Cl 6.3.5.2
  IS 1904
  - Type of Soil
  - Design Safe Bearing Capacity

## DESIGN DATA ….. Continued

- IMPOSED LOADS : IS 875 Part 2
  - Plaza Floor accessible to Fire Tender
  - Floor Loads : Enclose Plans – A4 size
  - Roof Loads
    : Terrace Garden – Additional Loads
- WIND LOADS : IS 875 Part 3
  - Wind Speed
  - Design Pressure Intensity

## DESIGN DATA ….. Continued

- SEISMIC LOADS : IS 1893 -2002
  - Seismic Zone
  - Seismic Zone Factor (Z) : Table 2
  - Importance Factor : Table 6
  - Response Reduction Factor : Table 7
  - Fundamental Natural Period : Cl. 7.6
  - Design Horizontal Acceleration : Cl. 6.4.2
  - Expansion / Separation Joint : Cl. 7.11
    : Indicate on Plans – A4 size

## 1. LOAD BEARING MASONRY BUILDING

- BUILDING CATEGORY : IS 4326 Cl. 7

| BUILDING | SEISMIC ZONE | | | |
|---|---|---|---|---|
| | II | III | IV | V |
| ORDINARY | B | C | D | E |
| IMPORTANT | C | D | E | E |

- TYPE OF WALL MASONRY
- TYPE AND MIX OF MORTAR
  : IS 4326 Cl. 8.1.2

## 1. LOAD BEARING MASONRY BUILDING ….. continued

- SIZE AND POSITION OF OPENINGS
  : IS 4326 Table 4, Fig. 7
- WALL : HEIGHT / THICKNESS
- WALL : LENGTH / THICKNESS

Use separate A4 Sheets for each wall

- HORIZONTAL SEISMIC BANDS
  : IS 4326 Cl. 8.3, Cl. 8.4

- VERTICAL REINFORCING BARS : IS 4326 Cl. 8.4
  - At Corners and T junction of walls
  - At Jambs of Door & Window openings

## 2. RCC FRAMED BUILDING

- TYPE OF BUILDING : IS 1893 Cl. 7.1
  - Regular Frames
  - Regular Frame with Shear Wall
  - Irregular Frame
  - Irregular Frame with Shear Wall
  - Soft Storey
- NUMBER OF BASEMENTS
- NUMBER OF FLOORS INCLUDING GF

## 2. RCC FRAMED BUILDING … Continued

- HORIZONTAL FLOOR SYSTEM
  - Beams and Slabs
  - Ribbed Floor
  - Flat Slab with drops
  - Flat Plate without drops

## 2. RCC FRAMED BUILDING … Continued

- SOIL DATA
  - Classification of Soil : IS 1498
  - Recommended SBC of Soil : IS 6403
  - Capacity of Piles : IS 2911
  - Under Ground Water Table
    - Depth
    - incorporated Capacity Calculations
  - Chemical Analysis
    - Ground Water
    - Foundation Soil

## 2. RCC FRAMED BUILDING … Continued

- FOUNDATION RECOMMENDATION
  - Type of Foundation
    - Isolated Footings
    - Interconnected Footings
    - Raft, K values (sub grade Reaction)
    - Piles ( type, dia., length, capacity)
  - Depth below GL
- SYSTEM OF INTER CONNECTED FOUNDATION : IS 1893 Cl. 7.12.1
  - Plinth Beams
  - Foundation Beams

## 2. RCC FRAMED BUILDING … Continued

- CONC. GRADE USED IN DIFFERENT MEMBERS : IS 456 Table 5
- METHOD OF ANALYSIS USED, Idealization
- COMPUTER SOFTWARE USED
- TORSION INCLUDED : IS 1893 Cl. 7.9
- BASE SHEAR : IS 1893 Cl. 7.5.3
  a. Based on Approximate Fundamental Period
  b. Based on Dynamic Analysis
  c. Ratio of a/b

## 2. RCC FRAMED BUILDING … Continued

- DISTRIBUTION OF SEISMIC FORCES ALONG HEIGHT : IS 1893 Cl. 7.7 , Provide Sketch
- DISTRIBUTION OF BASE SHEAR AND BASIS OF ANALYSIS, IF SHEAR WALL & COLUMN USED Provide Sketch
- COLUMN OF SOFT STOREY SPECIALLY DESIGNED : IS 1893 Cl. 7.10
- SYSTEM USED TO COUNTERACT EARTH PRESSURE IF BASEMENT USED

## 2. RCC FRAMED BUILDING … Continued

- MINIMUM CLEAR COVER PROVIDED IN
  - Foundation
  - Column
  - Beam
  - Slab
  - Wall

## 2. RCC FRAMED BUILDING … Continued

- **DUCTILE DETAILING OF RC FRAME**
  - **Type of Reinforcement used : IS 456 Cl. 5.6**
  - **BEAMS**
    - **Minimum Dimension : IS 13920 Cl. 6.1**
    - **Min. % and Max. % of Reinforcement : IS 13920-1993 Cl. 6.2, 7.2**
    - **Spacing of Stirrups in 2-d length near ends : IS 13920 Cl. 6.3.5**
    - **Ratio of SF due to gravity load and Plastic hinge formation / factored SF : IS 13920 Cl. 6.3.3**

## 2. RCC FRAMED BUILDING … Continued

- **DUCTILE DETAILING OF RC FRAME …. Continued**
  - **COLUMNS**
  - **Minimum Dimension : IS 13920 Cl. 7.1**
  - **Max. % of Reinforcement : IS 456 Cl. 26.5.3.1**
  - **Ties (dia. & spacing) near ends & within joints : IS 13920 Cl. 7.4**
  - **Ratio of shear capacity /calculated storey shear : IS 13920 Cl. 7.4**

# THANK YOU

बिहार सरकार
बिहार राज्य आपदा प्रबंधन प्राधिकरण
(आपदा प्रबंधन विभाग)
पंत भवन, द्वितीय तल, पटना–1

# (7)
# IMPLEMENTATION OF DRR:
# DRR Road Map
# NDMA Guidelines
# Technical Intervention

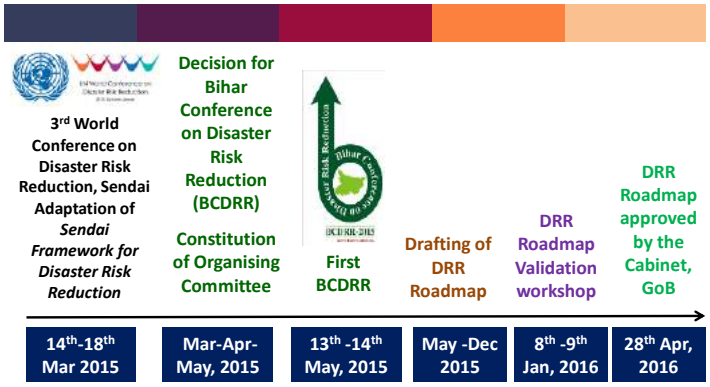
Government of Bihar
Department of Disaster Management

## BIHAR DISASTER RISK REDUCTION ROADMAP 2015-2030

**PARTNERSHIP OF ENGINEERS**

60 min

### Process of Roadmap development




### DRR Initiatives and Achievements in Bihar till 2015

**Policies**

- Kosi Disaster: Rehabilitation & Reconstruction Policy
- Bihar State Disaster Management Policy (2007)
- Agricultural Roadmap
- Bihar State Action Plan on Climate Change

**Institutions**

- Disaster Management Department (DMD)
- Bihar State Disaster Management Authority (BSDMA)
- Crisis Management Group (CMG)
- State Executive Committee (SEC)
- Bihar Institute for Public Administration and Rural Development (BIPARD)
- National Disaster Response Force (NDRF)
- State Disaster Response Force (SDRF)
- District Disaster Management Authority (DDMA)

## DRR Initiatives and Achievements in Bihar till 2015

**Institutions** cont.....

- Flood Management Information System Centre (FMISC)
- Bihar Aapda Punarvas Evam Punarnirman Society (BAPEPS)
- Bihar Inter Agency Group (BIAG)

**Plans, SOPs and Financial Management**

- State Disaster Management Plan (SDMP)
- State Disaster Response Fund
- State Disaster Mitigation Fund
- Building code and Bye-Laws
- SOPs for Flood, Drought, Drinking Water, Fire & Hospital Safety
- Directives and Guidelines
- District Disaster Management Plans (formulating)
- Departmental DM Plans / Office Disaster Management Plans (in formulation stage)

## DRR Initiatives and Achievements cont.....

**Infrastructure, materials and equipment**

- Emergency Operations Centre (EOC)
- District-level Disaster Management Warehouses
- Communications and transportation equipment
- Search and rescue equipment
- SDRF base at Bihta, with search & rescue equipment
- Flood Shelters

**Capacity Building**

- Search and Rescue
- Community Preparedness
- Safe Construction
- Mock Drills
- Advance trauma and life support through QMRT
- Earthquake resistant construction (Training of Engineers, Architects and Masons)
- Rapid Visual Screening
- Training of BAS & BPS officers

## DRR Initiatives and Achievements cont.....

**Public Awareness and Education**

- Hazard-specific Safety Weeks (Flood, Earthquake, Fire, Road Safety)
- School Safety Fortnight and Day
- Bihar Diwas, DM related activities & Exhibitions
- IEC Materials

**Risk Assessments**

- Flood Hazard Atlas, Flood Management Information
- Risk Informed Development Planning – System (RIDP-S)

**DRR Programs and Schemes**

- Kosi Flood Recovery Project
- School Safety Programmes
- Community Based Disaster Risk Reduction CBDRR
- Shatabdi Anna Kalash Yojana (Scheme)
- Bihar Scheme for Assistance to Farmers in Farm Distress

## Multi-Hazard Profile of Bihar

| | |
|---|---|
| **Recurring Floods:**<br>▪ 28 districts prone to floods<br>▪ 17% flood-prone area | **Earthquake:**<br>7 dist. in Seismic zone V<br>EQ in 1934, 1988 & 2015<br>63 lost life in 2015 EQ in Bihar |
| **Drought:**<br>13 dist.) suffer from drought<br>drought in 2002, 2007, 2008, 2009, 2010, 2011 & 2013 | **Cyclonic storms:**<br>27 dists fully affected<br>killed 59 people in April, 2015 |
| **Severe Cold wave, Heat Wave, Lightning, Hailstorm** | **Village fires in summer:**<br>covers all the 38 districts of Bihar |
| **Health emergencies** i.e. Acute Encephalitis Syndrome (AES) | |
| **Climate Change** showing signs | |

## List of Notified Disasters:

**Ministry of Home Affairs,** Government of India (GoI) notified list of **'natural calamities':**

Avalanche, cloud burst, **cold wave**, **cyclonic storms**, **drought**, **earthquake**, **fire**, **flood**, **hailstorm**, landslide, tsunami, and pest-attack.

**GoB notified state specific local disasters:**

Lightning, Heat Wave, Excess Rainfall, Unseasonal and Heavy Rain, Boat Tragedies, Drowning (rivers, ponds and ditches), **Snake bite & Animal attack**, Human Induced Group Accidents such as Road Accidents, Airplane Accidents, Rail Accidents, Gas Leakage and **Chemical, Biological and Nuclear (CBN) disasters**

## Disaster Risk Profile of Bihar: A, B, and C Districts


## BIHAR DRR ROADMAP 2015-2030

**Targets** **Milestones**

- **Resilient Villages**
- **Resilient Livelihoods**
- **Resilient Critical infrastructure**
- **Resilient Basic Services**
- **Resilient Cities**

**Specific Actions, Responsible Actors, Timeline**

## TARGETS:

1. **Lives lost due to natural disasters in Bihar would be reduced by 75% of the baseline level by 2030.**
2. **Lives lost due to transportation related disasters (viz. road, rail and boat accidents) in Bihar would be substantially reduced over baseline level by 2030.**
3. **People affected by disasters in Bihar would be reduced by 50% of the baseline level by 2030.**
4. **Economic loss due to disasters in Bihar would be reduced by 50% of the baseline level by 2030.**

## MILESTONES:

**BY 2020:**

1. Baseline status for each of the four targets is developed.
2. Training of Engineers, Architects, Masons etc. for safe construction of projects and buildings completed.
3. Structural safety audits of all government offices/ buildings and infrastructure (such as Secretariat, Collectorates, SDO/Block/Anchal Offices, Police Offices and Stations, Schools, Hospitals, Panchayat Bhawans, Anganwadi centres etc.) is completed and corrective measures initiated.
4. Safe construction of all major Government projects and building is initiated.

## MILESTONES:

**BY 2020:**

5. Emergency Support Functions are notified and made operational with fully-functional Emergency Operations Centres (EOCs) at state and district levels.
6. Structural safety of all commercial buildings (such as malls, cinema halls and other public places of mass gathering) is ensured.
7. Comprehensive multi-hazard risk analysis (current and emerging disaster risks) and incorporating in annual plans and PIPs of all line departments and annual plans of PRIs and ULBs.

## MILESTONES:

**BY 2020:**

8. Service Delivery Continuity Plans (SDCPs) and Infrastructure Continuity Plans (ICPs) for all basic services & critical infrastructures - to ensure department functions return to 'business as usual' in the quickest time.
9. An effective Early Warning System (EWS) is established, wherein all villages and cities in Bihar have systems for early warning information reception, dissemination and taking up immediate good enough pertinent action.
10. DDMAs strengthened with resources, mandates and capacities for playing an integral role in disaster risk reduction decision making at the district level.

## MILESTONES:

**BY 2020:**

11. Communities understand and practice 'do's and don'ts' during disaster situations as a result of a state-wide public awareness and education campaign launched at all levels.
12. Building bye-laws incorporating safe construction in all urban areas are approved.
13. Communities are encouraged and a policy regime is developed to enforce safe construction in rural areas.

## MILESTONES:

**BY 2025:**

1. Corrective measures, including retrofitting of all govt offices and social infrastructure are completed.
2. A system for Risk Informed Development Planning (RIDP) is adopted and operational at all levels of planning.
3. All PRIs and ULBs are adequately empowered through funds, functions and functionaries.
4. Communities in all villages and cities regularly monitor current and emerging disaster risks, including underlying risks, and assert for measures to be taken.
5. Platforms and mechanisms are institutionalized across Bihar for effective learning and sharing on DRR planning, implementing and drawing learning.

## MILESTONES:

**BY 2030:**

1. Policies and practices for agriculture and other livelihood related risk transfer, sharing, and compensation are adopted by agriculture and small industry based livelihoods systems in Bihar.
2. Rural and urban habitat planning processes like land zoning, town and city development planning take into account existing and emerging disaster risks.
3. All existing and new public and private buildings in Bihar are structurally safe from a multi-hazard perspective.

## SPECIFIC ACTIONS FOR DEPARTMENTS

### General points for all departments/ agencies:

- Specific Actions have been arranged department/ agency wise.
- Nodal department/ agency will lead the activities whereas supporting departments would provide requisite support
- Action (State, District, Block, and Gram Panchayat or Urban area) and the timeline (short-term, medium term and long- term) for each specific activity has been identified.
- Each department/ agency has to make budgetary provisions for the assigned activities in their annual budget; DMD can supplement funds if some of the activities can't be budgeted by the departments/ agency.

## Specific Actions for *Health Department*

### Resilient Basic services

1. Undertake corrective measures for enhancing the resilience of the infrastructure facilities (retrofitting, relocation) and service delivery systems.
2. Ensure that all new constructions of the primary, secondary and tertiary health facilities are green, disabled-friendly and flood, earthquake and fire resistant.

## Specific Actions for *Education Department*

**Resilient Basic services**

1. Develop a resilience index for education facilities and determine the current status.
2. Review school building guidelines/ designs and include structural safety elements.
3. Ensure that all new constructions of educational institutions are green, disabled friendly, earthquake and fire resistant with adequate escape routes.
4. Undertake corrective measures for enhancing the resilience of the infrastructure facilities especially in Group A and Group B districts.
5. Map schools wherein school functioning gets cut-off during disaster situations modify the annual lesson planning / timetable.

## Specific Actions for *Public Health Engineering Department*

**Resilient Basic Services**

1. Develop a resilience index for WASH facilities & services and determine Current Status based on resilience index.
2. Undertake Corrective Measures for infrastructure facilities (retrofitting, relocation) and service delivery systems
3. Exercise provision of WASH services, especially in the Critical and Inaccessible Areas.
4. Ensure that "piped water supply to every house" and "Toilet in all houses" are disabled & senior citizen friendly, earthquake & fire resistant.
5. Ensure all the Hand Pumps installed on above the Highest Flood Level (HFL) in category A and B districts
6. Ensure construction of raised toilets and drinking water facilities in Group A and B districts
7. Preposition of mobile toilets during disasters.

## Specific Actions for *Building Construction Department*

**Resilient Villages & Cities**

1. Ensure that all new public buildings henceforth are green, and multi-hazard resistant.
2. Conduct Safety Audit of existing public buildings from multi-hazard perspective in all the villages.
3. Retrofitting of all existing public buildings in a phased manner
4. Provide technical assistance to community at district level for building hazard resistant houses.
5. Identify safe places and construct multi-hazard shelters in Gram Panchayats in all Group A and B districts.
6. Set up 'Earthquake Safety Clinic' in all urban areas.
7. Create 'Safe Construction Resource Centres' in partnership with IIT, NIT and Polytechnics.

## Specific Actions for *Water Resources Department*

**Resilient Village:**

1. Identify high flood risk prone villages and develop inundation maps.
2. Undertake flood protection measures well in advance.
4. Undertake construction & repair of embankments.
5. Identify the areas and villages wherein land is getting eroded due to river waters and undertake land protection.
6. Augment existing Irrigation potential by more than 100%.

**Resilient Livelihoods:**

1. Initiate measures for repairs and de-siltation of canals and water bodies and increase the irrigation coverage especially in the 13 drought-prone districts (Group C).
2. Undertake drainage development plans to reduce the risk of flash floods.

## Specific Actions for
*Water Resources Department*

**Resilient Critical Infrastructure:**

1. Carry out 'risk impact' analysis of a proposed dam, embankment, aahar & reservoir before construction /repair.
2. Effective implementation of the Flood Control SOP and Embankment Management Guidelines of WRD.
3. Undertake a scenario based analysis of L2 & L3 scale of disaster events and develop a contingency plan.
4. Training of PRI members and community volunteers on breach signs, communication and immediate actions.
5. Engage neighbouring states to undertake risk impact analysis of dams located in these States on Bihar.
6. Capacity building of departmental Engineering staff in risk resilience designing and implementation of dams, embankments and reservoirs

## Specific Actions for
*Urban Development Department*

**Resilient Basic Services - Housing:**

1. Carry out 'risk impact' analysis of a proposed dam, embankment, aahar & reservoir before construction /repair.
2. Undertake a drive to analyse risk of all urban houses to determine the current status and to encourage inhabitants to undertake appropriate corrective measures.
3. Develop a menu of designs and manuals with varying cost slabs for urban housing from different geo-climatic zones for Group A and B districts.
4. Identify and provide incentives/awards to builders who have created models of resilient urban housing as per building bye-laws.
5. UDD to monitor of adherence to the building codes and take punitive actions for violations.

## Specific Actions for
*Urban Development Department*

**Capacity Building:**

1. Engineers, architects, masons, contractors, builders, and building artisans on disaster-resilient house construction and manuals and ULBs on building codes.

**Communication and Knowledge Building:**

1. Sensitize the citizens through citizen councils and civil society organizations for insisting on resilient housing.
2. Public awareness on disaster-resilient housing.
3. Develop and widely disseminate the Do's and Don'ts related to disaster-resilient houses and housing colonies.
4. Develop guidance material for homeowners on area, house design, technology choice and construction specification, quantities of different materials.

## Specific Actions for
*Urban Development Department*

**Resilient Cities:**

1. Launch 15-year “Resilient Cities Programme”:
   a. Disaster and climate change induced risk analysis
   b. Develop "resilient city checklist“ & a baseline status.
   c. Review and refine land zoning, town planning, city development plan, and urban settlement planning
   d. Identify all natural water bodies, plantations, wetlands and ensure that they are not encroached upon and actions for their restoration..
   e. Identify all hazardous industries and ensure that DM Plans are developed, approved and practiced.
   f. Make provisions for additional allocation under Grant-in-Aid to the ULBs

2. Ensure that all new public buildings are green & resilient to various hazards; Tax rebates for such construction
3. Conduct Safety Audit and Retrofitting of of existing public and community buildings.
4. Analysis of flooding and water logging risks, land-use patterns and existing & natural drainage systems.
5. Develop scenario based inundation maps for planning preparedness & response.
6. Assess, procure and install water pumps; Construct safe spaces / shelters; Pre-monsoon clearance of drainage / sewage systems.
7. Waste water and sewage treatment / recycling plants.
8. Monitor and prevent any construction of private and public buildings inside the flood-line.
9. Develop and implement a rehabilitation and resettlement policy for houses inside the flooding zone
10. Undertake comprehensive capacity enhancement of ULB members and UDHD officials
11. Capacity building through ToT, Training Workshops, Demonstrations, Learning Visits, Support Tools, etc. of:
    - ULBs, UDHD, Frontline Workers, and Volunteers on risk analysis, risk informed development planning, and implementing initiatives
    - Architects, builders, engineers, supervisors, and masons on construction and retrofitting
    - Citizen councils, youth club, college students, teachers, shop keepers, police personnel on (i) first aid, (ii) traffic rules, (iii) safe driving, (iv) vehicle fitness, (v) police centres for accident events.
12. Develop communication using different media like TV, Radio, Newspapers, Street Plays in Malls, Grounds, Schools, Colleges, and Demonstration Exercises.
13. Develop an annual report card based on the resilience checklist for ULBs to review their performance.

## Specific Actions for

***Rural Development Department***

### Resilient Villages:

1. Indira Aawas Yojana (IAY) should be hazard resistant.
2. Construction of water conservation and water harvesting structures in the villages especially in drought prone villages and districts under MGNREGA.
3. Undertake tree plantation in flood prone districts

### Resilient Livelihood:

1. Disaster resilient agricultural practices in the Bihar State Rural Livelihood Mission (*Jeevika*).
2. Availability of work to the disaster affected populace close to their homes/ temporary shelters / camps.
3. Restoration of agricultural lands and appropriate crops.
4. Repairs and restoration of public infrastructure and community assets.

### Resilient Basic Services:

1. Modify designs & Cost of IAY and *such schemes* for multi-hazard resilience under and geo-climatic contexts
2. Create mechanisms and procedures for strict monitoring of adherence to the building codes and safety norms

### Capacity Building:

1. Disaster resilient construction choices for community
2. Engineers, architects, masons, contractors, builders, and building artisans on disaster-resilient house construction
3. Panchayats and Vikas Mitras for resilient IAY / housing
4. Panchayats on building codes

### Communications and Knowledge Building:

1. Public awareness on disaster-resilient housing
2. Develop guidance material for homeowners on area, house design, technology choice and construction specification, quantities of different materials.

## Specific Actions for
### *Road Construction & Rural Works Department*

**Resilient Village:**

1. Conduct road safety audit in terms of floods and ensure that all village and major district roads constructed henceforth are flood resistant in flood prone districts.
2. Conduct safety audit of all bridges and ensure that all bridges are earthquake resistant.
3. Ensure that all MDRs and NHs passing through habitations are pedestrian- and slow moving vehicle-friendly to prevent accidents.
4. Ensure proper and standard signage are put on road side for safe travel.

**Resilient Critical Infrastructure:**

1. Develop a resilience index and / or quality standards pertaining to roads and bridges as critical infrastructure.
2. Map the existing roads and small and large bridges, including their GIS mapping and determine their resilience.
3. On the basis of this exercise, undertake corrective actions, including strengthening or rerouting in selected areas, reinforcing through specialized materials or design changes, and such especially for Group A and B districts.
4. Ensure that an annual disaster risk analysis exercise is conducted as part of the annual planning cycle for targeting, resource allocation and additional measures for specific vulnerabilities.
5. Make it mandatory to include disaster risk analysis as part of the designing of a proposed road and bridge construction activity before approval for construction is given.
6. Develop coordination plans with the engineering division of the armed forces for support in restoration, and / or temporary alternative arrangements for the damaged roads and / or bridges in case of disaster events.
7. Map existing road network within state along with alternate routes' reckoner for ensuring access to disaster affected areas for L1 & L2 category of disaster events, disseminate it widely and develop a mobile-based and/or Web-based Application for people to have access to this information.
8. Map the critical gateway Road routes to the State, and take steps to ensure their functioning in case of an L3 event.
9. Capacity Building of departmental Engineering staff in risk resilience designing and implementation of roads and bridges

## Specific Actions for
### *Social Welfare Department*

**Resilient Basic Services:**

1. Based on this resilience index assessment and structural safety guidelines, undertake corrective measures for enhancing the resilience of the infrastructure facilities (retrofitting, relocation) and service delivery systems (additional resources, personnel, supplies, and such) especially in Group A and Group B districts.
2. Ensure that the AWC is made part of the soon to be constructed *Panchayat Bhawans* and ensure that these AWCs as well as *Panchayat Bhawans* are structurally resilient from a multi-hazard context.

## ENABLING POLICY ARCHITECTURE

1. **Overview of disaster management related policy architecture of Bihar,**
2. **Legal Amendments required:** PRI act & ULB Act (by Urban Development and Housing Department)
3. **Develop policies:** Disaster Recovery Policy, Livelihood Recovery Policy, Water Management Policy, Waste (Solid and Liquid) Management Policy, Climate Change Adaptation Policy
4. **Notify the Emergency Support Functions (ESF)**
5. **Guidelines/ manuals/ directives**
6. **SOPs on** Earthquakes, Cyclonic Storms, Crowd Management, Debris clearance, dignified disposal of dead bodies and animal carcasses, Functioning of State and District Emergency Operation Centres (EOCs)
7. **Programmes:** Resilient Village programme, Resilient City programme and Chief Minister School Safety programme.

# NDMA Guidelines

10 min

## NDMA GUIDELINES

- **Guidelines on Management of Earthquakes**
- **Guidelines on Management of Tsunamis**
- **Guidelines on Management of Cyclones**
- **Guidelines on Management of Flood**
- **Guidelines on Management of Urban Flooding**
- **Guidelines on Drought Management**
- **Guidelines on Landslide and snow avalanches**
- **Guidelines for Nuclear and Radiological Emergencies**
- **Guidelines on Chemical Disaster (Industrial)**
- **Guidelines for Chemical(Terrorism) Disaster )**
- **Guidelines on Medical Preparedness and Mass Casualty Management**
- **Guidelines for Biological Disaster**
- **Guidelines for Psycho-Social Support**

## NDMA GUIDELINES cont…..

- **Guidelines on Formulation of State DM Plans**
- **Guidelines for Incident Response System**
- **Guidelines for National Disaster Management Information and Communication System**
- **Guidelines for Scaling, Type of Equipment and Training of Fire Services**
- **Guidelines for Seismic Retrofitting of Deficient Buildings and Structures.**
- **Guidelines for Preparation of Action Plan – Prevention and Management of Heat-Wave**
- **Guidelines on Management of School Safety**
- **Guidelines on Management of Hospital Safety**
- **Guidelines on Minimum Standards for Shelter, Food, Water, Sanitation, Medical Cover in Relief Camps**

# IMPLEMENTATION OF DRR

## Technical Intervention

10 min

## SENIOR ENGINEERS AS LEADERS TO ENSURE RVS, DESIGN, CONSTRUCTION & RETROFITTING

**Inclusion of DRR :**

- Distributions of responsibilities
- Safety Audit of existing public buildings
- Understanding the project requirements considering EQ resistance aspects
- Retrofitting of all existing public buildings
- Provide technical assistance to community at district level for building hazard resistant houses
- Compliance of code provisions on EQ resistance in the conceptual drawings

## SENIOR ENGINEERS AS LEADERS TO ENSURE RVS, DESIGN, CONSTRUCTION & RETROFITTING

**Inclusion of DRR :**

- The estimates for Administrative Approval
- Into the detailed structural drawings
- The estimates for TS and Tender
- Tests for Liquefaction Potential for new projects in contract Document
- During execution of Projects
- Checking the provisions during inspections
- Quality control and Technical audit
- Periodic Training of Technical Professionals

## THANK YOU