बिहार सरकार

बिहार राज्य आपदा प्रबंधन प्राधिकरण

(आपदा प्रबंधन विभाग)

पंत भवन, द्वितीय तल, पटना–1

(Training No. 5)

Training of Engineers in 38 Districts of Bihar

on Earthquake Resistant Buildings

READING MATERIAL

(15 presentations)

For Participants

1) Participants are suggested to study the reading material thoroughly. Mark the slide which is difficult to understand. Ask question during presentation by a resource person.
2) At the end of each presentation, you will get the 'points for consideration and discussion'. All question must be quite clear to you. If it is not clear, ask the trainers to clarify.

For Trainers

1) Trainers are suggested to provide 3/4 of the time on presentation and 1/4 of the time for question-answer.
2) Please ensure that all participants are able to explain each of the items listed in the 'points for consideration and discussion'.

Index

PREFACE

The guidelines consist of 15 Chapters, each covering One Training Lecture into which the Four Days Training Program was sub divided.

The Training Program is specially designed to take care of the engineering services requirements including attainment earthquake safety of various constructions, including housing for various categories of staff and the buildings for various service functions like schools, colleges, hospitals, administrative offices etc. Such functions include the following:

I. To maintain the already constructed Facilities.

II. To construct new buildings in accordance with the design details provided by the Design Offices.

III. To conduct RVS (Rapid Visual Screening) of Buildings for assessing their earthquake safety status. In case a building is assessed as damageable under the design earthquake; the assessment is to be done for the grade of damageability to which the building will be subjected under the earthquake.

IV. To assess the retrofitting needs of the building and to estimate the possibility of extent to carryout appropriate and economical retrofitting measures for further service life.

The Field Engineers should be fully conversant with fire safety requirements besides the building bye laws applicable in each case. The Training Program prepared for the Engineers servicing in the districts takes care of the above requirements. The details have been recommended to follow the provisions of various applicable Indian Standards such as IS1893, IS14326, and IS13920.

The Chapters prepared by Shri Barun Kant Mishra are fully detailed and Illustrated with diagrams which make it very easy to understand by the Engineers reading through the Chapters. Then is a big plus point of the Presentation as compared with the same material in text books, which normally use a lot of text and scanty sketches to explain the point.

In the end, I would like to state emphatically that **Drawing is the Language of the Engineer**- Whatever is drawn and shown on the Drawings is fully understood and properly executed in the field during the construction.

I am pleased to go through the Chapters prepared by Shri. Barun Kant Mishra and approve the same.

Prof. A. S. Arya

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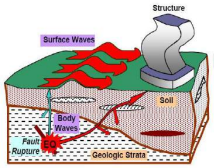
पंत भवन, द्वितीय तल, पटना–1

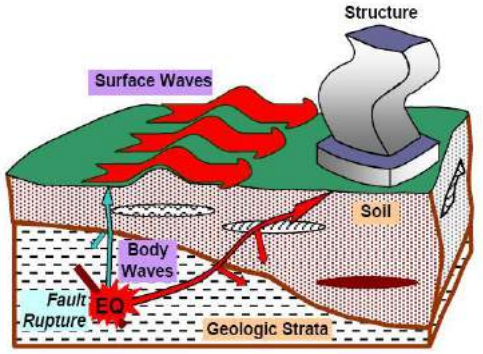
(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

प्रशिक्षण की आवश्यकता एवं परिचय



भूकम्प कैसे आता है ?

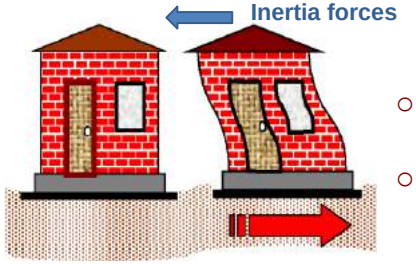
धरती के अंदर टेक्टोनिक प्लेटों के बीच अत्यधिक दबाव होने पर, विशाल चट्टान अचानक टूट जाते हैं और चट्टानों के बीच की दरारें शीघ्रता से खिसक पड़ती हैं।



- **इस विस्फोट से अतिशय यांत्रिक उर्जा उत्पन्न होती है।**
- **सभी दिशाओं में भूकम्प तरंग के रूप में उर्जा का संचरण होता है।**
- **भूकम्प तरंग के कारण धरती की सतह डोलने लगती है।**

भूकम्प में भवन का दोलन

- भूकम्प तरंग के कारण जमीन का तल डोलता है।
- भवन के नींव और निचले भाग जमीन के साथ चलते हैं।
- जड़त्व (Inertia) के कारण भवन के उपरी भाग अपने मूल जगह पर रह जाते हैं।
- उपरी भाग पर विपरीत दिशा में जड़त्व बल (inertia force) लगता है।
- और भवन डोलने लगता है।



- **भवन की दीवारें या पिलर छत को खींचकर रखते हैं।**
- **इससे कमजोर दीवारें या पीलर झुककर टूट सकते हैं।**

भूकम्प से क्षति

- सम्पत्ति की हानि
- आधारभूत संरचना की हानि
- धरोहर संरचनाओं की हानि
- घर के अंदर की सामग्रियों की क्षति
- मानव जीवनों की हानि
- अतिशय मानवीय पीड़ा

घर के अंदर की सामग्रियों की क्षति

प्रशिक्षण की आवश्यकता

- भूकम्प से लोग नहीं मरते, वल्कि कमजोर घरों के ढ़हने से मरते हैं।
- कुछ सेकेंडों के भूकम्प में जान–माल की अपार क्षति हो जाती है।
- चक्रवाती हवा एवं बाढ़ से भी बिहार प्रभावित होता रहता है।
- आपदाऐं विकास की गति को क्षीण कर देती है।
- समाज में आपदारोधी भवन निर्माण की तकनीकी जानकारी का अभाव है।

अभियंता ही भवन निर्माण की तकनीकी जानकारी जन–जन तक फैला सकते हैं।

अतएव, राज्य सरकार ने बिहार राज्य आपदा प्रबंधन प्राधिकरण के माध्यम से, राज्य के सभी अभियंताओं को भवनों के भूकम्परोधी तकनीक से संबंधित प्रशिक्षण प्रदान करने का निर्णय लिया है।

बिहार राज्य आपदा प्रबंधन प्राधिकरण द्वारा अभियंताओं / वास्तुविदों / संवेदकों / राज्यमिस्त्रियों को भवनों के, भूकम्परोधी निर्माण एवं रेट्रोफिटिंग की तकनीक से संबंधित प्रशिक्षण कार्यक्रमों की विवरणी

क्र. सं.	प्रशिक्षण का नाम	प्रशिक्षण अवधि	बैचों (प्रति 30 प्रशिक्षु)	कुल प्रतिभागी
1	पटना में अभियंताओं एवं वास्तुविदों के मास्टर ट्रेनर्स का प्रशिक्षण	5 दिन	8	240
2	पटना में संरचना अभियंताओं का प्रशिक्षण	5 दिन	1	30
3	पटना में वास्तुविदों का प्रशिक्षण	2 दिन	2	60
4	पटना में अभियंता प्रमुख एवं मुख्य/अधीक्षण अभियंताओं का प्रशिक्षण	2 दिन	4	120
5	38 जिलों के अभियंताओं का प्रशिक्षण	4 दिन	152	4560
6	38 जिलों के संवेदकों /निर्माणकर्ताओं की आपदारोधी जागरूकता	1 दिन	38	1140
7	38 जिलों में राजमिस्त्रियों के प्रशिक्षकों का प्रशिक्षण	3 दिन	92	2760
8	534 प्रखंडों के राजमिस्त्रियों का प्रशिक्षण	7 दिन	590	17700

जिलों में अभियंताओं के प्रशिक्षण के विषय

(1) Disaster Management & Disaster Damage Scenario

(2) Engineering Seismology and Types of seismic hazards

(3) Ground failure, Soil liquefaction, Land Zone Plan, Site Selection, Sub surface Investigations, Construction of Foundations

(4) Principles of Earthquake Resistant Buildings (IS:1893) and Architectural Considerations

(5) Masonry Buildings: Failures and Integrity

(6) Masonry Buildings: EQ Resistant Design (IS:4326) & Confined Masonry

(7) Inclined Roof Buildings, Bamboo housing, Hazard Resistant housing

जिलों में अभियंताओं के प्रशिक्षण के विषय *Continued*

(8) RVS of masonry buildings

(9) Practical RVS of a masonry building

(10) Masonry Buildings: Seismic Retrofitting

(11) RC Buildings: Failures and Recommendations

(12) Ductile Details of RC Members (IS:13920) & Other essential Details

(13) Construction Materials, Precautions in Construction, Quality Assurance & Quality Audit

(14) Mitigation of Non-Structural Hazards, Fire Safety, Safety of services, Green Building, Lightening

(15) Bihar Building Bye-Laws 2014, SDBR, DRR Road Map 2015-2030, EQ Advisory Cell

प्रशिक्षण के बारे में

Reading Material

प्रशिक्षण के विषयों को संक्षिप्त कर प्रस्तुत किया गया है। अतएव, पठन सामग्रियों को सावधानी से पढ़ने तथा प्रस्तुतीकरण एकाग्रता से सुनने की आवश्यकता है।

Points for considerations and Question-Answer:

प्रत्येक विषय से संबंधित प्रश्नों का लिस्ट देखें , प्रत्येक विन्दु की जानकारी लें एवं प्रश्नों त्तर में भाग लें।

Participation Certificate:

प्रश्नों त्तर में भाग लेने वाले एवं सभी पाली में उपस्थित सहभागियों को सहभागिता प्रमाणपत्र दिया जाएगा।

धन्यवाद

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(1)
Disaster Management
&
Disaster Damage Scenario

90 min

आइये अब हम कुछ प्रश्नों पर विचार करें

- आपदा प्रबंधन के शब्द Hazard, Vulnerability, Risk एवं Disaster के क्या अर्थ हैं ?
- आपदा प्रबंधन क्या है ?
- आपदा जोखिम को कम कैसे करें ?
- आपदा प्रबंधन की चार मुख्य अवस्थाएं कौन सी हैं?
- आपदा प्रबन्धन में अभियन्ताओं की क्या भूमिका है?

- खतरा (Risk) या दुर्घटना से, आपदा प्रकट हो सकती है।
- यह महाविपत्ति एव गहरे संकट की स्थिति है।
- जान का भारी नुकसान या अतिशय मानवीय पीड़ा
- सम्पत्ति की क्षति एवं नुकसान या पर्यावरण की क्षति एवं क्षरण
- संभलने के लिये बाहरी सहायता की आवश्यकता पड़ती है।

- Risk घटित होने पर, Disaster आ सकता है।
- Risk बनता है, Hazard एवं Vulnerable मिलकर।
- Hazard से Vulnerable को क्षति हो सकती है।

HAZARD या खतरा से नुकसान हो सकता है।

HAZARD दो प्रकार के हो सकते है:–

1. Natural
2. Manmade

Natural Hazards

Manmade Hazards

प्राकृतिक खतरों में वृद्धि हो रही है।

प्राकृतिक खतरों में वृद्धि के कारण

- **Vulnerable** कौन हैं?
- जो **Vulnerable** नहीं हैं, उसे या उससे क्या **Risk** है?
- क्या **Capacity** बढ़ने से **Vulnerability** में कमी होगी?

Vulnerability

अशिक्षा, गरीबी, स्वीकार्य जीवन पद्धति

खतरनाक क्षेत्र में सघन आबादी	नरम मिट्टी पर मकान एवं संरचनाएं	आपदाओं से 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 दवाब

क्षमता (Capacity)

- जोखिम न्यूनीकरण में सहायक उपलब्ध संसाधन
- पर्याप्त क्षमता Vulnerability 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।

(Hazard, Vulnerability, Risk & Disaster)

Hazard घटना या स्थिति हैं। इससे क्षति हो सकती हैं।

Risk = Hazard x Vulnerability

जिनको क्षति हो सकती है, वे **Vulnerable** हैं।

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

आपदा जोखिम (Disaster Risk)

खतरों को आपदा में परिवर्तित होकर क्षति पहुँचाने की सम्भावना।

आपदा जोखिम = खतरा X संवेदनशीलता / क्षमता

- खतरा: Intensity, Extent, Timing
- संवेदनशीलता: 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

आपदा जोखिम (Risk) की गणना
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 न्यूनीकरण (DRR)

खतरों की समझ
खतरा मानचित्र, भूकम्प जोन मैप

संवेदनशीलता विश्लेषण
उम्र, दिव्यांग, गरीबी, कमज़ोर मकान

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

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 तकनीक द्वारा, इसके आघात को काफी दुर्बल बनाया जा सकता है।

आपदा प्रबंधन की चार मुख्य अवस्थाएं

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

Preparedness : आपदा पूर्व तैयारी, चेतावनी।

Response : राहत और बचाव, क्षति मूल्यांकन।

Recovery : पुनर्वास, पुनर्निर्माण, पुनरुत्थान, सामान्य जीवन की प्राप्ति, Build Back Better (BBB)

बचाव प्रक्रिया का संचालन

सामुदायिक आश्रय एवं टायलेट का निर्माण

पीने का पानी

Response:

Normally, engineers are field workers.

राहत एवं जबाबी कार्रवाई के दौरान

अनिवार्य सेवाओं की पुनः शुरूआत

सुरक्षित/ असुरक्षित संरचनाओं को छाँटना

Recovery :

पुनर्वास और सामान्य जीवन प्राप्ति के दौरान

संरचनाओं का पुनर्निर्माण / सुदृढ़ीकरण

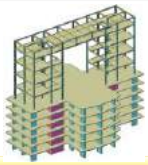
स्थायी आवास निर्माण

क्षतिग्रस्त आधारभूत संरचनाओं का पुनर्निर्माण / सुदृढ़ीकरण

आजीविका पुनरुत्थान में सहायता

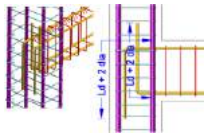
आश्रय पुनर्निर्माण / सुदृढ़ीकरण में तकनीकी सहायता।

Mitigation : आपदा न्यूनीकरण के दौरान



नवीनतम इंजीनियरी तकनीक का ज्ञानार्जन एवं उपयोग

सुरक्षित संरचनाओं का निर्माण



संरचनाओं में **Ductility** प्राप्त करने के उपाय

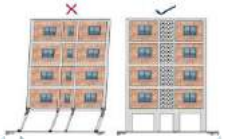
जोखिम क्षेत्रों की पहचान, भूमि उपयोग की योजना

सुरक्षित इंजीनिरिंग तकनीक को फैलाना

Preparedness :

वर्तमान संरचनाओं का मूल्यांकन एवं सुदृढ़ीकरण

DAMAGE GRADE G1, G2, G3, G4,G5



वर्तमान संरचनाओं का फोरेंसिक आकलन।

वर्तमान संरचनाओं का सुदृढ़ीकरण।

असुरक्षित संरचना पर चेतावनी देना।

असुरक्षित बसावट पर जागरूक करना।

आपदा पूर्व तैयारी की गतिविधियों में शरीक होना।

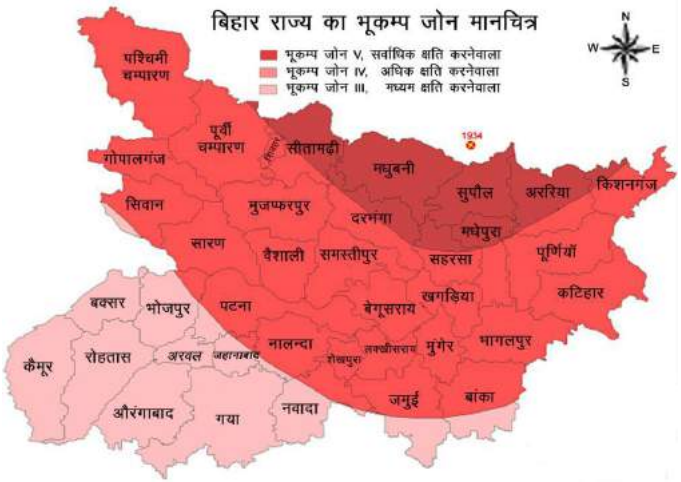
आपदा प्रबन्धन में अभियन्ताओं की भूमिका

- आपदा बिगाड़ती है; अभियंता बनाते हैं।
- सरकारों में आपदा प्रबन्धन की नीति है; जबकि, क्रियान्वयन की कामयाबी अभियंताओं के हाथों में है।
- आपदारोधी निर्माण सुनिश्चित करना, अभियंताओं की प्राथमिक जिम्मेवारी है।
- उपयुक्त तकनीक के उपयोग की विशिष्ट जानकारी वाले, कुशल अभियन्ता की माँग हमेशा बनी रहेगी।

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 कौन से थे ?
- विगत भूकंपों में हुई क्षति का परिदृश्य कैसे थे?
- बिहार में सम्भावित भूकम्प के प्रभाव क्या होंगे ?
- भूकम्प के प्रति हमारी प्रतिक्रिया किस प्रकार है।
- वर्तमान भूकम्प प्रबंधन में क्या–क्या त्रुटियां हैं ?



बिहार को प्रभावित करनेवाले विगत बड़े भूकम्प

1833 Bihar-Nepal earthquake

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

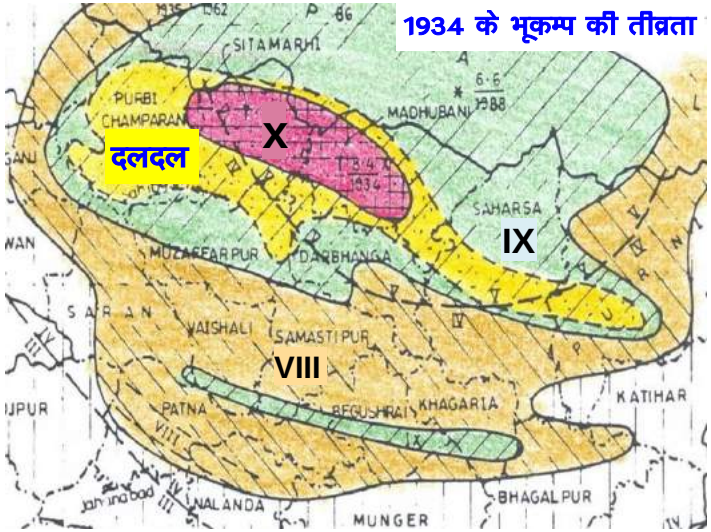
- भूकम्प केन्द्र : नेपाल में, सीमा से 100 कि.मी. पर
- विध्वंसक भूकम्प, नेपाल में 414 लोग मारे गये
- पूर्वी भारत एवं नेपाल में विस्तृत तबाही
- मुज़फ्फरपुर, मुंगेर एवं अन्य जगहों पर भवन ढ़ह गए
- मुजफ्फरपुर में तालाबों से 1.2 मी. पानी उछल गया
- छपरा में जमीन पर बड़े आकार की गहरी खाई बन गई

बिहार को प्रभावित करनेवाले विगत बड़े भूकम्प

1934 Bihar-Nepal earthquake

5 जनवरी 1934, दोपहर 2.13 बजे, M8.4

- भारत का अबतक का सबसे विनाशकारी भूकम्प
- भूकम्प केन्द्र : नेपाल में, सीमा के पास
- नेपाल में 8519 लोग एवं भारत में 7,153 लोग मारे गये
- मुंगेर एवं भटगॉव बिलकुल बर्बाद हो गये
- मोतिहारी, मुजफ्फरपुर, दरभंगा, पाटन एवं काटमांडू के अधिकतर हिस्से एवं उनके बीच बहुत बड़ी सख्या में गांव बर्बाद हो गये
- सीतामढ़ी एवं मधुबनी में बहुत घर झुक / धँस गये
- पूर्णियाँ में 95 % घर निवास योग्य नहीं रहे
- पटना, बाढ़ एवं जमालपुर में अतिशय क्षति, सड़क क्षतिग्रस्त



बिहार को प्रभावित करनेवाले विगत बड़े भूकम्प

1988 Bihar-Nepal earthquake

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
- भूकम्प के समय उत्तरी बिहार के इलाके बाढ़ग्रस्त थे।
- कच्ची ईंट से बने या कमजोर दीवार वाले मकान क्षतिग्रस्त हुए।
- मधुबनी, दरभंगा, सहरसा एवं मुंगेर सर्वाधिक प्रभावित हुए।
- 1934 से कम फिर भी बड़े पैमाने पर द्रवीकरण हुआ।
- 1934 के M 8.4 के भूकम्प की तुलना में, 1988 के M 6.6 भूकम्प में, 750 गुना कम उर्जा उत्सर्जन हुआ।

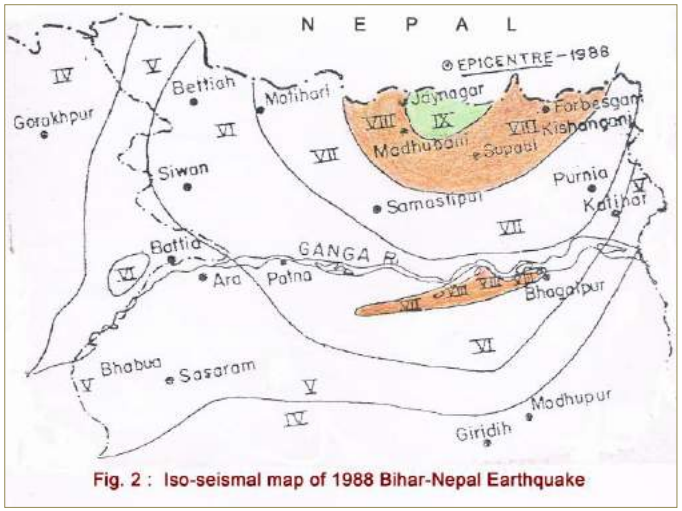


Fig. 2 : Iso-seismal map of 1988 Bihar-Nepal Earthquake

25 APRIL 2015 NEPAL EARTHQUAKE

25 अप्रील 2015, सुबह 11.41 बजे, **M 7.8**

- भूकम्प केन्द्र : नेपाल में, काठमांडू से 80 km उत्तर पश्चिम
- मुख्य आघातः 20 सेकेंड, गहराई 15 km, काठमांडू से 80 km
- Main Frontal Thrust में फिसलन
- बाद के आघातः 35 अदद् M 4.5 से ज्यादा परिमाण
- नेपाल में करीब 7000 लोग मारे गये और भारत में 78
- नेपाल में सभी मुख्य धरोहर संरचना बर्बाद, लाखों भवन ध्वस्त।
- दिल्ली, गुजरात, कर्नाटक एवं आंध्र प्रदेश तक कम्पन का अनुभव
- 120 km x 60 km भूखण्ड पर बसा काठमांडू मात्र 30 सेकेंड में 3 m दक्षिण खिसक गया।
- 600 m भरे झील पर बसे काठमांडू में भूकम्प प्रभाव amplified
- बिहार में भी कई मकान क्षतिग्रस्त। पटना में तीव्रता V.

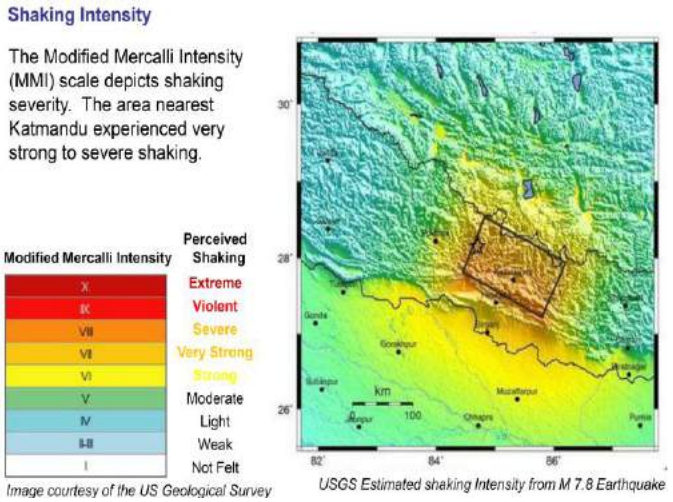


Image courtesy of the US Geological Survey

USGS Estimated shaking Intensity from M 7.8 Earthquake

BHUJ EQ 2001

- Bhuj was completely destroyed
- 281 bed District Hospital and 16 bed Mental Hospital at Bhuj completely destroyed. (many staff and patients killed)
- 42 Primary health Centers, 227 sub-centers, 42 Community Health centers reduced to rubble.
- Over 50,000 School Rooms Damaged or Destroyed
- About 100 multistoried buildings were damaged in Ahmadabad, 10 collapsed

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, Failure of 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)

भूकम्प की मानवीय प्रतिक्रिया				
अवस्था	समय अवधि	घटना	Positive	Negative
1	0–1 मिनट	भारी भूकम्प		भयाक्रान्त
2	1 मिनट से 1 सप्ताह	बाद वाला झटका	बचाव कार्य	डर, आशंका
3	1 सप्ताह से 1 महीना	बाद वाले झटके में कमी	अल्पकालीन मरम्मति	Blame to Builders, Designers, Officers
4	1 महीना से 1 साल		दीर्घकालीन मरम्मति, अच्छे स्तर के लिये कार्यवाही	
5	1 साल से 10 साल			सरोकार में कमी
6	10 साल से दूसरे भूकम्प तक			भूकम्परोधी प्रावधान के खर्चे से अरूचि, सुरक्षा नियमों की अवहेलना
7	दूसरी बार	1 ls 7 rd dh voLFkk dks nksgjkuk		

Gaps in the Management of Earthquakes

- **Low public awareness** on the need for incorporating earthquake-resistant features in non-engineered construction in suburban and rural areas
- **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 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;

(1)

Disaster Management and Disaster Damage Scenario

POINTS FOR CONSIDERATION AND DISCUSSION

1. What situation is said to be a disaster?
2. What is the difference between Hazard and Disaster?
3. What is the difference between Hazard and Risk?
4. What is the difference between Hazard and Vulnerability?
5. What are the reasons of increasing natural hazards?
6. Name two hazards that can be prevented.
7. How can you reduce Seismic Vulnerability?
8. To evaluate the Risk of a building in under a probable earthquake:
   a. Which factors shall be taken into account?
   b. What will be outcome of Risk evaluation?
9. What are the four main stages of Disaster Management?
10. Which works are taken up during Mitigation?
11. Which works are taken up during Preparedness?
12. Which works are taken up during Response?
13. Which works are taken up during Recovery?
14. What is the primary role of a building engineer?
15. Which districts of Bihar fall in Seismic Zone V and Seismic Zone IV?
16. In which year the most violent Earthquake occurred in Bihar.
17. In which year an Earthquake occurred when the areas in north Bihar were under floods.
18. What was the intensity of earthquake in 1934 around Sitamarhi and Madhubani?
19. What will be the probable damages, if a violent earthquake occurs in Bihar?
20. What are the gaps in management of earthquakes?

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

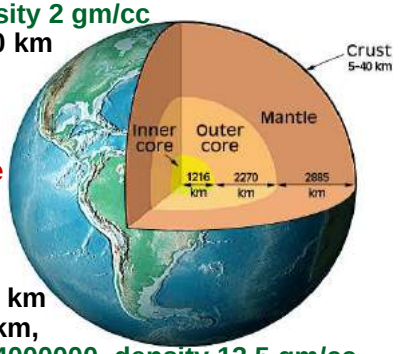
(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(2)
ENGINEERING SEISMOLOGY
TYPES OF SEISMIC HAZARDS

90 min

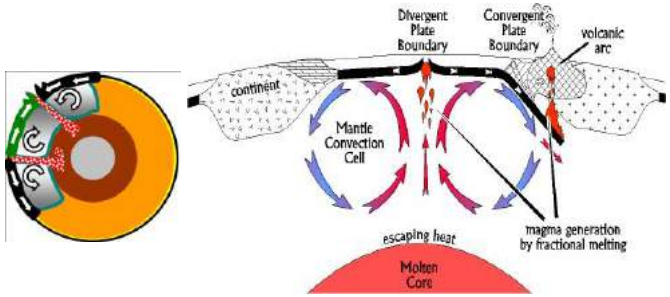
LAYERS OF THE EARTH

- **SURFACE: density 1.5 gm/cc, 25^{o}C**
- **CRUST: brittle, density 2 gm/cc**
  - **Continental : 25-40 km**
  - **Oceanic ~6 km**
- **MANTLE: Viscous**
  - **Upper : 650 km**
  - **Mostly Earthquake occurs here**
  - **Lower : 2235 km**
- **CORE**
  - **Outer liquid : 2270 km**
  - **Inner solid : 1216 km,**
  - **2500^{o}C, Pressure 4000000, density 13.5 gm/cc**
  - **Radio active decay, enormous heat generated**



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** के कुछ भाग **(lithosphere)**, धीमी गति से सरकते रहते हैं। इसे **Tectonic Plate** कहते हैं।

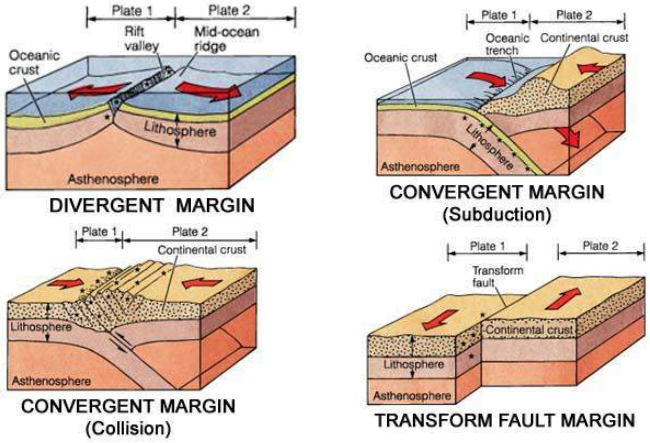
धरती की सतह करीब 70–100 कि.मी. मोटे सात विशाल **Tectonic Plate** एवं कुछ छोटे प्लेटों से बनी है।

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

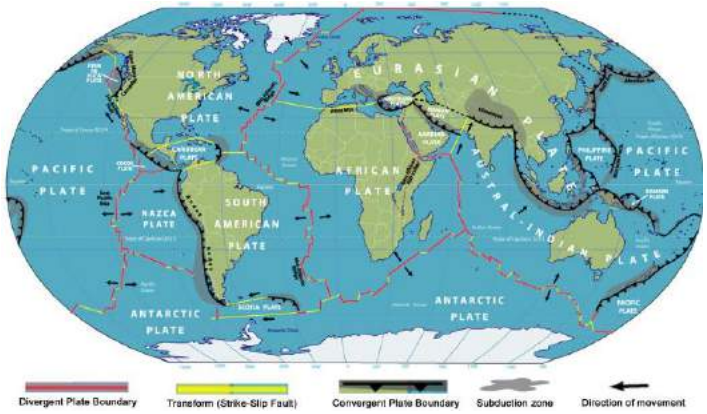
ज्यादातर, **Tectonic Plate** की सीमा पर भूकम्प आते हैं।

जब दो प्लेटें एक दूसरे को ढ़केलती है, तो पहाड़ बनते है; जब एक दूसरे से दूर जाती है, तो दरार बनतें है; जब अगल–बगल चलती हैं, तो सतह परिवर्तित हो जाती है।

टेक्टोनिक प्लेट का विचलन



TECTONIC PLATES

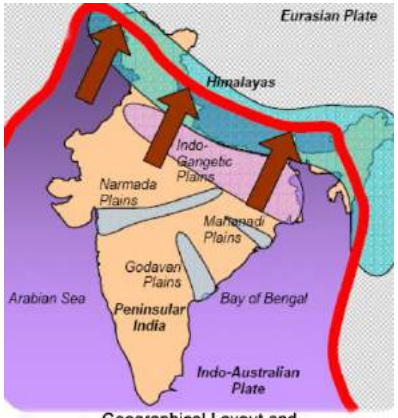


हिमालय में भूकम्प

Subduction of Indo-Australian plate into Eurasian plate.

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

नेपाल में भूकम्प के चलते बिहार प्रभावित होता है।



Geographical Layout and Tectonic Plate Boundaries in India

ELASTIC REBOUND THEORY

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

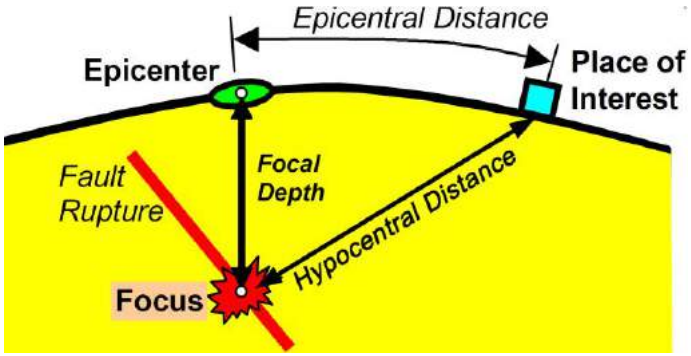
Tectonic plate के चलन से **Lithosphere** के चट्टान में **stain energy** का संचयन

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।



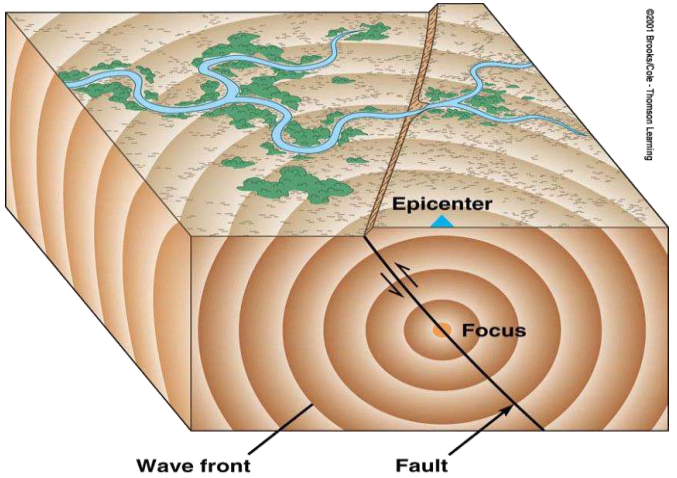
FOCUS / HYPOCENTER

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

EPICENTER:

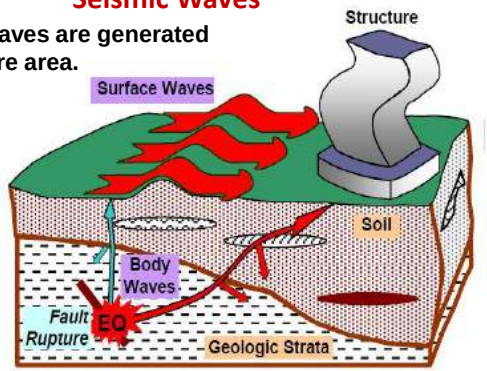
फोकस के सीधे उपर, धरती के सतह पर का भौगोलिक स्थल।

Focus से सभी दिशाओं में P-Wave एवं S-wave का propagation



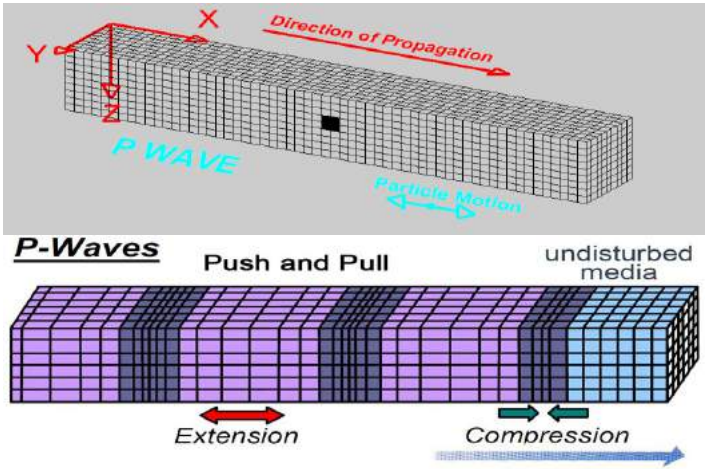
Seismic Waves

- Surface waves are generated in epicentre area.

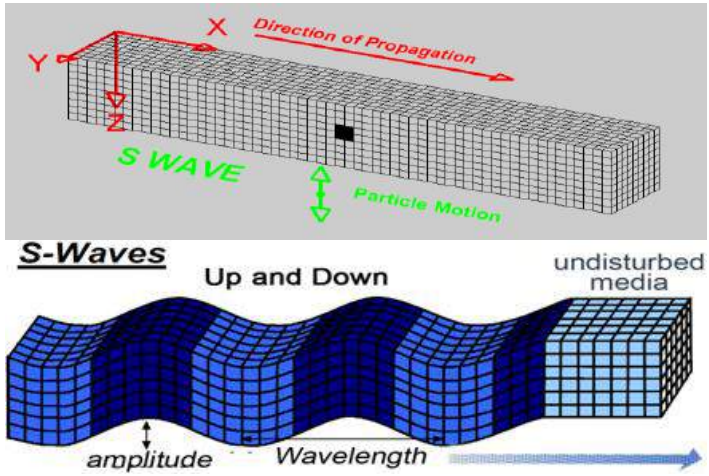


- Body Waves are generated by Fault rapture.
  - P-Wave (Longitudinal wave) : 3-8 km/sec
  - S-wave (Transverse wave) : 2-5 km/sec

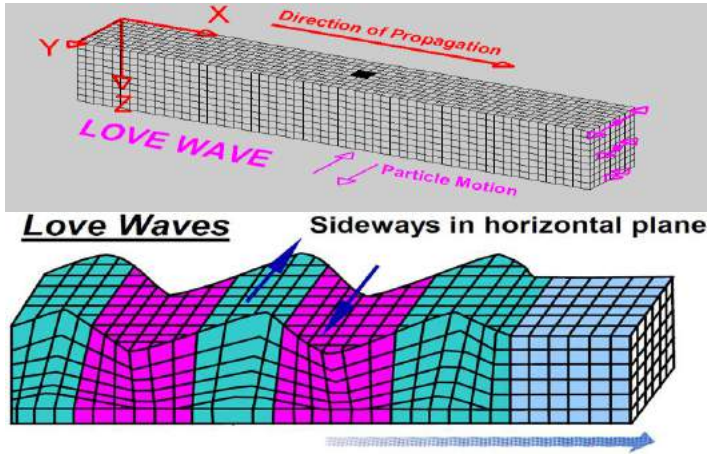
Seismic Waves: Body Waves: P-Waves



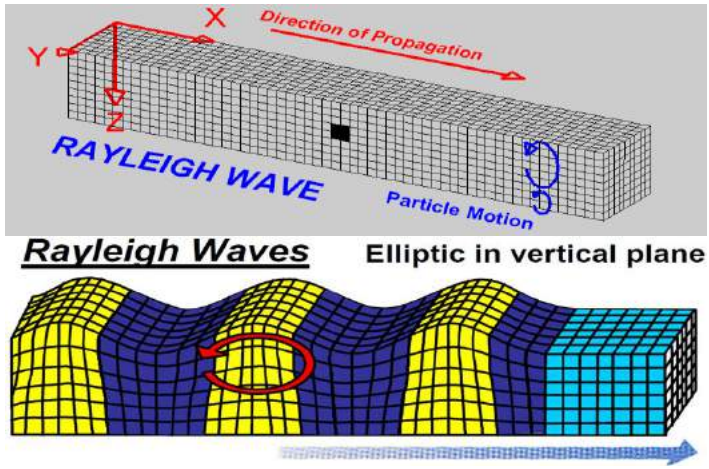
Seismic Waves: Body Waves: S-Waves



Seismic Waves: Surface Waves: Love Waves



Seismic Waves: Surface Waves: Rayleigh Waves

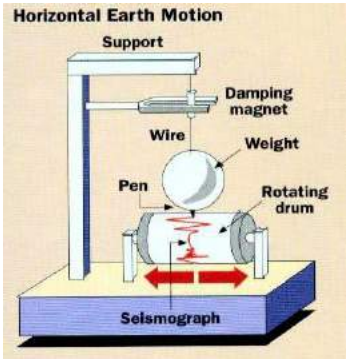


SEISMIC WAVES

- अचानक चट्टान के टूटने से भूकम्प तरंग (shock wave) सभी दिशाओं में चल पड़ती है।
- सबसे पहले, P-Wave पहुँचती है, यह Vertically झटका देती है, और वायुमंडल के संम्पर्क से, भूकम्प ध्वनि प्रकट होती है।
- उसके बाद, S-Wave horizontal दिशा में भारी झटका देता है और भवनों का दोलन होने लगता है।
- Epicentral area में Surface Waves उत्पन्न होती है, जिससे जमीन के सतह का horizontal एवं Vertical दोलन होता है।
  - सर्वाधिक क्षति S-Waves एवं Surface Waves मिलकर पहुँचाती है:
  - धरती के अंदर की अपेक्षा सतह पर ज्यादा कम्पन होता है।
  - 1956 में चीन में भूकम्प से 8 लाख लोग मर गये।

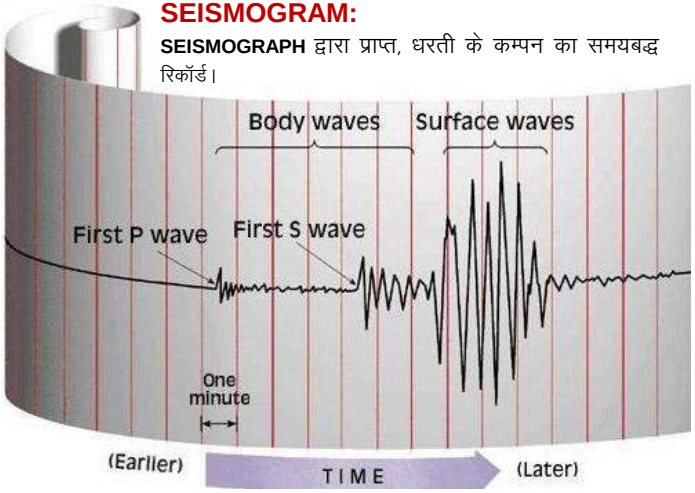
Seismometer

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।
seismogram 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 **logarithmic** 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 हिरोशिमा पर गिराये बम 4000 गुणा था।

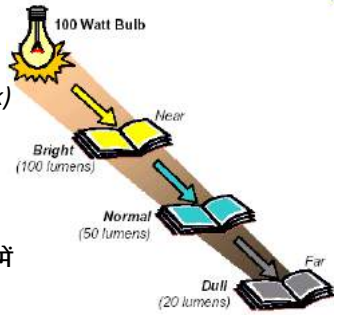
धरती पर प्रति वर्ष औसतन भूकम्प		
भूकम्प ग्रुप	Magnitude	औसत संख्या प्रति वर्ष
Great	8 and higher	0-1
Major	7 – 7.9	18
Strong	6 – 6.9	120
Moderate	5 – 5.9	800
Light	4 – 4.9	6,200 (estimated)
Minor	3 – 3.9	49,000 (estimated)
Very Minor	< 3.0 M2-3:; M1-2:	 ~1,000/day ~8,000/day

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।

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

Epicentre क्षेत्र में अधिकतम तीव्रता रहती है जो सभी दिशाओं में कम होती 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**

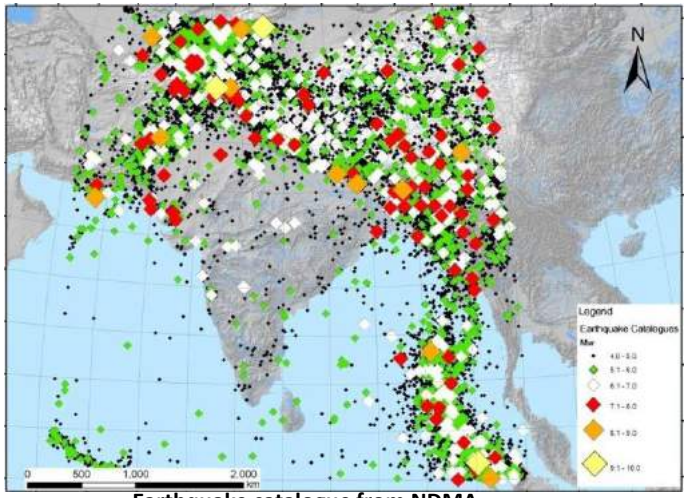
EARTHQUAKE DAMAGE
- मानव निर्मित संरचनाएं
- यातायात/संचार
- जीवनोपयोगी सेवाऐं
- भोजन सामग्री

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

ENGINEERING SEISMOLOGY

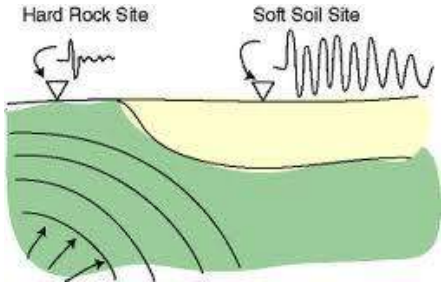
To estimate the parameters, seismologists need:

- **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**



Earthquake catalogue from NDMA

SITE EFFECTS



Amplification of motion at Soft soil site

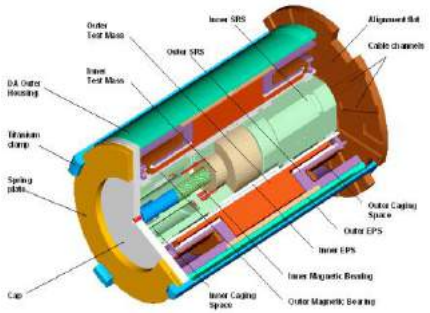
- **Surface topography**
- **Thickness of soil above the base rock**
- **Soft sedimentary sites amplify**
- **Density and elastic properties of soil**
- **Liquefaction/ subsidence**
- **Slope instabilities (landslides)**

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।

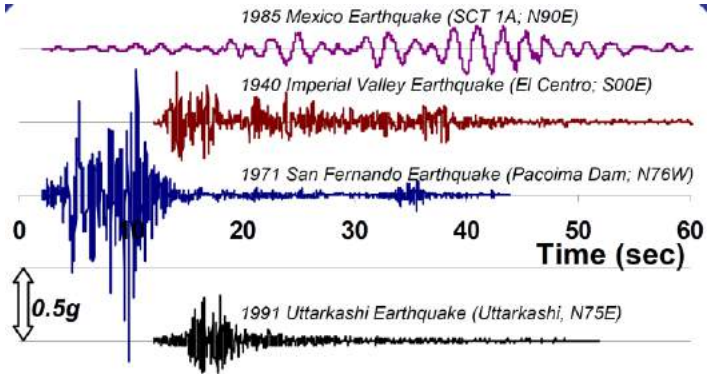


ACCELEROGRAPH

ACCELEROGRAM:

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

EARTHQUAKE GROUND MOTION TIME HISTORY



CHARACTERISTICS OF EQ GROUND MOTION

PEAK GROUND ACCERATION (PGA)

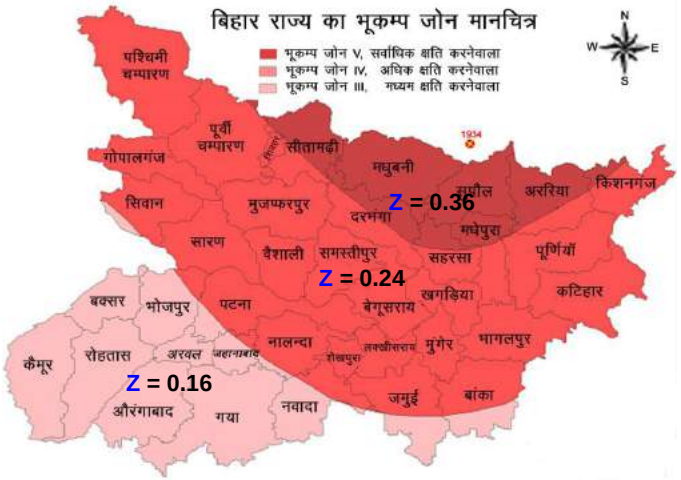
- **The changes in PGA is influenced by intervening media, topography & geology.**
- **Horizontal component of PGA can be related to the force on a short-period building.**

FREQUENCY CONTENTS

- **Ground motion frequency: 1 to 15 Hz**
- **Frequency range gradually reduces with increasing distance**

EFFECTIVE DURATION

- **Duration when the ground acceleration remain above a certain threshold level**
- **It has significant effect on inelastic deformation and energy dissipation demand of structure**

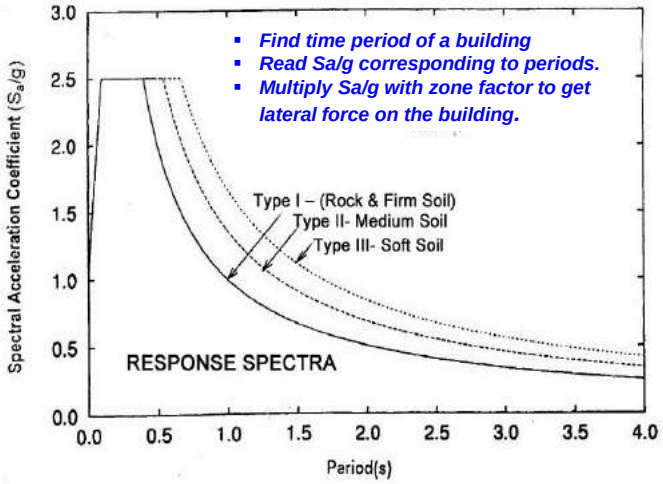


Z is Peak ground acceleration in MCE

SEISMIC HAZARD INTENSITIES

वर्तमान भवनों की असुरक्षितता (Vulnerability) भूकम्पीय तीव्रता एवं जोखिम से सम्बंधित है। भूकम्पीय तीव्रता बढने से भूकम्पीय जोखिम बढती है और भवनों की असुरक्षितता बढ जाती है।

भूकम्प जोन	PGA	भूकम्पीय तीव्रता	भूकम्पीय जोखिम
V	0.36g	MSK IX or more	बहुत अधिक
IV	0.24g	MSK VIII	अधिक
III	0.16g	MSK VII	मध्यम



भूकम्प की भविष्यवाणी : कब? कहाँ? कितना?

- आनेवाले भूकम्प के आकार की जानकारी ज्यादातर विगत भूकम्पों से मिलती है।
- भूकम्प जोन मैप सापेक्षिक तीव्रता (कहाँ? कितना?) की जानकारी देता है।
- Seismologists चट्टानों में दवाब का स्तर एवं नन्हें आघात के तरंगों का अध्ययन करते रहते हैं।
- कुओं में जलस्तर, कीचड़ एवं बेतरतीब गैस निस्सरण के वैज्ञानिक अवलोकन का उपयोग सम्भव है।
- सही समय, स्थान या विस्तार के लिहाज से अचानक fault के विचलन एवं भूकम्प की भविष्यवाणी, (कब?), अब तक सम्भव नहीं है।

भूकम्प–आपदा न्यूनीकरण बेहतर विकल्प है।

SEISMIC MICROZONATION

Estimates local site specific hazards likely to be caused by

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

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

Thank You

(2)

Engineering Seismology and Types of seismic hazards

POINTS FOR CONSIDERATION AND DISCUSSION

1. Why convection currents are generated in the mantle?
2. What is the reason for movement of tectonic plates?
3. What is approximate thickness and movement per year of tectonic plates?
4. What are the reason for earthquake hazard in the area of Bihar?
5. What message do you get from the 'Elastic Rebound Theory'?
6. What is the difference between Epicentre and Focus of an earthquake?
7. Which seismic waves damage the building structures most?
8. Where is the shaking more severe: on the earth surface or within the earth?
9. What is the difference between seismogram and accelerogram?
10. What is the difference between magnitude and intensity of an earthquake?
11. What will be the ratio of the energy released between M 6.3 and M 7.3 earthquakes?
12. Approximately, how many M6.5 earthquakes appear annually on the earth?
13. What will be the intensity of earthquake, if considerable damage is seen in well-constructed buildings?
14. Name the three main factors on which the Intensity of earthquake shaking depend on.
15. During an eartquake, what does an accelerogram measure? Acceleration or Acceleration vs time interval?
16. Soft soil layer exists below the foundation. Will earthquake shaking be amplified at the site?
17. Name the three important characteristics of Earthquake Ground Motion.
18. How can you relate a seismic zones with the peak ground acceleration in the zone?
19. How Response Spectrum is used to determine lateral seismic forces?
20. Why seismic microzonation is needed?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(3)

Ground failure, Soil liquefaction,

Sub surface Investigations,

Land Zone Plan, Site Selection,

Construction of Foundations

90 min

GROUND FAILURES DURING EARTHQUAKE

- **Surface fault rupture**
  Large-scale relative displacements on opposite sides of the fault extending to the ground surface
- **Liquefaction**
  Transformation of granular soil from a solid state to a liquefied state
- **Landslides**
  Permanent shear deformations within the slope materials
- **Ground settlements and movements**
  Ground surface settlements and lateral movements (especially in artificial fill soils)

GROUND FAILURES DURING EARTHQUAKE

Liquefaction

Ground Settlement

Surface fault rupture

Landslide

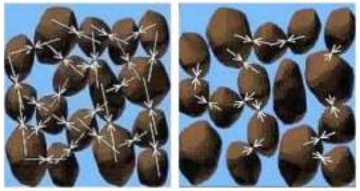
March 11, 2011 EQ M9.1 Tsunami in Japan

LIQUEFACTION

Instantaneous transformation of soil of solid consistency into a liquefied state, during earthquake vibrations.

Normal Conditions

water fills the spaces between sand grains, the grains touch and friction holds the grains together.



Earthquake Shaking

Pressure in water-filled pores increases, water pressure breaks the grain friction, the grains flow like a liquid.

TYPES OF LIQUEFACTION FAILURES

1. Loss of bearing capacity to support structures (shear failure)
1. Settlement of soils (settlement failure)
2. Lateral spreading of soils (soil flow failure)
3. Instability of ground slopes (slope failure)

Loss of soil bearing capacity due to liquefaction:

Soil in a liquefied state have no shear strength and reduced capacity to support the structures. Hence the buildings settle (sink), tilt or overturn.

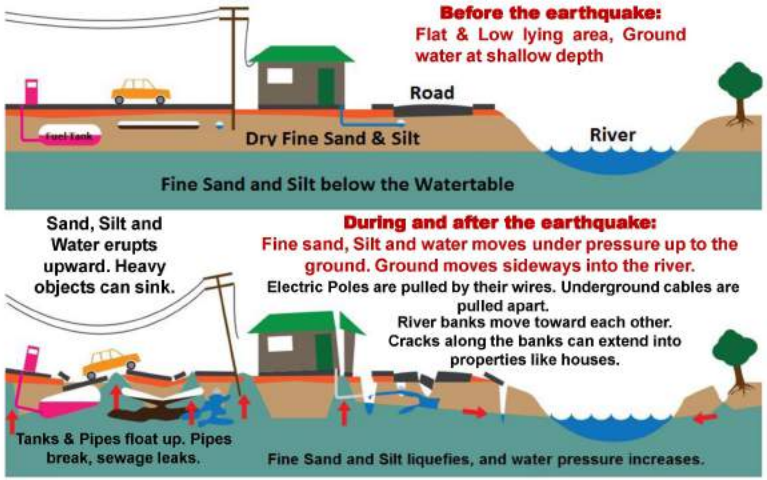
TILTING AND SINKING DUE TO LIQUEFACTION

Settlement about 1 m,

bulge in the road.

LIQUEFACTION OF SOIL
ONLY MINOR CRACKS IN THE WALLS,
BUT SETTLED DOWN BY ABOUT 70MM.

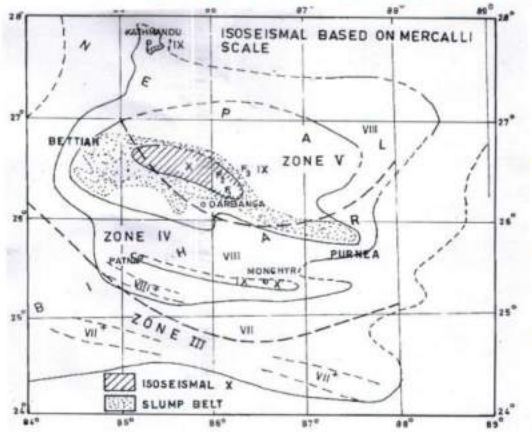
LIQUEFACTION AND ITS EFFECT



FACTORS AFFECTING LIQUEFACTION

- Loose, Fine & uniform size granular sediment
  - SP – poorly graded sand
  - SM – silty sand
  - SC – clayey sand
- Grain size 0.02- 0.2 mm > 50%, (sand, silt)
- Relative density (void ratio) < 50%, (loose soils)
- Water saturated soil mass below foundation
- Intense Ground shaking, PGA = 0.1 g or more
- Duration of shaking: for some time
- No drainage can occur during shaking

SLUMP BELT IN 1934 EARTHQUAKE



Affected area and Isc-seismals of Nepal-Bihar Earthquake of Jan 15,1934

POTENTIAL SITES FOR LIQUEFACTION

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

LIQUEFACTION MITIGATION MEASURES

Ground improvement techniques
- Excavation & removal of liquefiable soils
- Soil stabilization methods
- Soil densification methods
  1. Dynamic compaction
  2. Vibro-floation
  3. Compaction grouting
  4. Compaction piles
- Drainage techniques

Appropriate foundation selection & structure design
- Pile foundations
- Raft foundations

BUILDING FOUNDATION FAILURE

Damages due to differential settlement

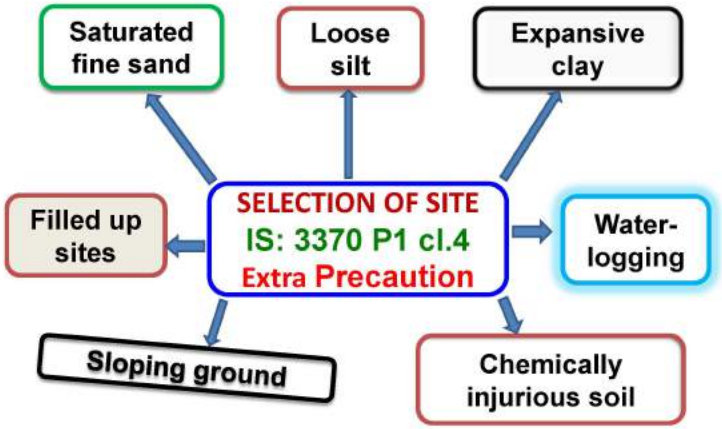
FAILURE OF STRUCTURE

TILTING

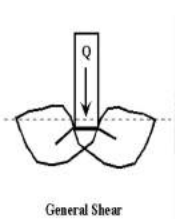
CRACKING

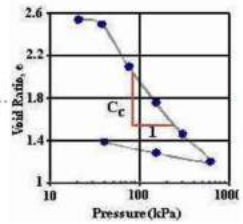
SITE SELECTION

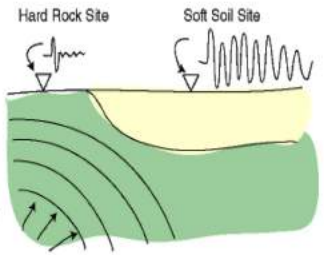
- Shape of the plot: construction can be easily made with lower cost
- Location of the plot with more routes
- Good foundation soil available at reasonable depth
- Sites: Elevated, leveled
- Uniform slope for sewerage disposal
- Water table at deeper depth
- Provide seismic gap for different soil types



SOIL INVESTIGATION : WHY?



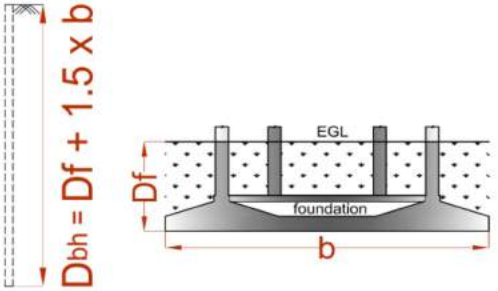


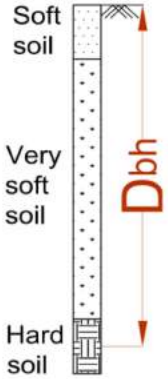


C, Φ. Settlement
IS:1892– 1979

Hard, Medium or Soft (IS 1893 PART 1)

MINIMUM DEPTH OF BOREHOLE
IS:1892– 1979





To carry loads

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.

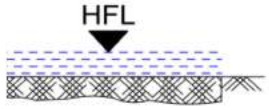
IS 2911 (Part 1/Sec2)

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

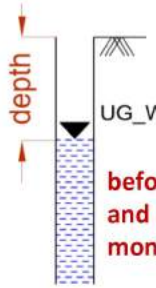
ADDITIONAL EXPLORATION
IS:1892– 1979

Chemical analysis of soil & water

IS: 3370 Part I
Protecting coat against injurious soils
(*asphalt, chlorinated rubber, epoxy or polyurethane*)



Highest Annual flood



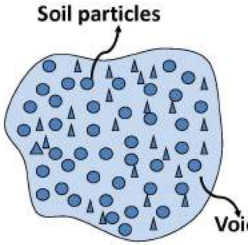
before and after monsoon

NECESSARY SOIL TESTS OF DIFFERENT LAYERS

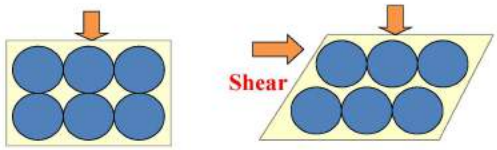
Standard Penetration Test	(IS 2131-1981)
Visual classification	(IS 1498 - 1970)
Grain size analysis	(IS 2720 Part IV)
Unit weight and Specific gravity	(IS 2720 Part III)
Natural moisture content	S 2720 Part II)
Plastic and Liquid limits	S 2720 Part V)
Unconfined compression	S 2720 Part X)
Tri-axial compression, C, Ø	S 2720 Part XI)
Direct Shear test (sandy soil)	(IS 2720 Part XIII)
Consolidation test for Cohesive soil	(IS 2720 Part XV)
Chemical analysis and pH	(IS 2720 Part XXVI)
Chlorides and sulphates	(IS 2720 Part XXVII)

SUB SURFACE INVESTIGATIONS

PROPERTIES OF SOIL AS LOAD BEARING STRATA



- Soil particles: Size & Properties
- Loose, medium, dense.
- Dry, partial saturation, fully saturated
- Position of water table



Soil deformations under load

IS 1498:1970 – SOIL 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

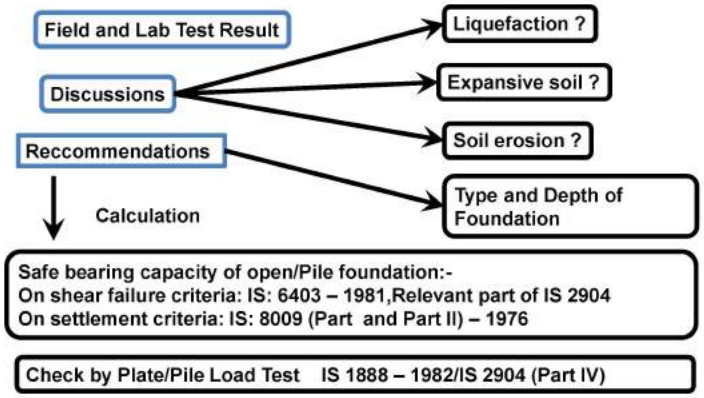
- ML – silt with low plasticity
- CL – clay with low plasticity
- OL – organic silt & clay with low plasticity
- MI – silt with medium plasticity
- CI – clay with medium plasticity
- OI – organic silt/clay with medium plasticity
- MH – high plastic silt
- CH – high plastic clay
- OH – organic silt &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

SOIL TEST REPORT



LAND ZONE PLANNING

SOIL SURVEYS

- Classification of the soils
- Outline boundaries of soils on a map
- Predictions of behaviors of the soils

SOIL SURVEY REPORTS

- Physical & chemical properties
- Soil & water features
- Chemical analysis
- Clay mineralogy
- Engineering index data
- Soil classification

LAND ZONE PLANNING

ZONES

- **Engineering construction**
- **Urban / Rural / Historic / Others Zones**
- **Residential / Commercial / Institutional / industrial Zones**
- **Open Space / Restricted Parking / Watershed**
- **Arts and Crafts / Resort and Recreation**
- **Quarries (sand and gravel)**
- **Forests**
- **Irrigation**

BIS CODES FOR PROTECTION OF FOUNDATION

IS:1892 – 1979 Subsurface investigation for foundations: Code of Practice

IS: 2131-1981 Method of Standard Penetration Test for soils (First Revision)

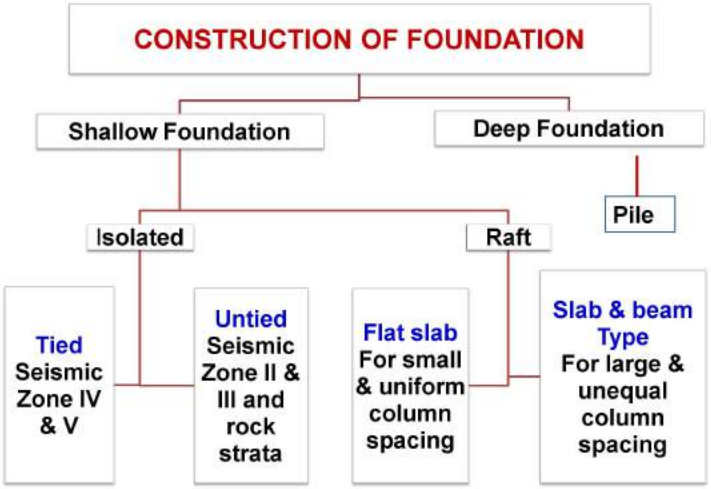
IS: 1498-1970 Classification and identification of soils for engineering purposes

IS 1904 - 1986 Foundations in Soils: Code for General Requirements

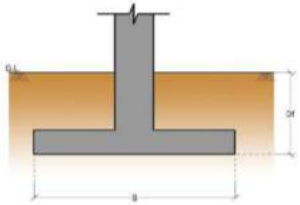
IS 6403 – 1981 Determination of bearing capacity of Shallow foundations: Code

IS 2950 Part 1-1981 Design and Construction of Raft foundations: Code of Practice

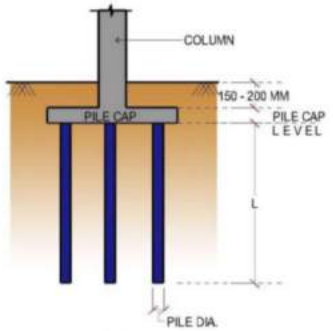
CONSTRUCTION OF FOUNDATION



SHALLOW AND DEEP FOUNDATIONS



Shallow foundations
Good soil strata available at shallow depths (2 – 3m)



Pile foundations
Good bearing strata available at deeper depths

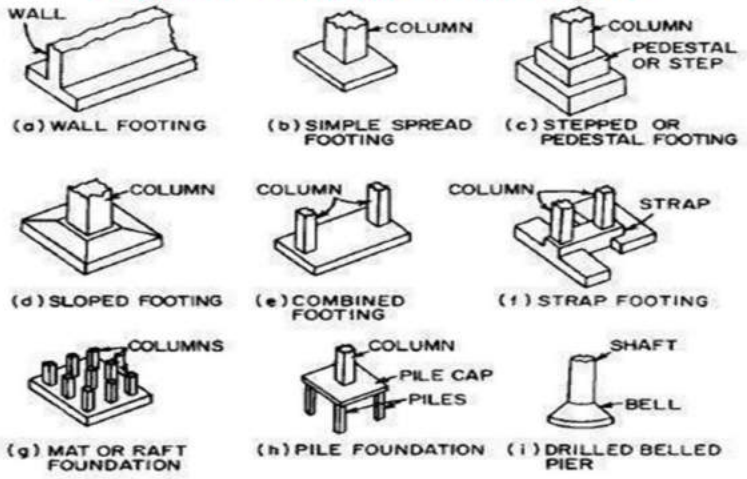
Shallow foundations

- Isolated footings (spread foundations)
- Combined footings
- Raft/mat foundations
  - Flat Plate Type
  - Flat Slab Type
  - Beam-Slab Type
  - Cellular Type
  - Rigid Frame Type
  - Piled Raft

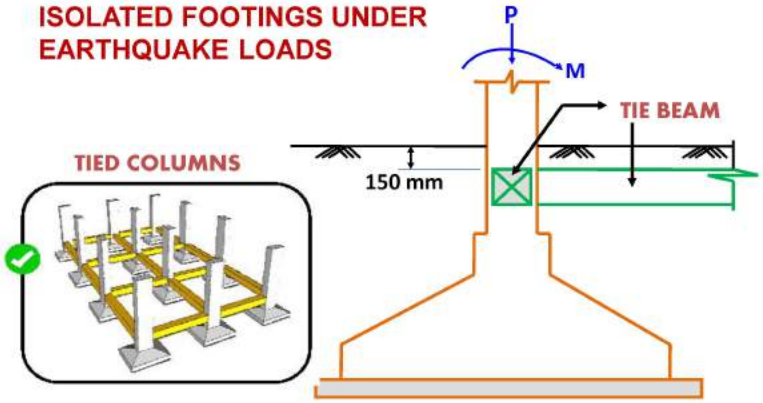
Pile foundations

- Piles/pile caps under columns
- Raft supported on piles

COMMON FOUNDATIONS FOR BUILDINGS

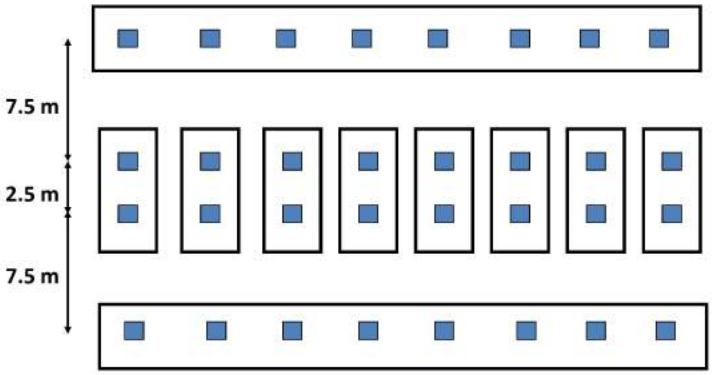


ISOLATED FOOTINGS UNDER EARTHQUAKE LOADS



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

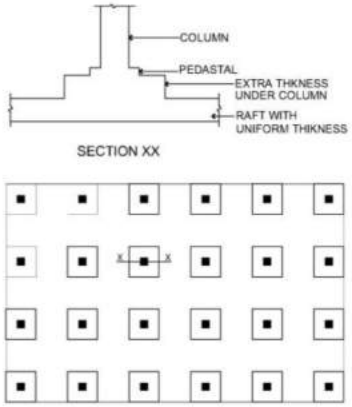
BUILDINGS WITH COMBINED FOOTINGS



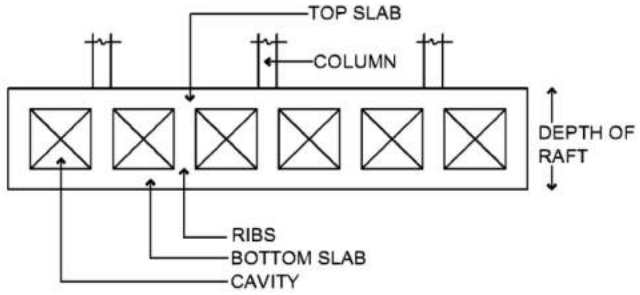
BEAM - SLAB TYPE RAFT

FLAT PLATE TYPE RAFT

FLAT SLAB TYPE RAFT

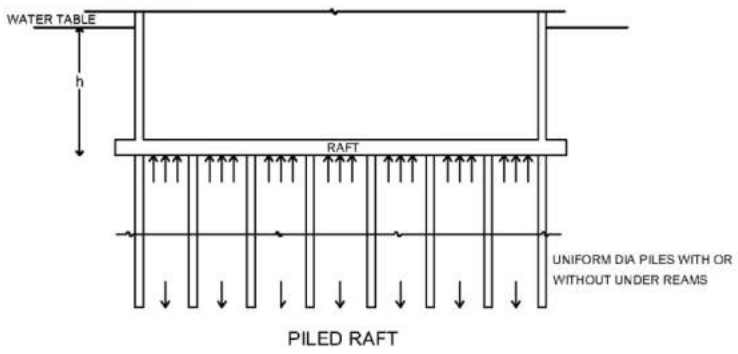


CELLULAR RAFT



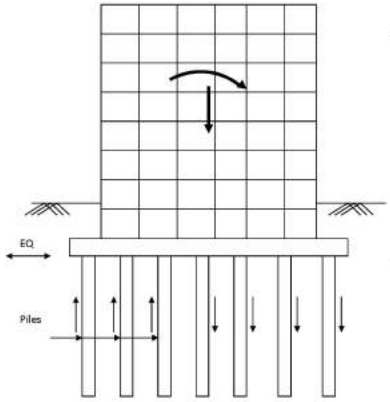
CELLULAR RAFT

PILED RAFT (RAFT SUPPORTED ON PILES)



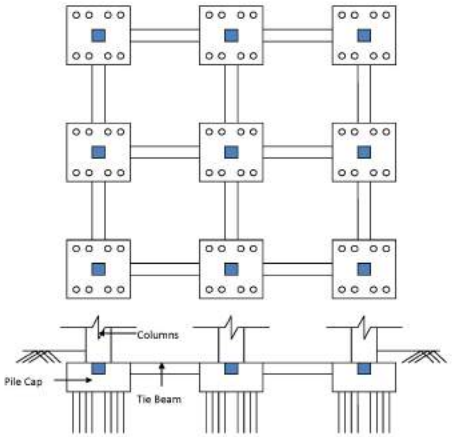
PILED RAFT

EFFECT OF EARTHQUAKE ON PILE FOUNDATIONS:



- **Due to heavy overturning moments under earthquake conditions. Piles may be subjected to tensile forces/ compressive forces alternatively (load reversal).**
- **Additional axial loads on piles due to earthquake forces.**

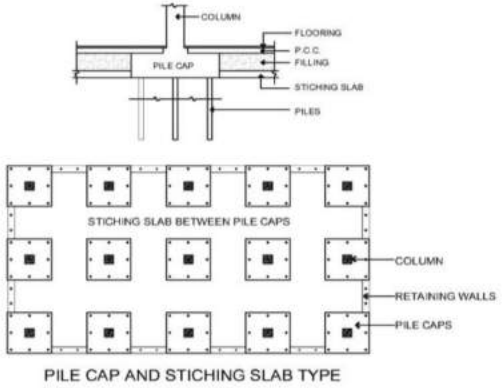
EFFECT OF EARTHQUAKE ON PILE FOUNDATIONS:



- Tie all pile caps by stiff beams to ensure integral action of piles under earthquake forces.
- Total earthquake base shears equally shared by all piles.

PILECAPS AND STICHING SLAB SYSTEM

- **group of piles provided under columns**
- **pile caps bottom connected through stiching slab to provide continuous base**
- **stiching slab systen span between pile caps and resist uplift pressure**



PILE CAP AND STICHING SLAB TYPE

FOUNDATION FOR MASONRY BUILDING

भूकम्परोधी आर.सी.सी. बैंड एवं खडें छड़ों के साथ
WALL FOOTING

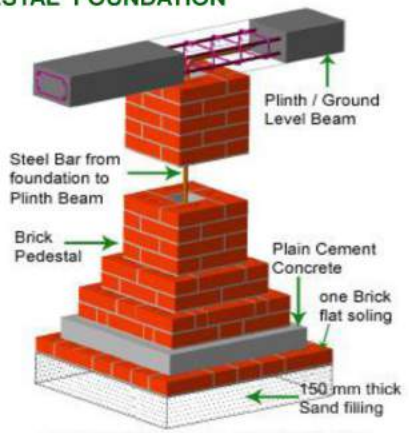
- भूतल से 0.6 मीटर नीचे ठोस मिट्टी परत उपलब्ध हो,
- बहते जल से कटाव न हो
- भूकम्प में, द्रवीकरण की भी सम्भावना नहीं हो

पूरे दीवार के नीचे खुला नींव

FOUNDATION FOR MASONRY BUILDING
BRICK PEDESTAL FOUNDATION

Cohesive soils (clayey, silty clayey or clayey silty)

- Safe bearing capacity of 7 to 9 t/m².
- Foundation depth of 1.5 m
- Suitable for one storey buildings



BRICK PEDESTAL FOUNDATION

FOUNDATION FOR MASONRY BUILDING
RCC COLUMN FOUNDATION

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.

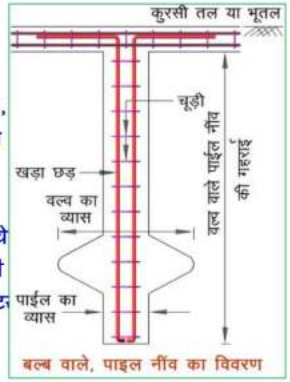
आर.सी.सी. पाया नींव

FOUNDATION FOR MASONRY BUILDING
PILE FOUNDATION

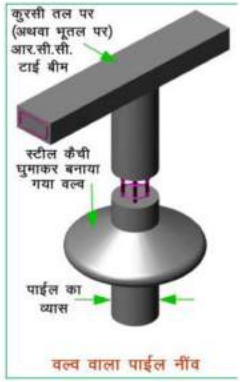
यदि बहते जल से कटाव की या मिट्टी के द्रवीकरण की सम्भावना हो।

निचले भाग में बल्ब वाले, 3 मीटर से 8 मीटर लम्बे आर.सी.सी पाइल

एकमंजिले मकान के लिये सामान्यतः 1.5 मीटर की आपसी दूरी पर 3.3 मीटर लम्बा पाइल



बल्ब वाले, पाइल नींव का विवरण



बल्ब वाला पाईल नींव

FOUNDATION TYPE IN DIFFERENT SUB SOIL	
Soil Profile	Foundation type
Dense sand up to great depth	Spread Footings, Piles (if uplift)
Stiff clay or stiff silt and clay up to great depth	Spread Footings. Piles (if special condition)
Upper firm clay followed by soft clay	Spread Footings for small loads, otherwise Pile foundation
Upper layer soft clay followed by firm or rock	Pile Foundations
Upper layer soft clay followed by deep layer of dense sand	Pile Foundations

FOUNDATION TYPE IN DIFFERENT SUB SOIL	
Soil Profile	Foundation type
Loose sand up to great depth	Raft, driven piles
Soft clay with increasing stiffness with depth	Raft, piles
Compact sand followed by medium soft clay followed by hard clay	Deep piles
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 piles
Soft clay, followed by dense sand followed by soft clay	Driven / cast in situ Piles or Raft
Fill followed by rock	Piles / Shallow foundation placed on rock

THANK YOU

(3)

Ground failure, Soil liquefaction, Land Zone Plan, Site Selection, Sub surface Investigations, Construction of Foundations

POINTS FOR CONSIDERATION AND DISCUSSION

1. What are the types of ground failure, observed during a severe earthquake?
2. What are the types of ground failure, due to liquefaction?
3. What are the factors, which affect the liquefaction?
4. What are the potential sites, where liquefaction may occure?
5. What are the methods, used to mitigate the liquefaction?
6. What are the important points, which need to be considered, during selection of a building site?
7. What are the two main reasons, which requre soil investigation for a building site?
8. What will be minimum depth of a borehole, to be adopted during a soil test?
9. What are the defined sizes of particles of sand, silt and clay?
10. What do you understand from soil classification SP and ML?
11. What are the tests to be conducted during a soil exploration?
12. What are important information, a Soil Test Report must contain?
13. Which IS code is used to determine the bearing capacity of Shallow foundations?
14. What are the considerations, taken up during Land Zone Planning?
15. What are the common foundation types adopted for buildings?
16. Which types of foundation need tie beam connectivity at ground level?
17. What are the types of foundation, normally used for masonry buildings?
18. What is the difference between plain pile and under reamed pile?
19. What will be the type of foundation for soft clayey silt formation?
20. What will be the type of foundation for loose sand up to 8 m depth?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

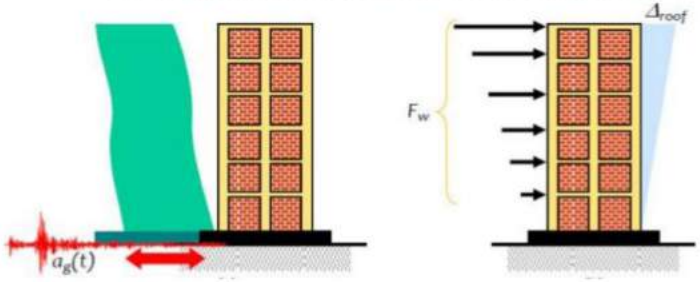
(4)
Principles of Earthquake Resistant Buildings (IS: 1893)
and
Architectural Considerations

90 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



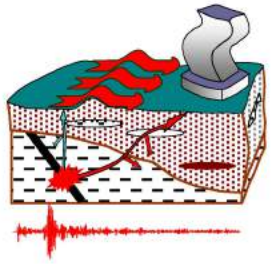
Earthquake
- Inertia Force
- Magnitude and Duration
- Properties of the Structure;
  a. Stiffness Distribution
  b. Mass Distribution

Wind
- External Force
- Intensity of wind
- Area Of Exposure
- Surrounding Structure

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 epicenter
4. characteristics of path travelled by seismic waves
5. soil strata beneath the structure



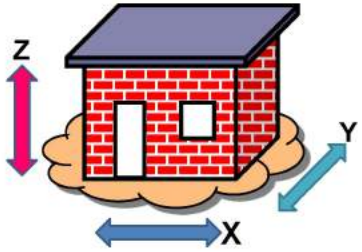
CHARACTERISTICS OF EQ GROUND MOTION

- **Peak ground motions:**
  Acceleration, velocity and displacement primarily influence the vibration amplitudes.
- **Periods of vibration of a structure:**
  Amplified motion due to Resonance conditions
- **Duration of motion:**
  A ground motion with moderate peak acceleration and a long duration may be more damaging than a ground motion with a larger acceleration and a shorter duration.

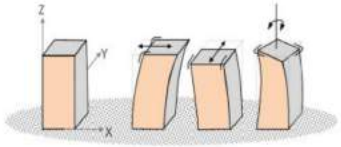
Buildings are the main source of damage to life and cause disruption after earthquakes

EARTHQUAKE SHAKING

- Complex horizontal & vertical shaking of earth surface
- Random oscillations induced in the structures
- Random oscillations in magnitude and direction



Seismic shaking of a building in X, Y and Z direction



Seismic vibration of building normally adopted in design
Translation in X and Y direction and rotation about Z

RESPONSE OF STRUCTURES

- **Stiffness**
  Stiff members have less deflection
- **Strength**
  Load carrying capacity of a member
- **Ductility**
  Large inelastic deformations without breaking
- **Damping**
  Ability of structures to dissipate energy during dynamic response

EARTHQUAKE-RESISTANT DESIGN PHILOSOPHY

(dual design philosophy)

1. **Safety-level design**: Safety of structure (or its occupants) should not be compromised under extreme earthquake events
2. **Serviceability-level design**: Serviceability (utility) of structure should not be unexpectedly disrupted under more regularly occurring earthquake events

Design codes *satisfies both performance requirements through a combination of* analysis, design and detailing specifications.

MCE & DBE

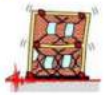
- **Extreme earthquake event, PGA, Z**
  - *Maximum Considered Earthquake (MCE)*
    - Has very low probability of occurrence
    - Must not result in excessive casualties or damages
    - 2% probability to exceed in 50 years
    - Return period 2500 years,
- **Moderate earthquake event, Z/2**
  - *Design Basis Earthquake (DBE)*
    - Has moderate probability of occurrence
    - Must result in moderate and repairable damage
    - Must result in very few casualties
    - 10% probability to exceed in 50 years
    - Return period 475 years,

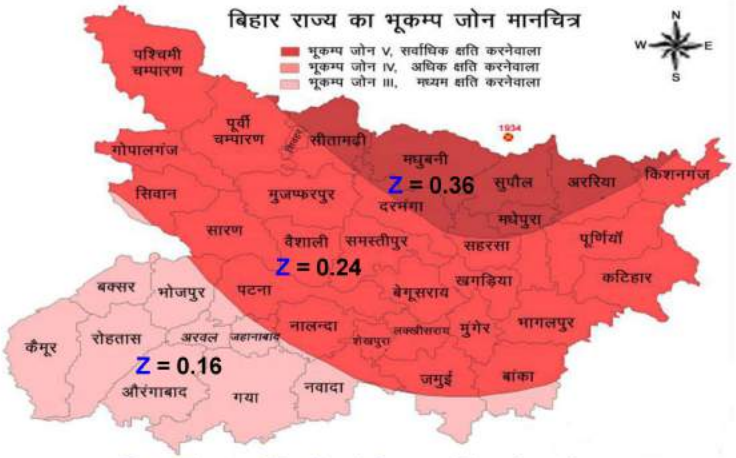
EQ RESISTANT DESIGN PHILOSOPHY

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

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

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



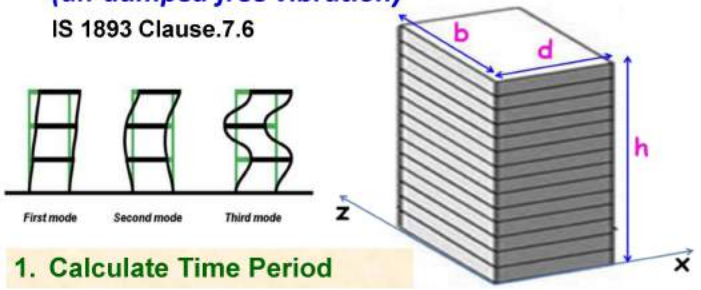


Zone Factor, Z is Peak Ground Acceleration in Maximum Considered Earthquake (MCE)

FUNDAMENTAL TIME PERIOD OF A BUILDING

(un-damped free vibration)

IS 1893 Clause.7.6

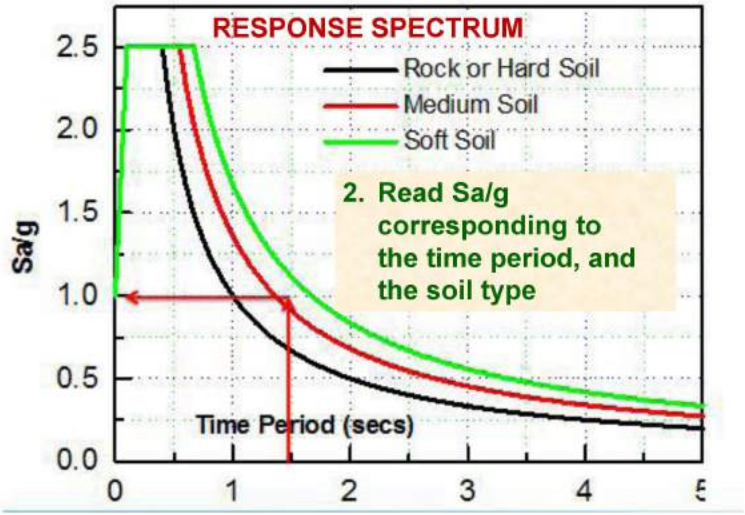


1. Calculate Time Period

$T_a = 0.075\ h^{3/4}$, 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



IMPORTANCE FACTOR, I *(IS 1893 p1, 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

3. Select Importance Factor, I and Response reduction factor, R

4. Compute Design Horizontal Seismic Coefficient, Ah

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

Ah is acceleration of structure.
Z is ground acceleration.
Sa/g converts Z into Ah.

5. Compute Seismic Force = mass x acceleration

V_B = Mass of structure x Ah

6. Compute Seismic Force at each Floor, Q_i

$$Q_i = V_B \frac{W_i\ h_i^2}{\sum_{j=1}^{N} W_j\ h_j^2}$$

W_i is mass of i^{th} floor.
h_i is height of i^{th} floor.

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

$$Ah = \frac{Z}{2} \cdot \frac{I}{5} \cdot \frac{Sa}{g}$$

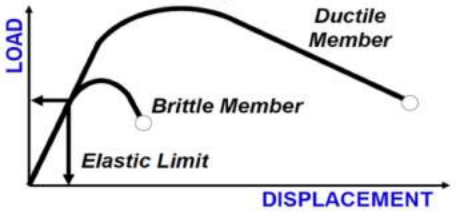
All possible safety margins have already been used by IS code during earthquake-resistant design

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***

DUCTILITY

Ability of a member or structure to deform beyond its elastic limit without failure



Ensure ductile element(s) yield prior to failure of brittle elements

- Ductile detailing provisions in IS:13920
  - Minimum sizes RCC members
  - Confinement of concrete in critical zones
  - Minimum and maximum reinforcement
  - Distribution of longitudinal and transverse steel
  - Relative capacity of members meeting at a joint
- Utilize Response reduction factor, R to design for lower earthquake forces

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

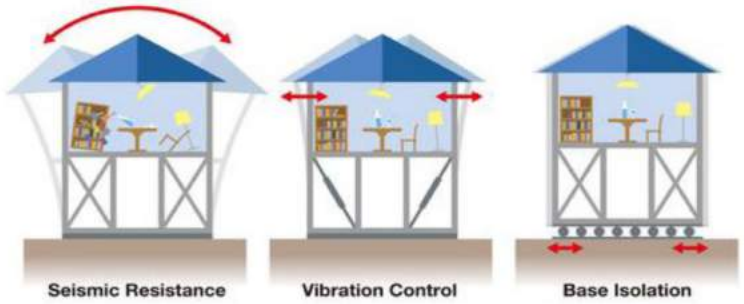
STATIC ANALYSIS

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

EARTHQUAKE RESISTANT BUILDINGS

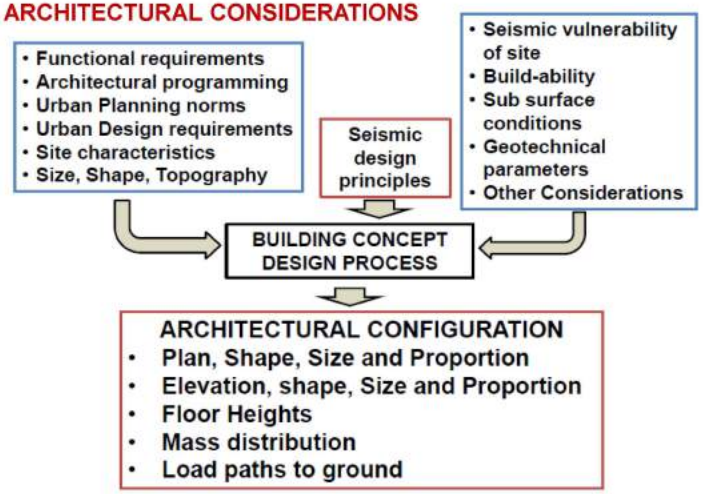
1. Seismic strengthening
2. Energy absorbing devices
3. Base isolation technique



URBAN PLANNING FOR DISASTER RESILIENCE

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

ARCHITECTURAL CONSIDERATIONS



SEISMIC RESISTANCE

Primary requirements

Structural configuration : plan / elevation layout
(Simple, symmetric & integrated)

Lateral stiffness :
Uniform in both direction, floor wise less deviation

Lateral strength :
Sufficient load carrying capacity

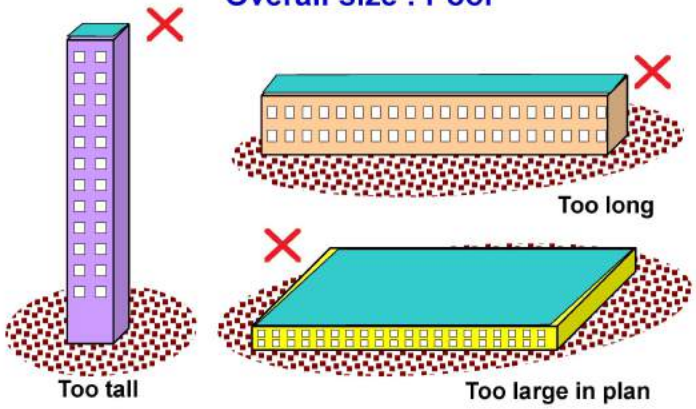
Ductility
Large inelastic deformations without breaking

Good Structural configuration is ensured by:
- **Simple regular geometry &**
- **Uniformly distributed mass & stiffness**

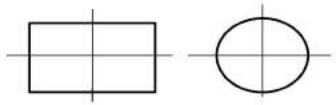
in both **plan and elevation**

BUILDING CONFIGURATION

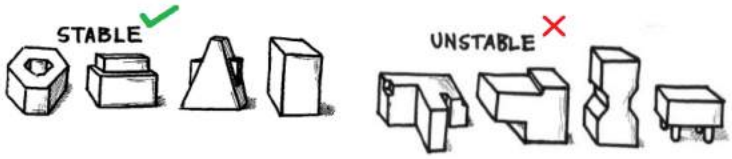
Overall size : Poor



COMPACT SYMMETRICAL PLAN
good seismic performance

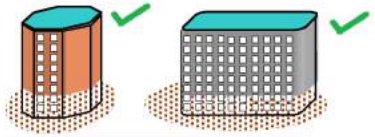


- Undergoes predominantly bending deformation under Earthquake loads
- Less torsion or twisting behavior about vertical axis.



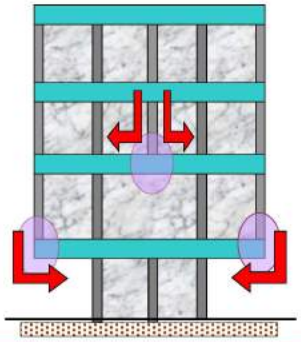
BUILDING CONFIGURATION
Overall size

Corners and Curves :: *poor*



Simple Plan ::*good*

BUILDING CONFIGURATION
Indirect load path: Poor



Hanging or Floating Columns

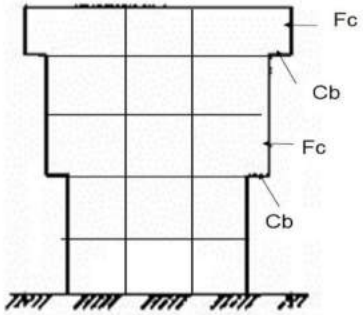
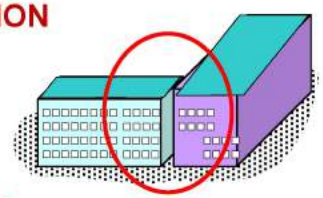
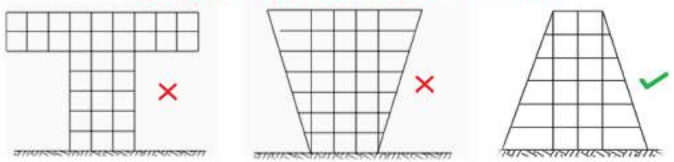


Fig.:-Floating columns
Fc= Floating Columns
Cb= Cantilever Beams

BUILDING CONFIGURATION
Gap between buildings



BUILDING CONFIGURATION



Enlarged top stories

Pyramid Elevation

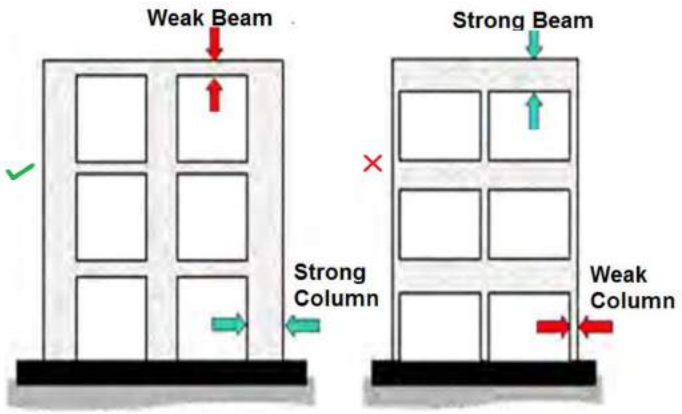
Problematic

- High Centre of gravity
- Heavy overturning moments
- Problem of stability
- Uneven foundation pressure
- Foundation tilting
- Avoid in high seismic zone

- Ideal shape
- Low center of gravity
- Symmetry

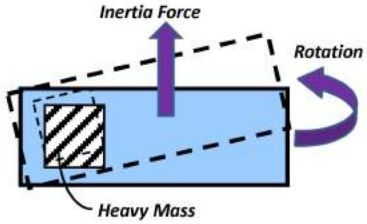
RELATIVE STRENGTH OF BEAM & COLUMN

$\Sigma M_c \geq 1.4\ \Sigma M_b$



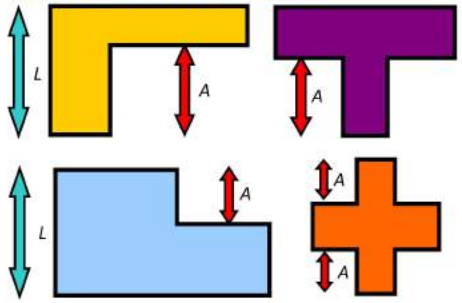
IRREGULAR FORM AND CONFIGURATION
PLAN IRREGULARITIES

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

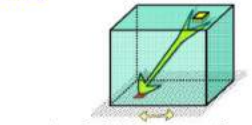


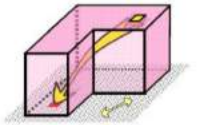
IRREGULAR FORM AND CONFIGURATION
PLAN IRREGULARITIES

2. RE-ENTRANT CORNERS



$$\frac{A}{L} > 0.15 - 0.20$$

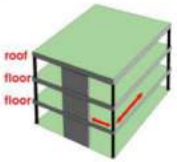

straight load path

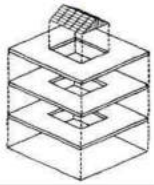

changed load path

IRREGULAR FORM AND CONFIGURATION
PLAN IRREGULARITIES

3. DIAPHRAGM DISCONTINUITY

Floor diaphragm is a horizontal system that connects together the vertical elements and transfers the lateral forces to the columns and shear walls. Large openings in the diaphragm limits its ability in transferring forces.



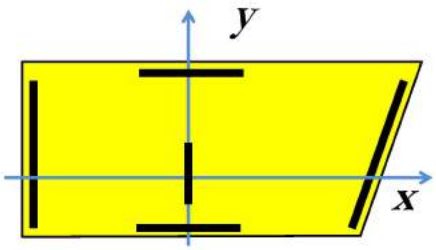


Irregular Diaphragms have cut-out or open areas > 50 % of the gross enclosed diaphragm area

IRREGULAR FORM AND CONFIGURATION
PLAN IRREGULARITIES

4. NON-PARALLEL SYSTEMS

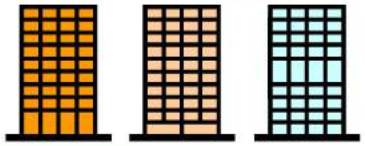
Vertical elements resisting lateral force are **not parallel to** the **major orthogonal axes or the lateral force resisting elements**

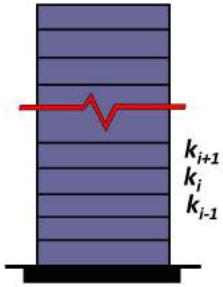


IRREGULAR FORM AND CONFIGURATION
VERTICAL IRREGULARITIES

1. STIFFNESS IRREGULARITY

Soft Storey
Intermediate sift storey
Extreme Soft Storey



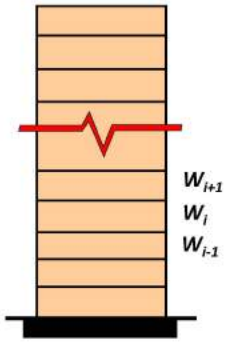


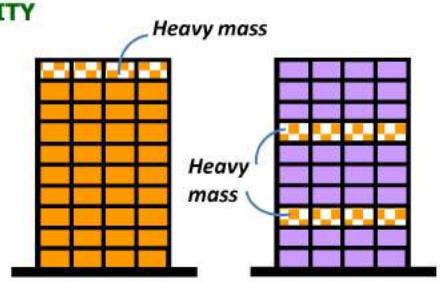
$$k_i < 0.7 k_{i+1}$$

$$k_i < 0.8\left(\frac{k_{i+1} + k_{i+2} + k_{i+3}}{3}\right)$$

IRREGULAR FORM AND CONFIGURATION
VERTICAL IRREGULARITIES

2. MASS IRREGULARITY

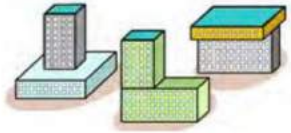


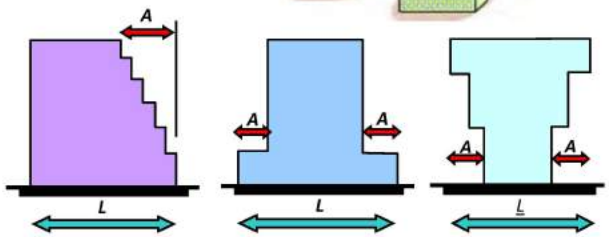


$$W_i > 2W_{i-1}$$
$$W_i > 2W_{i+1}$$

IRREGULAR FORM AND CONFIGURATION
VERTICAL IRREGULARITIES

3. VERTICAL GEOMETRIC IRREGULARITY



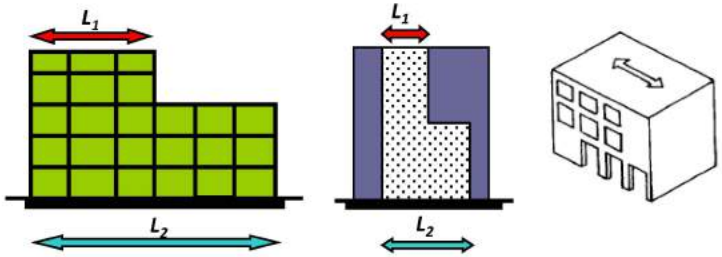


$$\frac{A}{L} > 0.15 - 0.20$$

IRREGULAR FORM AND CONFIGURATION
VERTICAL IRREGULARITIES

4. IN-PLANE DISCONTINUITY OF VERTICAL ELEMENTS

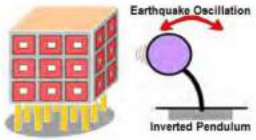
Interruption of vertical members, Abrupt changes in stiffness ratio



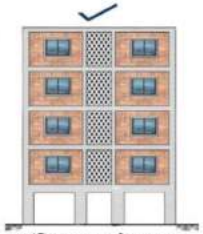
$$L_2 > 1.5L_1$$

भू-मंजिल पर खुला पार्किंग वाले भवन

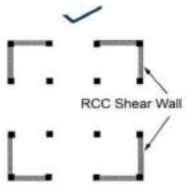
उपरी मंजिलों पर भरे गये दीवारों के कारण, उपरी मंजिलों की अपेक्षा, भूमंजिल पर **stiffness** में भारी कमी रहती है। इसके चलते, भूकम्प के दौरान उपरी मंजिलें एक साथ दोलन करते हैं, और भूमंजिल के पीलर में अत्यधिक विचलन होता है, इससे भवन के धराशायी होने की प्रबल सम्भावना बनी रहती है।



भूमंजिल पर खुला पार्किंग वाले भवन में क्षति



भूमंजिल पर बड़े आकार के पीलर एवं बीम

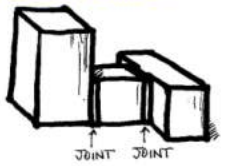


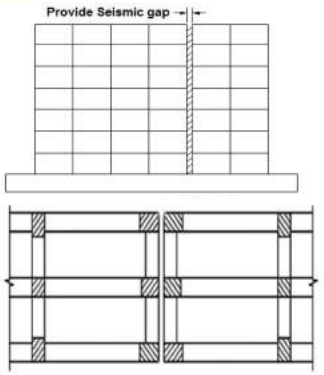
भूमंजिल पर पीलरों के बीच दीवार

SEISMIC SEPARATION JOINTS

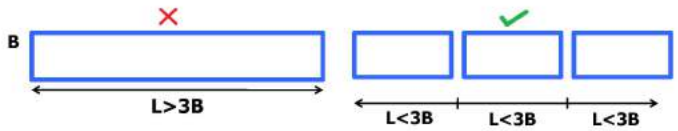
Dissimilar Buildings vibrate in different phase during earthquake shaking and they may collide with each other. Hence provide seismic gap between two adjacent buildings.

Pounding Damage

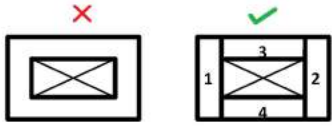




SEISMIC SEPARATION JOINTS

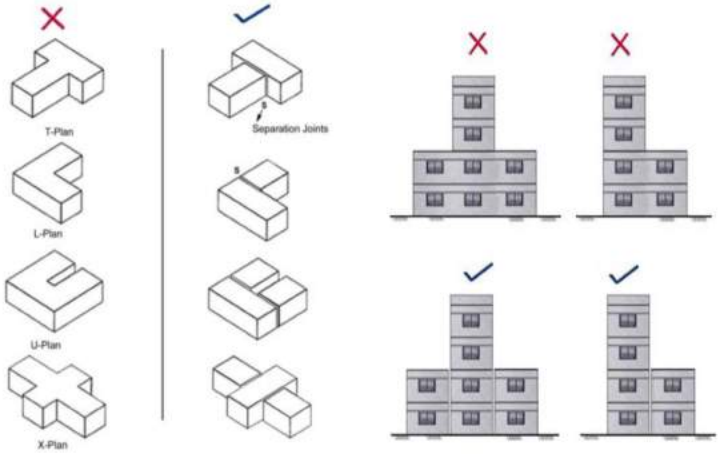


Long rectangular blocks



Floor with large opening

SEISMIC SEPARATION JOINTS



SELECTION OF APPROPRIATE STRUCTURAL SYSTEM

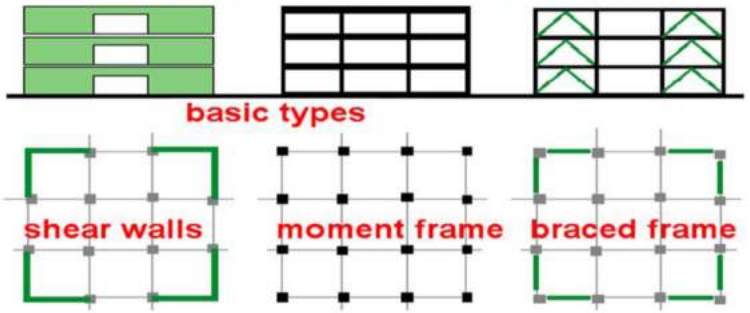
1. Load Bearing wall systems (Brick or Concrete Masonry)
   - Small span low rise residential buildings
   - Up to 2 storey (High Seismic Zones)
   - Upt o 4 storey (Moderate Seismic Zones)
2. R.C.C Framed Buildings
   - More suitable for Seismic zones
3. Steel Buildings
   - Large span Industrial Structures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

SELECTION OF STRUCTURAL SYSTEM

R.C.C Framed Construction

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

SELECTION OF STRUCTURAL SYSTEM

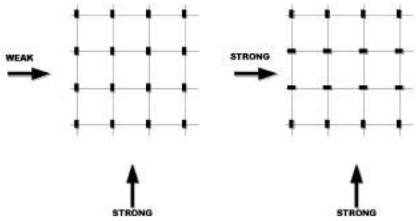


Shear walls are very stiff.
Moment resistant frames are flexible.
Braced systems are in between.

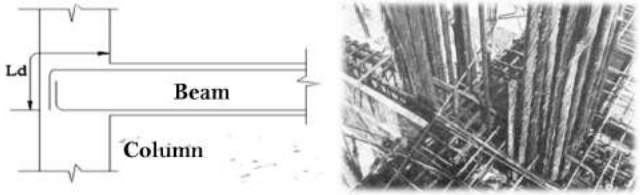
Desirable Structural Framing Arrangements

- 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, why?

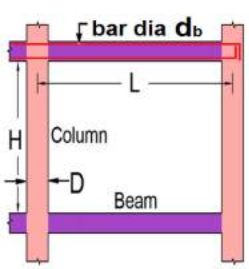


Structural member sizes usually depend on
- Moments / Shear considerations
- Deflection (Stiffness consideration)

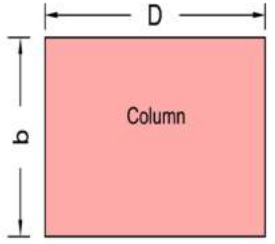
But, the sizes important for
- Beam - column joint design
- Reinforcement anchorage
- Confinement of joints
- Reduce reinforcement congestion

COLUMN AND BEAM SIZES IN RCC FRAME

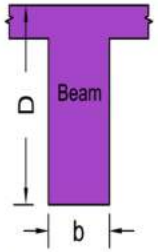
sizes in preliminary design



ELEVATION
BEAM - COLUMN FRAMING



$b > 300$ mm
$b > 0.45\ D$
$D > 15\ d_b$

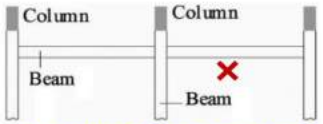


$b > 200$ mm
$b > 0.3D$
$D > L / 4$

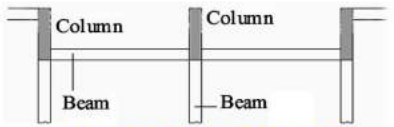
STRUCTURAL CONSIDERATIONS FOR SEISMIC RESISTANCE

FLOATING COLUMN

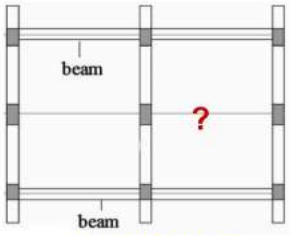
PROBLEMATIC FRAMING ARRANGEMENT



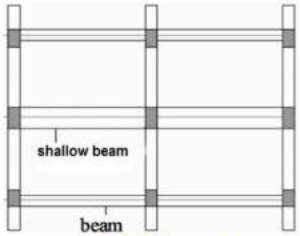
Eccentric Beam (Torsion)



Increased column size to connect Beam

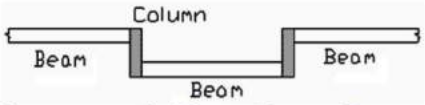


Untied Column

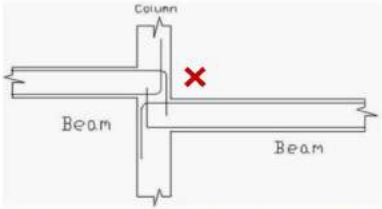


Tied Column

PROBLEMATIC FRAMING ARRANGEMENT



Non-concentric Discontinuous Beam
(Reinforcement Congestion in columns)

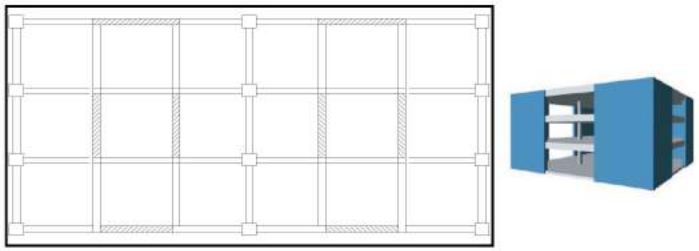


Discontinuity and change in beam level
(reinforcement congestion in column)

BEAM-COLUMN SYSTEM: (CHECK LIST)

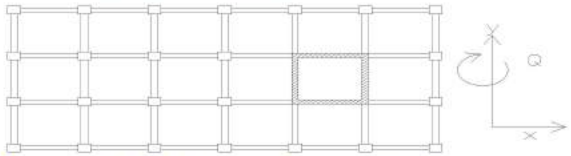
- ✓ Column orientations in both directions
- ✓ Completeness of frames
- ✓ Adequate Beam-column sizes
- ✓ Concentric beam alignment
- ✓ Avoid abrupt change in column sizes
- ✓ Avoid floating columns
- ✓ Avoid strong beam-weak column
- ✓ Square / circular column (most preferred)
- ✓ Well tied free standing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

FRAME-SHEAR WALL COMBINATION

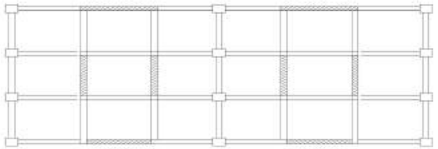


- Height range 30-35 Storey.
- Shear walls provides lateral stiffness
- Shear walls predominantly carry earthquake loads.
- Frames require to carry 25% of earthquake forces.

SHEAR WALL LOCATION



Unsymmetrical placement causes torsion



Place Symmetrical along both axes

Other aspects of Seismic resistance

- Projecting parts
  - Avoid as for as possible
- Continuity of construction:
  - All elements tied together
- Redundancy
  - At least 3 columns in a row
- Protection of Building contents
  - Non structural components
  - Architectural elements
  - Building services
- material properties:
  - High strength to weight ratio
  - Ductility

THANK YOU

(4)

Principles of Earthquake Resistant Buildings (IS:1893) and Architectural Considerations

POINTS FOR CONSIDERATION AND DISCUSSION

1. What are the BIS Codes, for earthquake resistant design of buildings?
2. What is the basic difference between Wind load and Seismic Load?
3. What are the main four responses of a building structure to earthquake shaking?
4. What is the difference between Maximum considered earthquake and Design basis earthquake?
5. What is the 'Earthquake Resistant Design Philosophy'?
6. What message does seismic zone factor z=0.36 convey?
7. How Design Horizontal Seismic Force is computed for a building structure?
8. What percentage of MCE is taken up during the design, in case of SMRF?
9. How ductility of a structure can help during occurrence of MCE?
10. What are the considerations, while planning an urban area for disaster resilience?
11. At what stage of architectural planning, structural irregularities must be considered?
12. What are good structural configurations for seismic safety of buildings?
13. What do you mean by 'Strong column and Weak beam design'?
14. What are the types of 'Plan irregularities' and 'Vertical irregularities'?
15. How the issue of open ground parking (extreme soft storey) is resolved at planning stage?
16. What is the basic reason for pounding between adjacent buildings?
17. What is the limiting length of a building with respect to its width?
18. How a seismic separation gap is provided to improve an irregular building?
19. What are the ideal 'Structural Framing Arrangements'?
20. What are the considerations to achieve a rigid RCC beam-column joint?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(5)
Masonry Buildings:
Failures vs Integrity

90 min

TYPES OF MASONRY CONSTRUCTION IN BIHAR

Foundation
- Open foundation:
  - Continuous wall footing
  - Isolated footing with tie beams
- Pile foundation with tie beams

Wall materials
- Unpacked Stone (rare)
- Packed Stone (rare)
- Un-burnt brick
- Burnt brick

Masonry mortar
- Mud
- Lime-sand
- Lime-surkhi
- Cement-sand

Inclined Roof
- Grass/ Thatch over Bamboo/ Wood rafters
- Burnt clay tiles
- Metal/ Asbestos sheets

Flat Roof
- Burnt brick over wooden beam
- RCC beam-slab

TYPES OF MASONRY CONSTRUCTION IN BIHAR VARIOUS ROOF TYPES OVER BRICK MASONRY


thatch roof


clay tile roof


CGI sheet roof

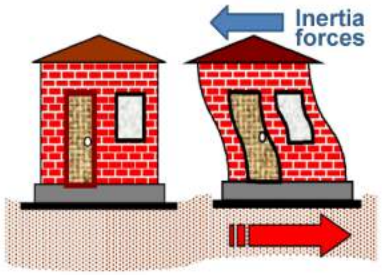

RCC slab roof

POOR PERFORMANCE OF MASONRY BUILDINGS

- Non adherence to building codes and byelaws
- Inadequate structural system
  - Irregular plan and configuration
  - Heavy dead weight and very stiff buildings
- Deficiencies in design/detailing
  - Inappropriate sizes and positions of openings
  - Very long walls, unsupported cross walls
  - Very low tensile and low shear strength mortars
- Deficiencies in Construction
  - Weak connection between walls
  - Weak connection between roof and wall
  - Sub-standard materials, lack of skill & workmanship
- Foundation: Improper site/design/construction
- Lack of maintenance: aging, corrosion & cracking
- Alterations/ extensions: not considering EQ effects
- Old decaying buildings: without seismic strengthening

भूकम्प में भवन का दोलन

- भूकम्प तरंग के कारण जमीन का तल डोलता है।
- भवन के नींव और निचले भाग जमीन के साथ चलते हैं।
- Inertia के कारण भवन के उपरी भाग पर विपरीत दिशा में inertia Force लगता है और भवन डोलने लगता है।
- भवन के दीवार या पीलर छत को खींचकर रखता है।



- इससे कमजोर भवन की दीवार को झुककर टूटने का खतरा बना रहता है।

TYPICAL DAMAGES IN MASONRY BUILDINGS during earthquake shaking

- Roof tiles dislodge
- Walls:
  - Diagonal / vertical / horizontal cracks
  - Diagonal Cracks near openings
  - Walls Tear apart
  - Corner failure
- Failure of connections:
  - Wall with roof
  - Parapet with roof

भूकम्प से हुई क्षति


दीवार में महीन तिरछी टरारें


दीवार के कोना पर खड़ी टरार


खिड़की के पास तिरछी दरारें


दीवार में आरी–तिरछी दरारें


कई दीवारों में बहुत दरारें


दीवार का कोना खुल जाना

भूकम्प से हुई क्षति


दीवार का कोना ढ़हना


दीवार का कोना ढ़हना


तिकाने दीवार का ढ़हना


कंक्रीट छत का गिरना


मुड़ेर का गिरना


ईंट जोड़ाई पीलर में दरार

भूकम्प से हुई क्षति


दीवार का पलटना


दीवार का पलटना


भवन के कुछ हिस्सों का ढ़हना


भवन के छत का गिरना


पूरी तरह गिरा हुआ मकान


भूकम्प में पूरे भवन का ढ़हना

आँधी से क्षति


छत का उपर उठना


छत के खपरैल का खिसकना


छत की टीन–चादरें उड़ना


गिरी हुई दीवारें एवं छत


चहारदीवारी का गिरना


फूस के घरों का तहस–नहस होना

बरसात / बाढ़ से क्षति


बायीं ओर नींव धँसने से क्षति


दीवार का पलटना


छत का गिरना


मकान का झुकना


जलबहाव से नींव का कटना

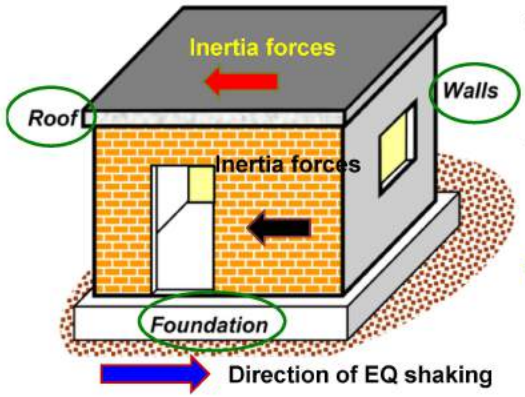

फूस के घरों का कटाव

FAILURE MODE OF MASONRY BUILDINGS

- Load Transfer Mechanism
- In-plane failure: Bending, shear
- Out-of-plane failure:
  - Bending
  - Failures at Corners
  - Thin and tall walls to topples
  - Longer wall bending
  - Gable end wall
- Roof on Two Walls
- Roof on complete Wall Enclosure
- Diaphragm Failure
- Long Building with Roof Trusses
- Influence of Openings
- Unsymmetrical plan
- Seismic zone and risk of damage to house types
- Sum up the reasons of failure

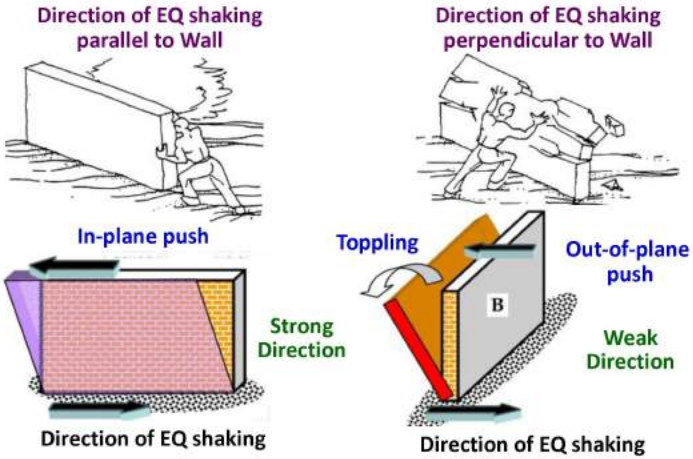
MASONRY BUILDING; LOAD TRANSFER MECHANISM

three basic components of masonry building



- Ground motion generates Inertia forces at the location of mass
- Inertia forces has to reach the ground through walls
- Walls are most vulnerable to damage

IN-PLANE & OUT-OF-PLANE FORCES

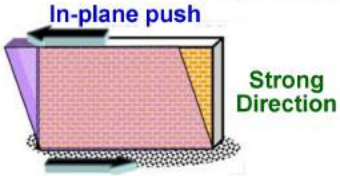


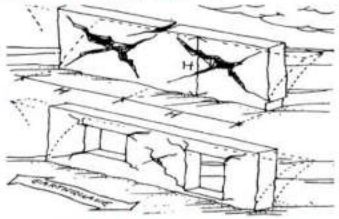
IN-PLANE PUSH

ACTING ALONG

STRONG DIRECTION OF WALL

IN-PLANE SHEAR OF WALLS



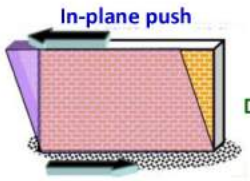


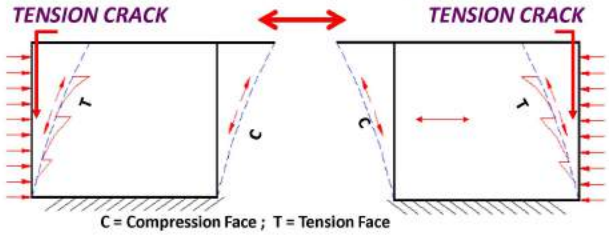
WALLS attract large horizontal inertia forces and act as brick Shear Walls

Diagonal Tension Cracking of masonry walls due to excessive shear

In-plane Shear Failure of Wall

IN-PLANE BENDING OF WALLS

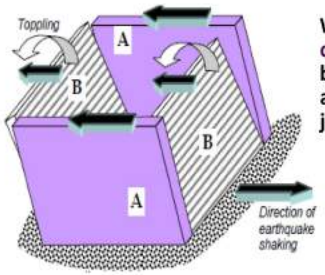




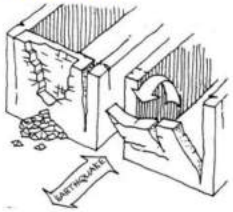
OUT-OF-PLANE PUSH ACTING ALONG WEAK DIRECTION OF WALL

OUT-OF-PLANE BENDING OF WALLS

Wall Enclosure without Roof or flexible roof



Weak connection between walls at vertical joints

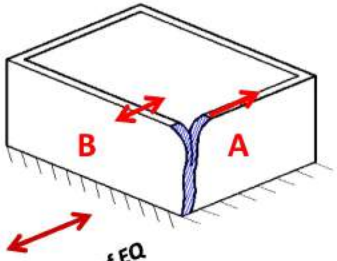


Toppling of wall B due to Horizontal inertia force

Overturning of wall

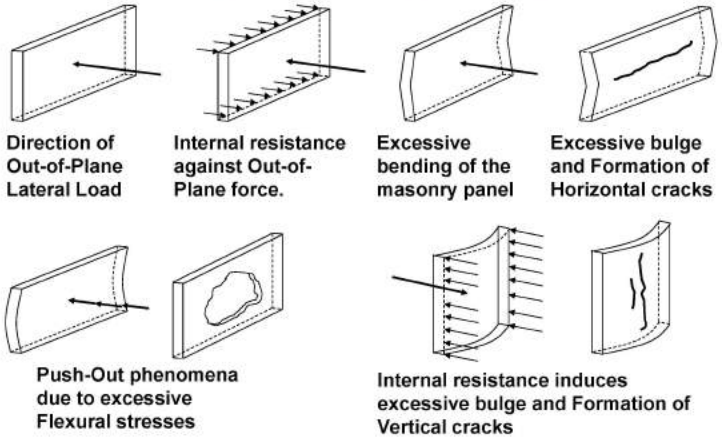
SEPARATION OF WALLS AT THE CORNERS

Wall B tends to tear apart from A



FAILURE AT CORNER

Masonry walls: Out-of-plane response



Direction of Out-of-Plane Lateral Load

Internal resistance against Out-of-Plane force.

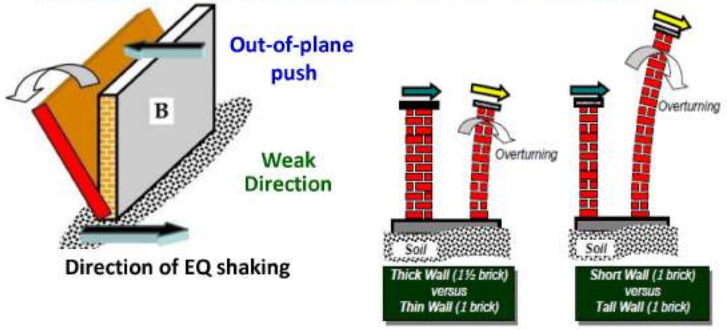
Excessive bending of the masonry panel

Excessive bulge and Formation of Horizontal cracks

Push-Out phenomena due to excessive Flexural stresses

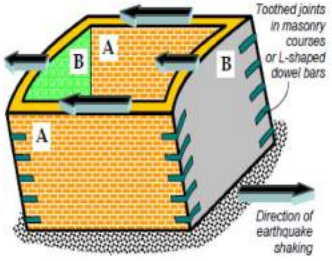
Internal resistance induces excessive bulge and Formation of Vertical cracks

THIN AND TALL WALLS TEND TO TOPPLE

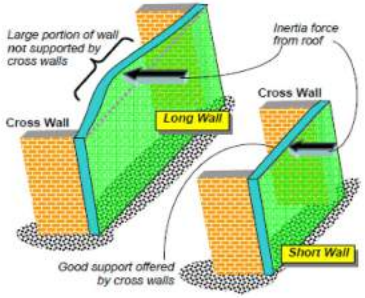


Limit the Height-to-Thickness Ratios

LONGER WALLS ARE PRONE TO BENDING



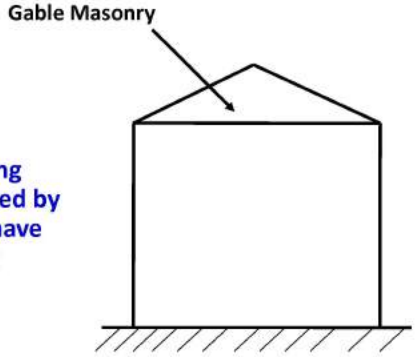
Walls in weak direction gets lateral resistance of cross walls.



Limit the Length-to-Thickness Ratios

COLLAPSE AND DAMGE OF GABLE WALLS

Gable walls in sloping roofs are not supported by cross walls and may have out-of-plane bending



Out-of-plane failures of gable wall

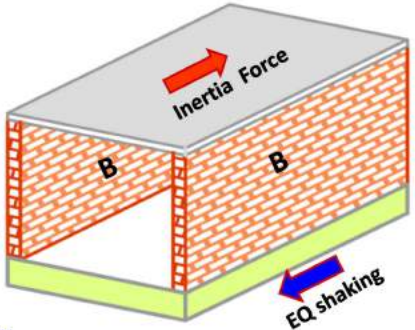
EFFECT OF ROOF PLACED OVER WALLS

R. C. SLAB ON TWO WALLS

DIAPHRAGM ACTION:

RC slabs have enough strength in bending in the horizontal plane to transfer inertia force to walls.

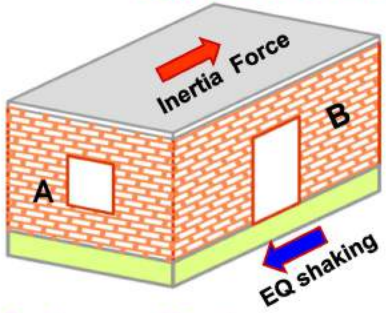
Timber with brick tile covering is very flexible.



The walls B may shear

If ground motion is perpendicular to the plane of wall B, it may collapse very easily.

RIGID R.C. ROOF ON COMPLETE WALL ENCLOSURE



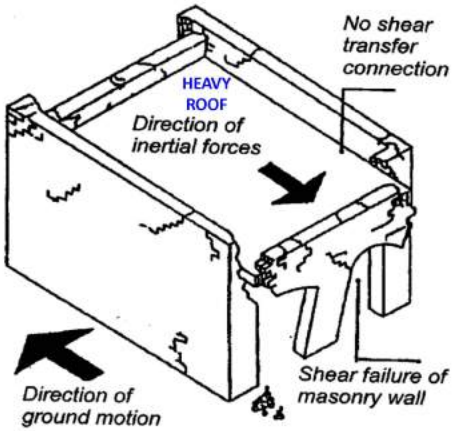
Enclosure will act as a box for resisting the lateral loads

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.

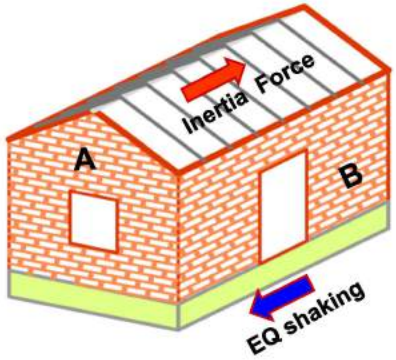
DIAPHRAGM FAILURE



FLEXIBLE ROOF ON COMPLETE WALL ENCLOSURE

The roof inertia will go to the wall on which it is supported.

Walls **A** has little out-of-plane bending strength and may overturn

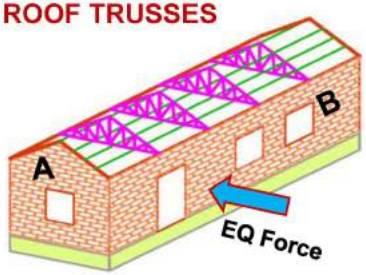


Out-of-plane failure of gable wall

LONG BUILDING WITH ROOF TRUSSES

ground motion
Perpendicular to Wall **B**

the inertia forces will be transmitted from sheeting to purlin to trusses and from trusses to wall **B**.



- Trusses may slide on walls unless properly anchored
- Horizontal force is not transmitted to end walls **A** due to lack of horizontal bracing between trusses.
- Long Wall **B** does not get much support from the walls **A**.
- Wall **B** may overturn in bending as a cantilever

Kerinci 1995

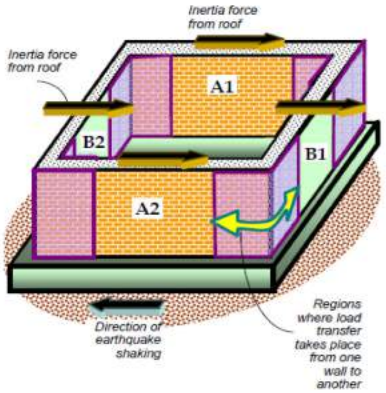
Flores 1992

Roof truss slides from its supports

EFFECT OF OPENINGS IN WALLS

INFLUENCE OF OPENINGS IN MASONRY WALLS

Wall Enclosure without Roof or flexible roof

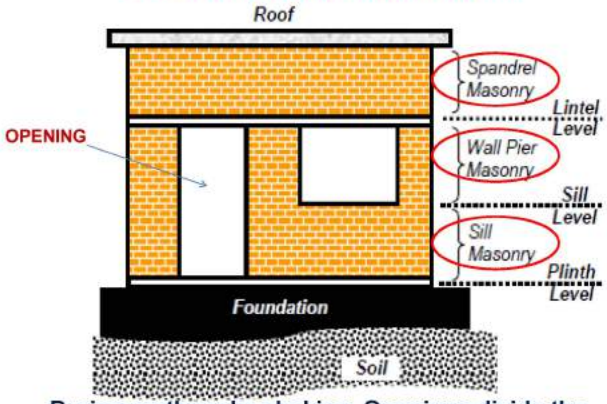


Walls B1, B2 seek support from walls A1, A2 during seismic shaking.

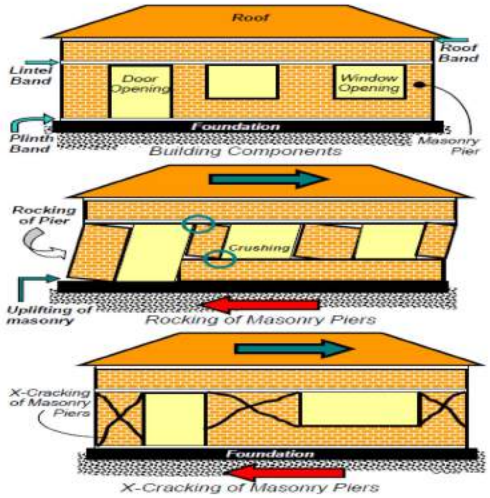
Opening in wall A1, A2 reduces shear capacity

Opening in wall B1, B2 reduces bending capacity

ELEMENTS IN THE MASONRY WALL



During earthquake shaking, Openings divide the masonry walls into 3 discrete units.



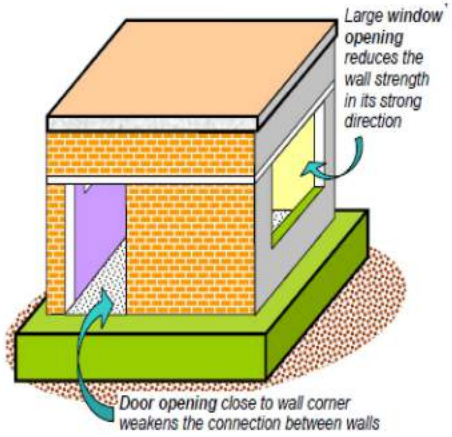
INFLUENCE OF OPENING IN STRONG WALL

When the ground shakes:

The wall piers disconnects from the masonry at the opposite diagonals

The masonry piers develop diagonal shear cracks.

LOCATION AND SIZE OF OPENINGS

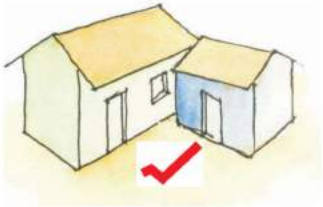


Openings near the wall corners hamper the flow of forces from one wall to another.

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

FAILURE AT CORNERS OF OPENINGS

FAILURE OF UNSYMMETRICAL PLAN BUILDINGS



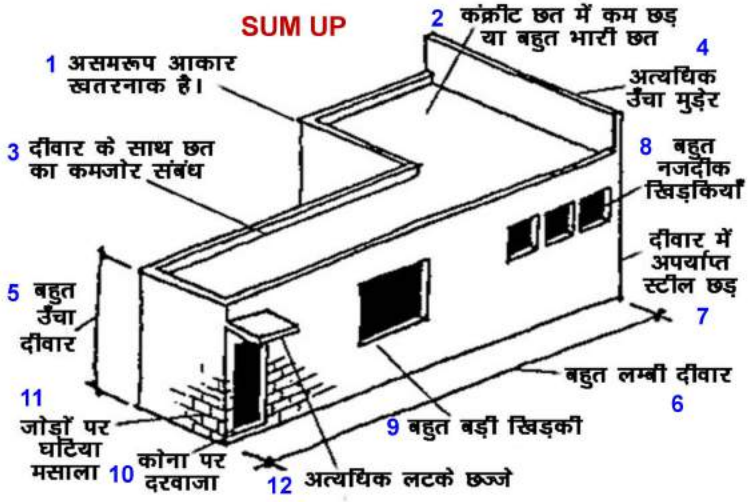
Weak Connection between wall and wall

Weak Connection Between wall and roof

Poor construction material / workmanship

भूकम्प जोन एवं भारवाहक दीवारों में सम्भावित क्षति

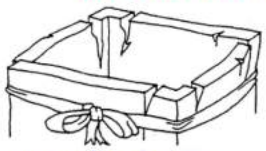
क्र. स.	भूकम्प जोन	III	IV	V
	अधिकतम सम्भावित भूकम्पीय तीव्रता	MSK VII	MSK VIII	MSK IX या अधिक
1	बिना भूकम्पीय बैंड एवं खड़े छड़ के, आर.सी.सी. छत एवं अच्छे सिमेंट गारे में पर्याप्त मोटाई के ईंट–दीवार वाले एक या दो मंजिले मकान	कई में, दीवार में दरार	बहुतों में, दीवार में दरार	सामान्य या भारी क्षति
2	उपर (1) की तरह, परन्तु तीन या चार मंजिले मकान	बहुतों में, चौड़े दरार	बहुतों में, भीषण क्षति, कुछ मंजिलें ध्वस्त	कुल ध्वस्त
3	उपर (1) की तरह, परन्तु दीवार की मोटाई के अनुपात में लम्बाई एवं उँचाई ज्यादा हो	बहुतों में, चौड़े दरार	बहुतों में, भीषण क्षति, कुछ मंजिलें ध्वस्त	कुल ध्वस्त
4	भूकम्पीय बैंड तथा खड़े के साथ, अच्छे सिमेंट गारे में ईंट–दीवार वाले एक या दो मंजिले मकान	कुछ में, बाल के बराबर दरार	कुछ में, दीवार में मामूली दरार	केवल कुछ में, चौड़े दरार

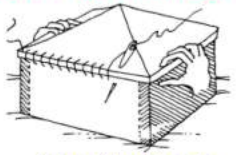


BOX ACTION IN MASONRY BUILDINGS

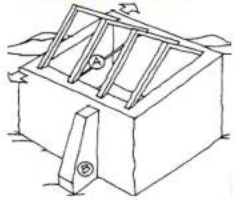
ईंट जोड़ाई दीवारों पर आधारित मकान की भूकम्प से सुरक्षा हेतु सबसे महत्वपूर्ण यह है कि सभी दीवारें साथ–साथ काम करें और मकान एक पूर्ण बॉक्स की तरह काम करे।

BOX ACTION IN MASONRY BUILDINGS

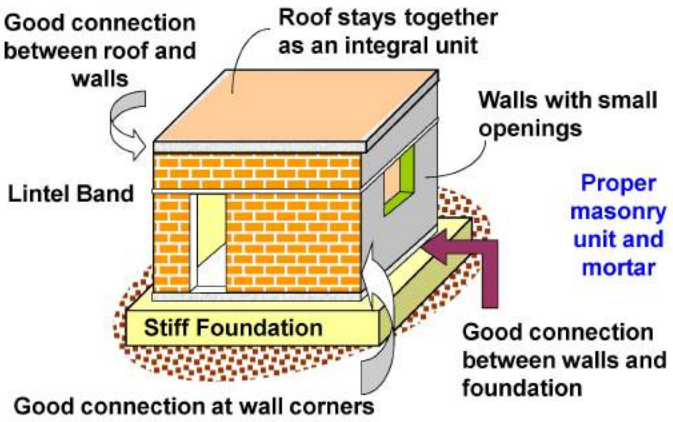

integrity of walls


integrity of roof

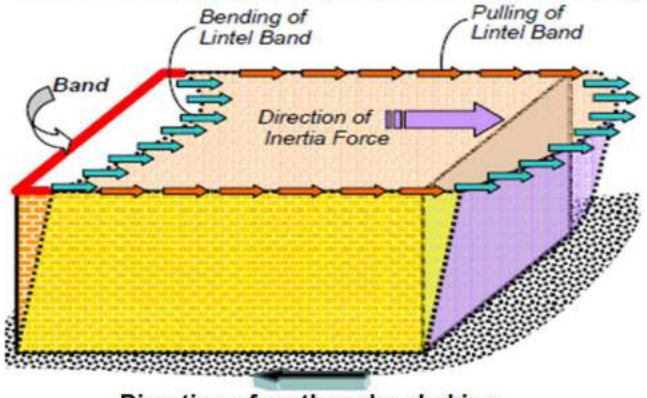

Diagonal bracing of flexible roof


Tie for rafter & Butress for wall

BOX ACTION IN MASONRY BUILDINGS

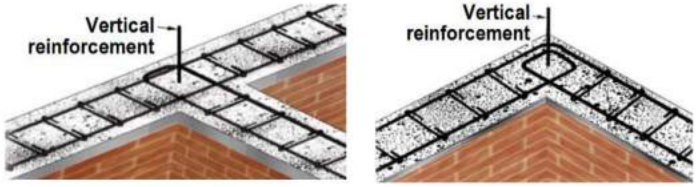


LINTEL BANDS UNDER EARTHQUAKE SHAKING



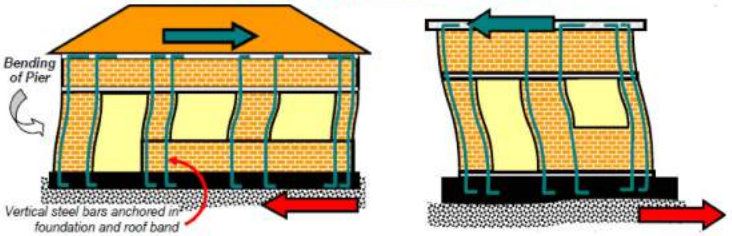
Lintel band reduces out-of-plane deflection of wall to 1/5th

BAND REINFORCEMENT DETAILING



- Bands hold all walls together
- Main types Bands in masonry buildings
  - Lintel band Provided in all buildings
  - Plinth band resists uneven foundation settlement
  - Sill band for large openings
  - Roof band required if RCC roof is not provided
  - Gable band-used in pitched or sloped roof building

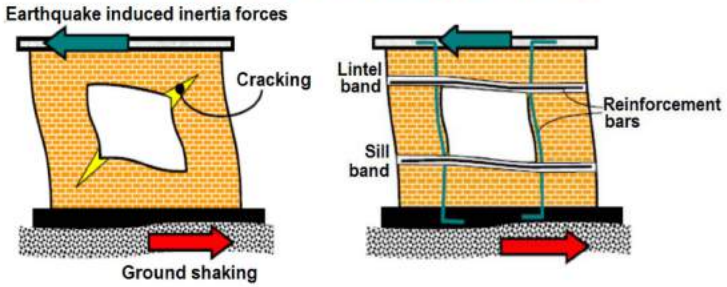
VERTICAL REINFORCEMENT IN MASONRY



Vertical bars anchored into foundation and into roof:

- *prevents from sliding or rocking*
- *Causes bending of wall*
- *Delays the shear-cracking*
- *Protect from sliding*

PROTECTION OF OPENINGS IN WALLS



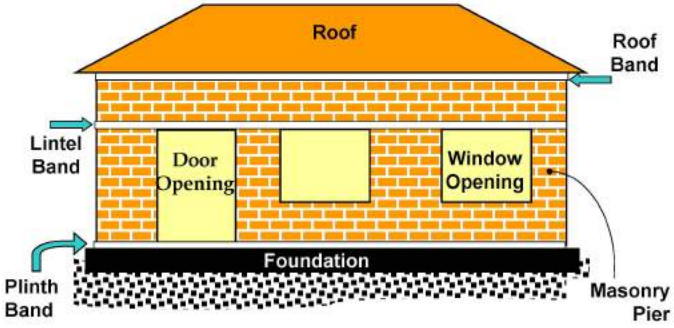
Diagonal cracks at corner of opening, in wall without reinforcement

The cracks are bigger when the opening sizes are larger.

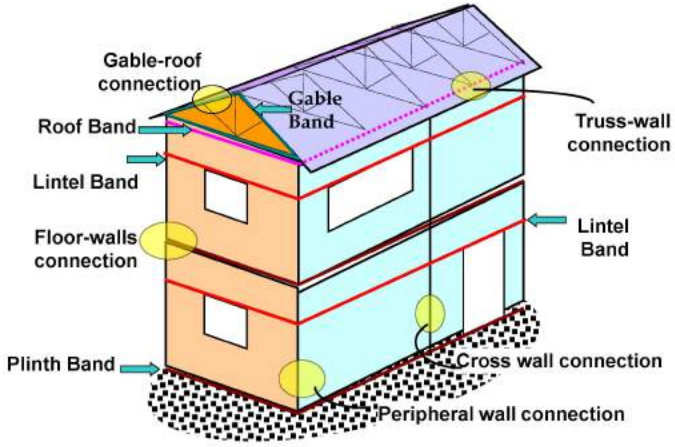
Lintel band, sill bands and vertical steel provide protection

Provide small openings

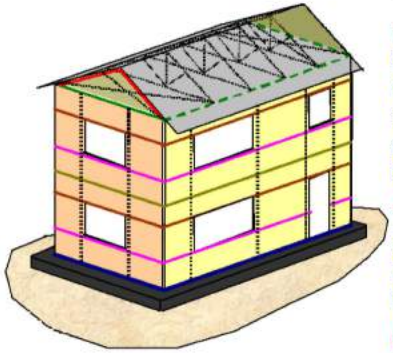
BANDS IN HIPPED ROOF BUILDING



BANDS IN SLOPED ROOF BUILDINGS



CONFINED MASONRY WALL BUILDING



Provision of :

TIE COLUMNS: Vertical RCC Bands at openings and at corners of walls, anchored into foundation and anchored into Roof / Roof band

TIE BEAMS: Horizontal RCC Bands at Lintel Level, Sill Level, Plinth Level, Roof Level

INCLINED BANDS: at Gable Ends

GENERAL PRINCIPLES FOR IMPROVING EARTHQUAKE RESISTANCE

- **LIGHT WEIGHT:**
  Particularly roof and upper storeys
- **SYMMETRY:**
  symmetrical plan & elevation:
  Symmetrical with respect to mass and stiffness
- **RECTANGULARITY:** in plan and in elevation
- **INTEGRITY:** all portions of building tied together
- **LOAD PATH:** simple & shortest, from top to foundation
- **REDUNDANCY:** Extra Structural members
- **FOUNDATION:** on firm and uniform ground

EARTHQUAKE PROTECTION MEASURES

- Maximum height of building 10 to 15m
- Well burnt bricks, crushing strength > 3.5 Mpa
- Cement Mortar: Cement-sand 1:6 to 1:4 or richer
- A toothed joint for perpendicular walls, alternatively in lifts of about 450 mm
- Vertical joints in the masonry broken properly from course to course
- RCC bands in horizontal direction
- Vertical steel at corners: Foundation to roof
- Reinforce larger door & window openings
- Horizontal dowel bars at wall junction
- Tie level cross bracing for inclined roofs
- Use steel ties with arches

भूकम्परोधी भवन का निर्माण

- भवन की लम्बाई, अपने चौड़ाई के तीन गुने से कम
- दोनों क्षैतिज दिशाओं में, एक सिरे से दूसरे सिरे तक दीवार
- सभी दीवारों की पर्याप्त मोटाई
- दरवाजों एवं खिड़कियों के लिंटल एक ही तल पर
- दरवाजों एवं खिड़कियों के आकार सीमित
- लटके बालकोनी के आकार सीमित
- आपातकालीन सेवा प्रदान करने वाले भवन, स्कूल तथा सामुदायिक भवन को अपेक्षाकृत ज्यादा सशक्त

Thank You

(5)

Masonry Buildings: Failures vs Integrity

POINTS FOR CONSIDERATION AND DISCUSSION

1. What are the types of masonry construction in Bihar?
2. Enumerate the reasons for poor performance of masonry buildings in Bihar.
3. Why the wall of a masonry building is most vulnerable, during earthquake shaking?
4. What are the types of damages seen in masonry building, during earthquake shaking?
5. What are the two types of In-plane failure in masonry building, due to earthquake shaking?
6. What are the the types of Out-of-plane failures in masonry building, due to earthquake shaking?
7. What is effect on a thin wall and a long wall during earthquake shaking?
8. In what condition a building having 'Roof on Two Walls' may fail during earthquake shaking?
9. How a 'Roof on complete Wall Enclosure' behave during earthquake shaking and why?
10. Which part of a 'Long Building with Roof Trusses' is most vulnerable?
11. Why diagonal cracks in wall piers are generated during earthquake shaking of masonry buildings?
12. Why symmetrical plans are recommended for masonry buildings?
13. What will damage of a 3 story building without horizontal band and vertical steel in Seismic zone IV?
14. What are the twelve irregularities in masonry buildings?
15. What do you mean by 'Box action in masonry buildings'?
16. What are the two important responses of the lintel bands during shaking of masonry buildings?
17. What are the responses of vertical steel during earthquake shaking of masonry buildings?
18. How can you protect of the openings against earthquake shaking?
19. What are the general principles for improving earthquake resistance of masonry buildings?
20. Name important points to be incorporated in Construction of earthquake resistant masonry buildings?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(6)
Masonry Buildings:
EQ Resistant Design (IS:4326)
& Confined Masonry

30 min

INTRODUCTION

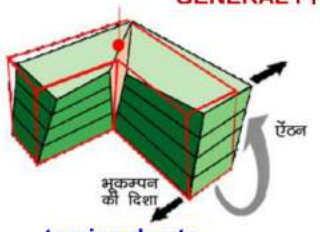
- IS 1893 - 2016
  Main IS Code for Earthquake resistant design of structures
- IS: 4326- 1993 (Reaffirmed 2003)
  Earthquake resistant design of Masonry buildings
- IS 13827
  Improving earthquake resistance of earthen buildings
- IS 13828
  Improving earthquake resistance of Low strength masonry buildings

IS 4326 : 1993 (Reaffirmed 2003)

GENERAL PRINCIPLES

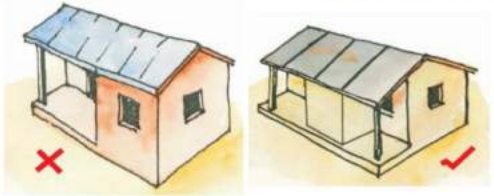
- Lightness : Particularly roof and upper storeys
- Continuity of Construction :
  - Tie all portions of building as one integral unit,
  - Use crumple sections to separate parts of buildings, or new and the existing structures, and parts of different rigidities.
- Use thin ceiling plaster
- Avoid false ceiling or provide light, framed & secured
- Connect non-structural parts with the structure
- Foundation not to be placed on loose soils, it may subside or liquefy, resulting in large differential settlements
- Buildings shall be fire resistant in accordance with the provisions of BIS codes.

GENERAL PRINCIPLES continued.....



torsion due to unsymmetrical plan

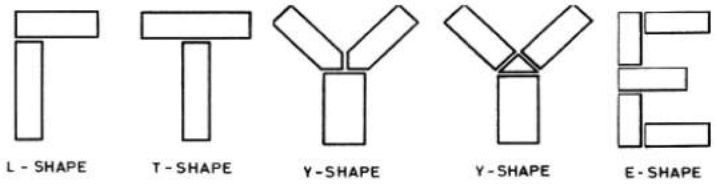
torsion due to unsymmetrical loads



GENERAL PRINCIPLES continued.....

Building configuration to minimize torsion:

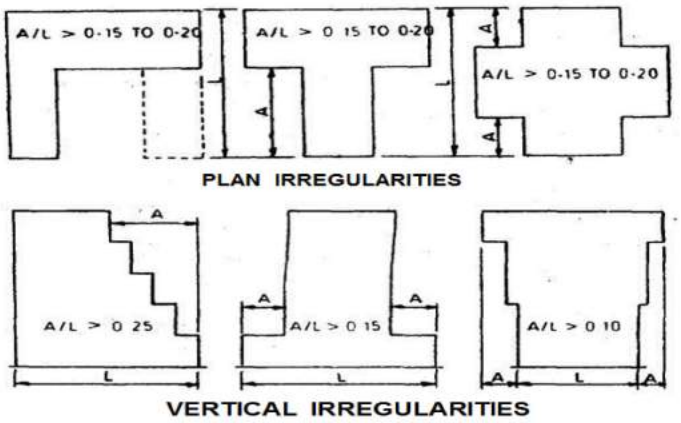
- Keep symmetrical plan & elevation with respect to mass and stiffness;
- provide separation joints as necessary, design for torsion effect if asymmetry.



Building Plan Shapes

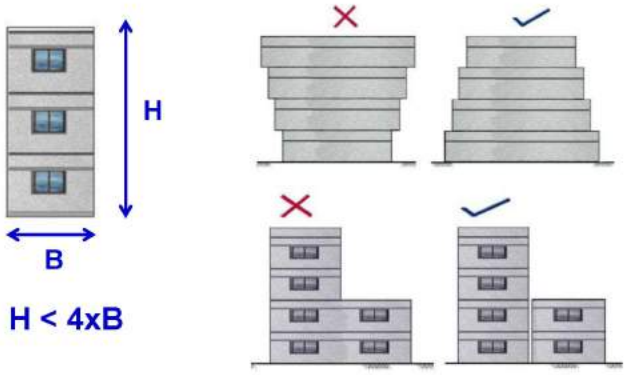
GENERAL PRINCIPLES continued.....

length of plan projection < 15 – 20% of total length



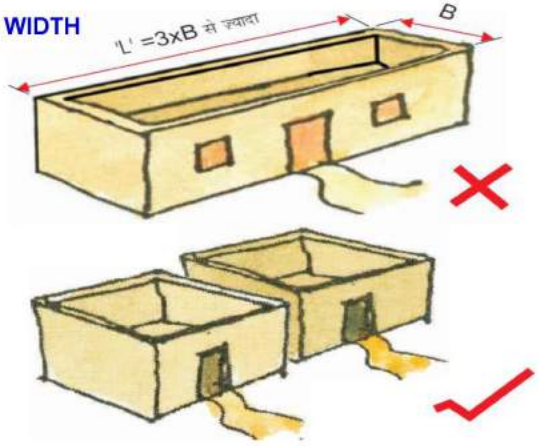
GENERAL PRINCIPLES continued.....

adopt simple rectangular shapes

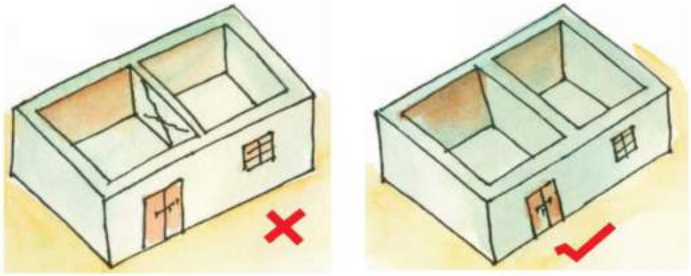


GENERAL PRINCIPLES continued.....

LENGTH < 3 x WIDTH



GENERAL PRINCIPLES continued.....



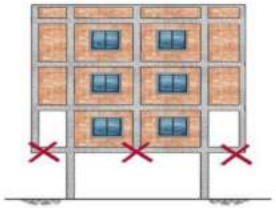
PROVIDE THICK PARTITIONS

GENERAL PRINCIPLES continued.....

Avoid cantilevers, or tie firmly

Improper load path

Avoid cantilevers, or tie firmly



Improper load path

SPECIAL CONSTRUCTION FEATURES

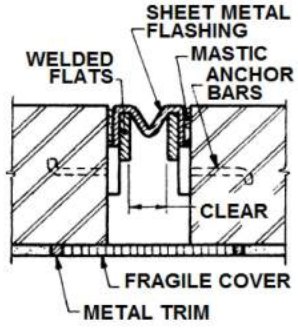
Seismic Gap to avoid pounding

Sl. No.	Type of Constructions	Gap / Storey, For αh = 0.1 2
1	Box system or frames with shear walls	15 mm
2	Moment resistant reinforced concrete frame	20 mm
3	Moment resistant steel frame	30 mm

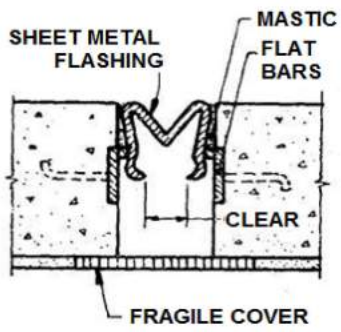
minimum gap 15 mm.

SPECIAL CONSTRUCTION FEATURES continued ....

DETAILS OF SEPARATION JOINT



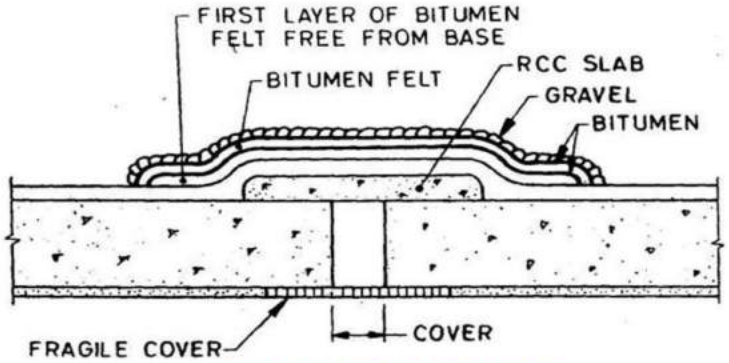
BRICK WALL



CONCRETE WALL

SPECIAL CONSTRUCTION FEATURES continued ....

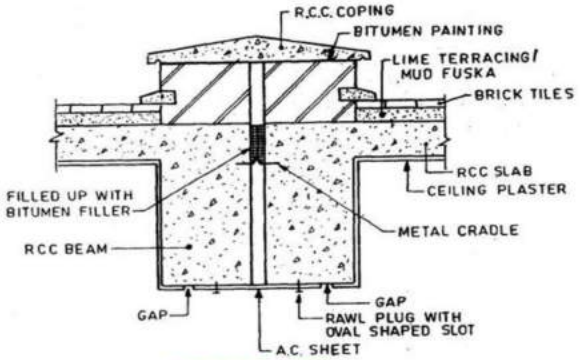
DETAILS OF SEPARATION JOINT



RCC SLAB ON ROOF SURFACE

SPECIAL CONSTRUCTION FEATURES continued ....

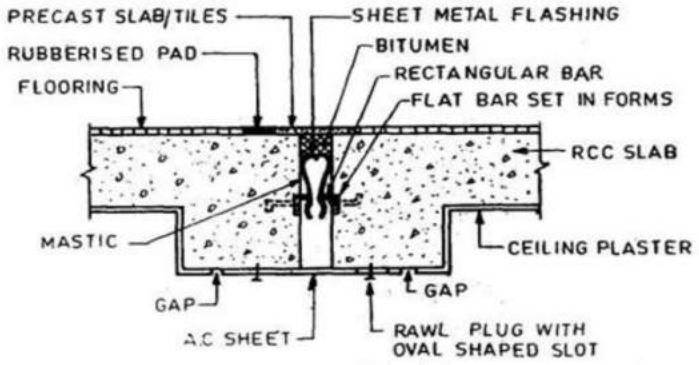
DETAILS OF SEPARATION JOINT



AT ROOF LEVEL

SPECIAL CONSTRUCTION FEATURES

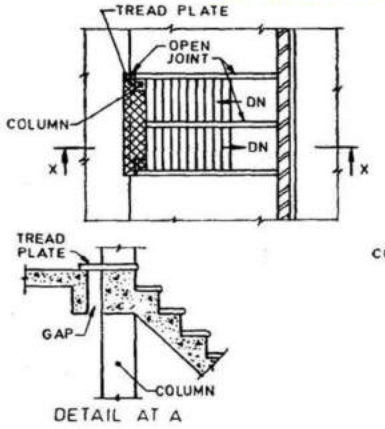
DETAILS OF SEPARATION JOINT



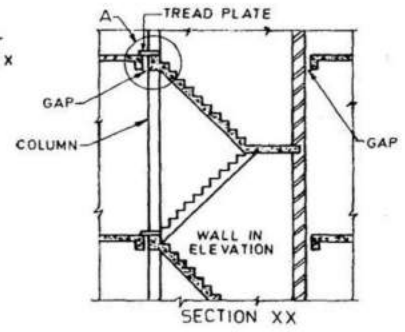
AT FLOOR LEVEL

SPECIAL CONSTRUCTION FEATURES continued ....

DETAILS OF SEPARATED STAIR

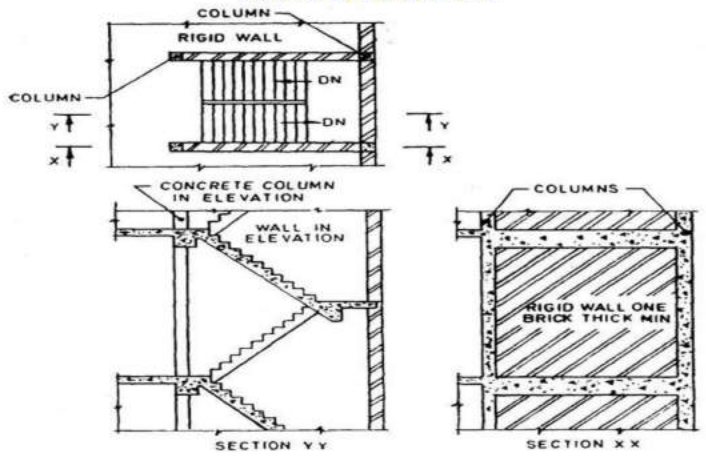


DETAILS OF SEPARATED STAIR



SPECIAL CONSTRUCTION FEATURES continued ....

RIGIDLY BUILT IN STAIR



BOX TYPE CONSTRUCTION

- Masonry wall along both the axes ot the building.
- All portions of building as one integral unit
- Walls support vertical loads
- Walls act as shear walls for horizontal loads acting in its plane.
- Ensure connections between wall panels to transfer of shear.
- The bearing walls in both directions shall be straight and symmetrical in plan.
- Limit length, width & thickness of walls.
- Limit the size and location of opening
- Reinforce with horizontal RCC band and vertical steel at every corner of rooms
- RCC roof is preferable.

BUILDING CATEGORIES for Earthquake Resisting Features				
Importance factor	Seismic zones			
	II	III	IV	V
1.0	B	C	D	E
1.5	C	D	E	E
Low strength masonry shall not be used for category E				

BRICK & MORTAR

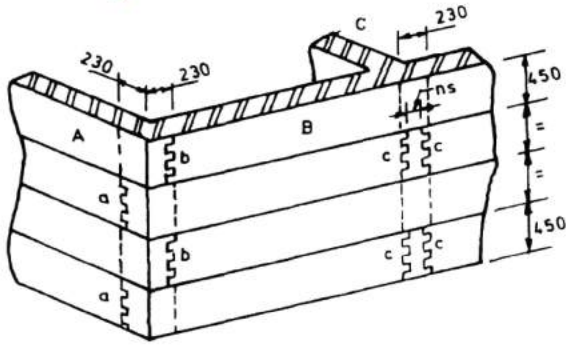
Well burnt bricks conforming to (IS 1077 : 1992)
Crushing strength of masonry unit > 3.5 Mpa

MORTAR MIXES USED IN MASONY (*Clauses 8 1.2.1 and 8.2.6*)	
Category of Construction	Proportion of Mortar
B, C	Cement-lime-sand 1:2:9 or Cement-Sand 1:6 or richer
D, E	Cement-lime-Sand 1 : 1 : 6 or Cement-sand 1:4

Use cement-sand mortar 1:3 with Clear cover of 10 mm for steel bars provided in masonry

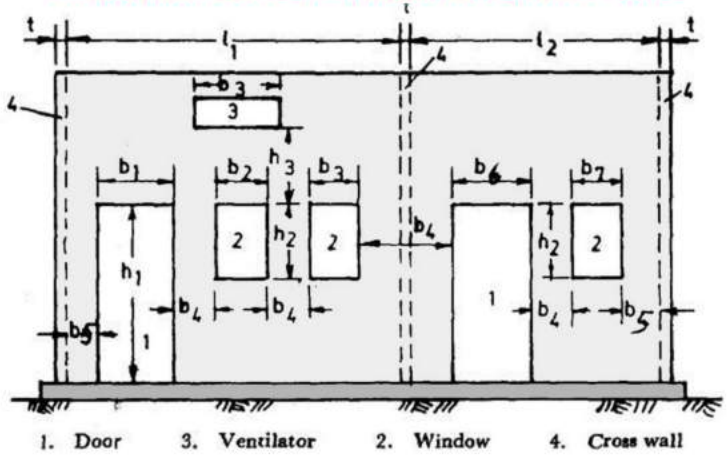
MASONRY BOND

first make a stepped joint at corners to a height of 600 mm and then building the wall in between them. Or, the toothed joint should be made in both the walls alternatively in lifts of about 450 mm



LIMITING LENGTH & HEIGHT OF LOAD BEARING WALLS

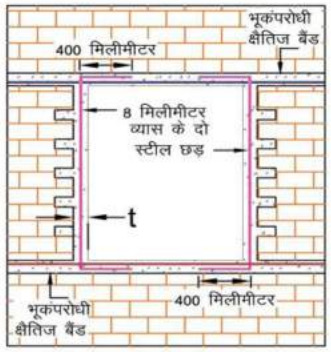
DIMENSIONS OF OPENINGS AND BRICK PIERS



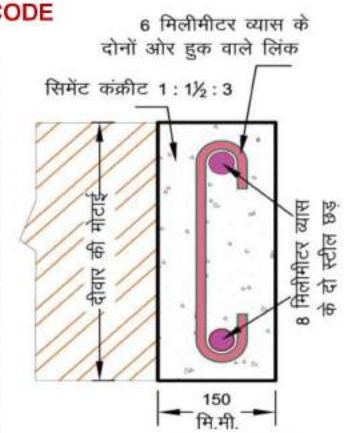
1. Door 3. Ventilator 2. Window 4. Cross wall

SIZE AND POSITION OF OPENING IN BEARING WALLS (Clause 8.3.1 and Fig. 7)				
Sl. No.	Position of Opening	Details of Opening for Building Category		
	B	B	C	D and E
1.	Distance b_5 from the inside corner of outside wall, Min	Zero mm	230 mm	450 mm
2.	For total length of openings, the ratio $(b_1 + b_2 + b_3)/l_1$ or $(b_6 + b_7)/l_2$ shall not exceed.			
	a) one-storey building	0.60	0.55	0.50
	b) Two-storey building	0.50	0.46	0.42
	c) 3 or 4 storey building	0.42	0.37	0.33
3.	Pier width between consecutive opening b_4 Min	340 mm	450 mm	560 mm
4.	Vertical distance between two openings one above the other h_3 Min	600 mm	600 mm	600 mm
5.	Width of Ventilator b_3 Max	900 mm	900 mm	900 mm

STRENGTHEN OPENINGS IF NOT COMPLYING WITH THE CODE



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



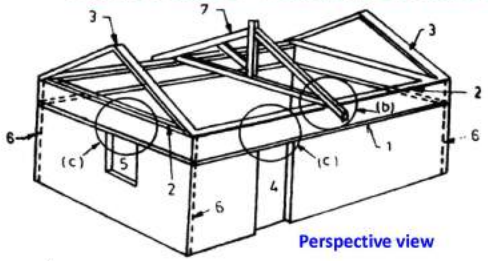
t पर आड़ीकाट

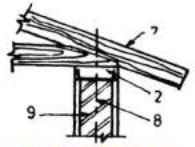
SEISMIC STRENGTHENING

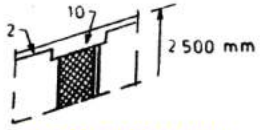
भूकम्प जोन	मकान की अधिकतम उँचाई	ईंट जोड़ाई मसाला का अनुपात	क्षैतिज भूकम्परोधी आर.सी.सी. बैंड	दीवार के कोनों एवं किनारों पर खड़े स्टील के छड़
V	तीन मंजिल (12 मीटर से कम)	सिमेंट:बालू – 1:4	कुरसी बैंड लिंटेल बैंड सिल्ल बैंड छत बैंड	कमरों के सभी कोनों पर तथा एक मीटर से बड़े दरवाजों एवं खिड़कियों के दोनों तरफ
IV	चार मंजिल (15 मीटर से कम)	सिमेंट:बालू – 1:6	कुरसी बैंड लिंटेल बैंड छत बैंड	कमरों के सभी कोनों पर तथा 1.5 मीटर बड़े से द्वारों के दोनों तरफ
III	चार मंजिल (15 मीटर से कम)	सिमेंट:बालू – 1:6	कुरसी बैंड लिंटेल बैंड छत बैंड	दो मंजिल से उँचे मकान के कमरों के सभी कोनों पर

SEISMIC STRENGTHENING continued ...

REINFORCING PITCHED ROOF MASONRY BUILDING







1. Lintel band
2. Eave level (Roof) band
3. Gable band
4. Door
5. Window
6. Vertical steel bar
7. Rafter
8. Holding down bolt
9. Brick/Stone wall
10. Door lintel integrated with band

HORIZONTAL RCC SEISMIC BAND IN WALLS

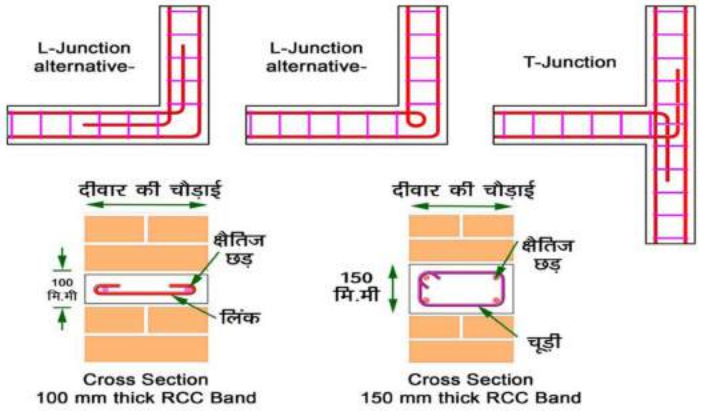
- प्रत्येक मकान में, PLINTH BAND एवं LINTEL BAND आवश्यक है।
- जहाँ GL या PL पर RCC BEAM हो, वहाँ PLINTH BAND आवश्यक नहीं है।
- PRECAST RCC BEAM (या PLANK) से जोड़कर बनाये गये छतों में तथा ढलान छत वाले मकानों में, छत के निचले स्तर पर (EAVES पर) HORIZONTAL ROOF BAND आवश्यक है।
- एक या दो तरफ ढलान वाले मकानों में त्रिभुजाकार ओरी पर SLOPING GABLE BAND आवश्यक है।
- RCC या RB के HORIZONTAL छतवाले मकानों में, जहाँ छत दीवार के उपर, दीवार के 2/3 मोटाई तक चढ़ती हो, ROOF BAND आवश्यक नहीं है।
- आधा ईंट मोटी दीवारों में सभी मकानों में खिड़कियों के SILL BAND चाहिए।

LONGITUDINAL STEEL IN RC BANDS

Span m	Build.Categ. B		Build.Categ. C		Build. Categ. D		Build.Categ. E	
	No. of Bars	Dia mm	No. of Bars	Dia mm	No. of Bars	Dia mm	No. of Bars	Dia mm
<= 5	2	8	2	8	2	8	2	10
6	2	8	2	8	2	10	2	12
7	2	8	2	10	2	12	4	10
8	2	10	2	12	4	10	4	12

NOTES:
- Span of wall = centre lines of its cross walls or buttresses.
- Insert pilaster or buttress if span > 8 m
- Bars given above are high strength deformed bars
- Width of R.C. band is same as the thickness of the wall.
- Wall thickness shall be 200 mm minimum.
- A clear cover of 20 mm from face of wall
- Thickness of RC band 75 mm minimum, if two bars are specified.
- Thickness of RC band 150 mm if four bars are specified,
- Concrete mix shall be of Grade 20, 1:1.5:3 by volume.
- links or stirrups 6 mm dia spaced at 150 mm

DETAILS OF HORIZONTAL RCC SEISMIC BANDS



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

STEEL DOWEL BARS

In category D and E buildings

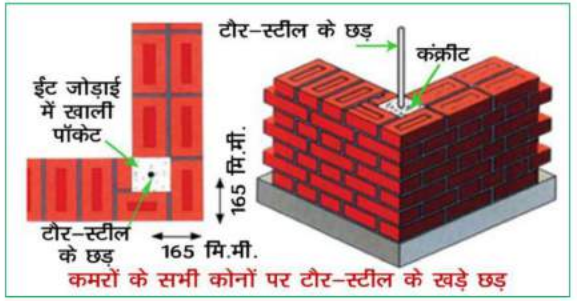
- at the sill level of windows
- at corners and T-junctions of walls
- length of 900 mm from the inside corner in each wall
- in the form of 8 mm dia U stirrups.
- laid in cement-sand-mortar1 : 3
- minimum cover of 10 mm on all sides

VERTICAL STEEL REINFORCEMENT IN MASONRY WALLS

No. of Storeys	Storey	Diameter of Single Bar in mm			
		Categ. B	Categ. C	Categ. D	Categ. E
One	-	Nil	Nil	10	12
Two	Top Bottom	Nil Nil	Nil Nil	10 12	12 16
Three	Top Middle Bottom	Nil Nil Nil	10 10 12	10 12 12	12 16 16
Four	Top Third Second Bottom	10 10 10 12	10 12 12 12	10 16 16 20	Four storeyed building not permitted

NOTES:-
1. H. Y. S. D. bars
2. Cover the vertical bars with concrete M20 or mortar 1 :3 in suitably created pockets

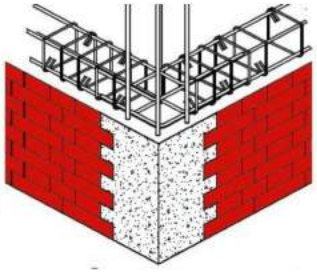
सभी कमरों के कोनों पर, कंक्रीट में खड़ा छड़



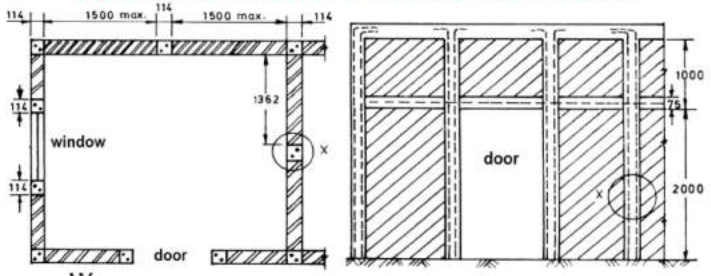
- सभी कमरों के कोनों पर, कंक्रीट डालने के लिये, ईंट जोड़ाई में खाली पॉकेट बनायें।
- पॉकेट में छड़ खड़ा करके कंक्रीट ढ़ालें।
- ये खड़े छड़ नींव से प्रारम्भ होकर, सभी आर.सी.सी. बैंड होकर, अंतिम छत की ढ़लाई के अंदर 300 मिलीमीटर मुड़ जानी है।

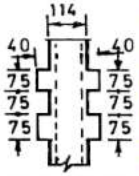
PRECAUTION IN CONSTRUCTION OF RCC STIFEFENERS IN BRICK MASONRY

- Make 40 mm toothed Joint in the brickwork
- Casting of stiffener should not be more than 1.2 m high, so that concrete may be vibrated & compacted
- Cast the Stiffener during curing period of the brickwork so that concrete water is not absorbed by brick masonry



FRAMING OF THIN LOAD-BEARING BRICK WALLS





- Load bearing wall 125 mm thick
- Columns at corners & junction of wall
- Maximum spacing of columns 1.5 m
- Horizontal band at sill, lintel and floor level
- Limited up to two storey.
- Maximum length of walls 7 m
- Storey height to 3 m

EARTHQUAKE RESISTANCE OF EARTHEN BUILDINGS AS PER IS 13827

AVOID IN SEISMIC ZONE IV & V

- Earthen wall
- Unburnt bricks
- Burnt brick with mud mortar

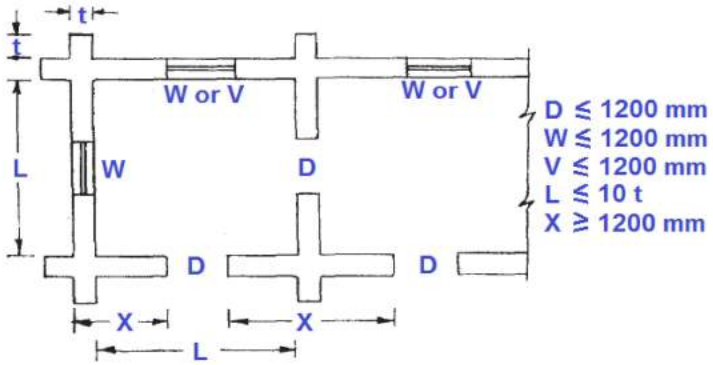
GENERAL PRINCIPLES

- Lightness : Particularly roof and upper storeys
- Simple Rectangular and symmetrical shape
- Avoid L and T shape plan
- Single storey building in zone IV & V
- Double storey in zone III
- Load bearing walls continuous in both directions
- Precautions against rains / floods
- Roof projections and water proof mud plaster
- Buildings for I= 1.5 not to be constructed

CONSTRUCTION OF EARTHEN WALLS

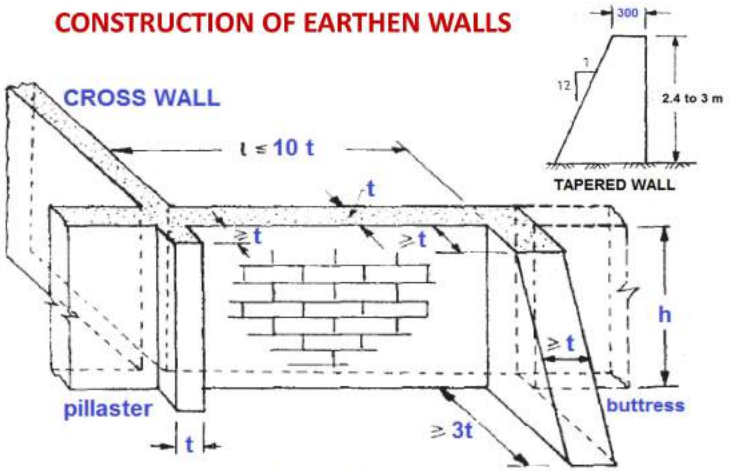
- Built by hand formed layers using mud lumps/ sun-dried blocks or adobe/ using rammed earth/ using wood, bamboo or cane with mud plastering.
- Thickness, t > 300 mm at top , a batter of 1:12
- Height, h < 8 t; Length of wall < 10 t
- Longer walls to have intermediate vertical buttresses.
- Width of opening < 1.2 m
- distance between outer corner & opening < 1.2 m
- Sum of widths of openings < 33.3 % of length of wall in zone V and 40 % in IV
- Bearing of Lintels on each side to be 300mm or more

CONSTRUCTION OF EARTHEN WALLS



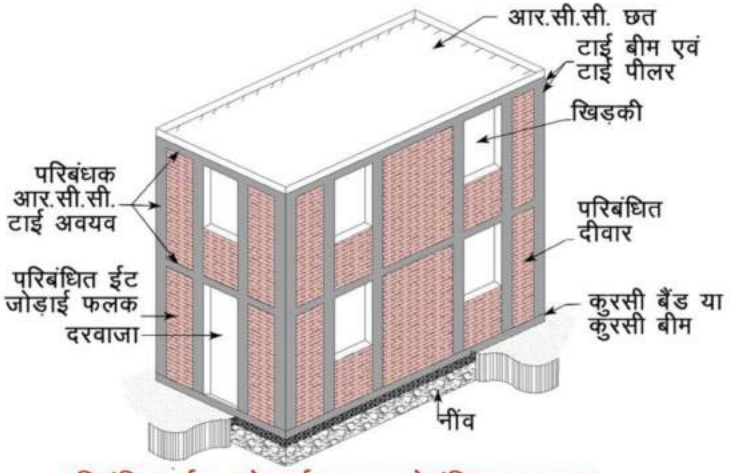
PLAN : WALLS AND BUTTRESSES

CONSTRUCTION OF EARTHEN WALLS



WALLS AND BUTTRESSING

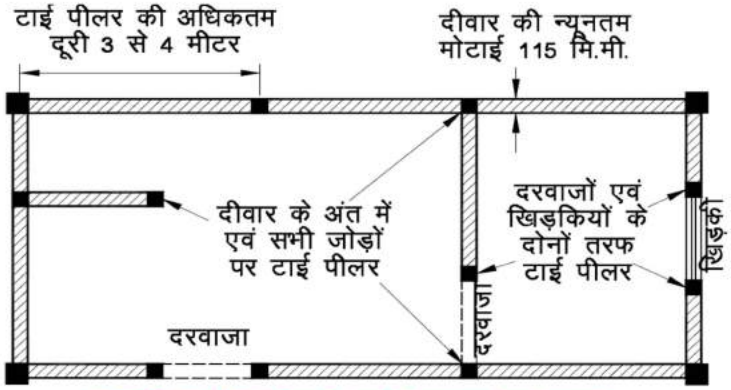
CONFINED MASONRY BUILDING CONSTRUCTION



परिबंधित ईट जोड़ाई वाला दोमंजिला मकान

STRUCTURAL COMPONENTS OF A BUILDING USING CONFINED MASONRY

- *Floor and roof slabs* – transmit both vertical gravity and lateral loads to walls, acts as diaphragm
- *Masonry walls* – bears vertical load and lateral shear
- *Confining elements* – provide the necessary tensile strength and ductility to the walls
- *Lintel level bands* (as per IS 4326) – resist out of plane bending and improves connection with cross walls. Stronger lintel will be required for very wide windows
- *Plinth band or tie-beam* – transmit vertical arend horizontal loads from the walls to foundation, protects from settlements
- *Foundation* – transmits loads from the structure to the ground.



परिबंधित ईंट जोड़ाई वाले मकान का प्लान

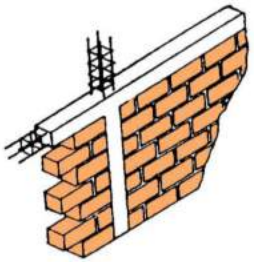
CONFINED MASONRY CONSTRUCTION

An alternative to RC Frame Construction for low rise buildings

'RC confining members'

built on all four sides of all masonry wall panels

- Vertical members are 'tie-columns' or 'practical columns'
- Horizontal elements are 'tie-beams'
- Confining members are minimally reinforced and casted along with masonry work



Tie-Columns and Tie-Beams

Building Categories for Earthquake Resisting Features In Masonry and Earthen Buildings

Importance Factor	Seismic Zone			
	II	III	IV	V
1.0	B	C	D	E
1.5	C	D	E	E^+
Note:- Category A is now defunct as zone I does not exist now.				

Importance of Building

Important buildings and structures Is defined in IS 1893 and should have higher strengthening provisions..

HEIGHT OF BUILDINGS

Depending on the crushing strength of the building unit, confined masonry buildings may be constructed up to five stories in height for various Building Categories as suggested below:

परिबंधित ईंट जोड़ाई वाले मकान के अनुमान्य मंजिलें	
मकान के प्रकार	मंजिल
B	पॉच मंजिल
C	चार मंजिल
D	चार मंजिल
E	तीन मंजिल

CONFINING ELEMENTS

- **TIE-BEAMS**
  - At plinth level and every floor level
  - Maximum Vertical spacing 3 m
- **TIE-COLUMNS**
  - Maximum spacing:
    - 4 m in 200 mm or thicker walls
    - 3 m in 100-114 mm thick walls
  - Locations:
    - at the corners of rooms and all wall-to-wall intersections
    - at the free end of a wall
    - at the jambs of doors / windows of 900 mm or wider openings

MASONRY UNITS

- burnt clay bricks
- hollow clay tiles
- Hollow concrete blocks
- Solid concrete blocks
- Dressed rectangular stones

- Usually, no reinforcement in masonry walls
- At least two fully confined continuous panels at the periphery of the building, in each horizontal direction.
- Walls may be connected with the confining elements using steel dowels

WALL THICKNESS AND MORTAR

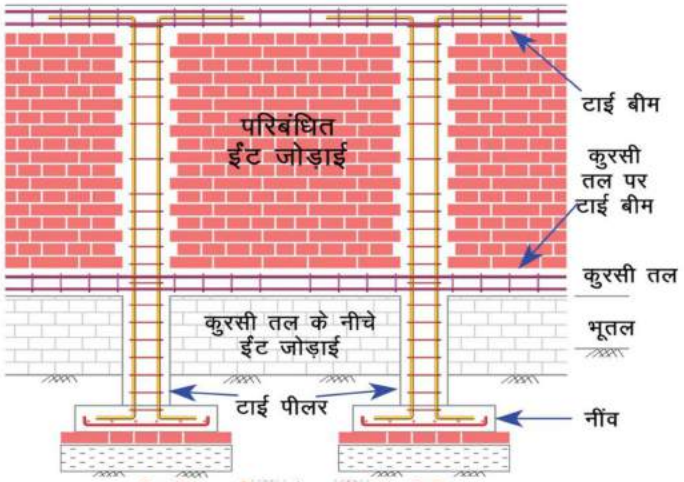
- **WALL THICKNESS**
  - Minimum thickness 100 - 115 mm up to 2 storied residential buildings
  - 200 - 230 mm for more than 2 storied and for all *important* buildings
  - height to thickness ratio less than 30
- **MORTAR** as per IS 4326:

Category of Building	Mortar
B, C	Cement: Sand - 1:6, or richer
D, E	Cement: Sand - 1:4, or richer

WALL DENSITY

Wall density can be defined as the *total cross sectional areas of all confined wall panels in one direction* divided by *the sum of the floor plan areas of all floors* in a building.

Wall density in each of two orthogonal directions	
Seismic Zones	**Suggested Wall density**
III	2%
IV	3%
V	4.5%



परिबंधित ईंट जोड़ाई की विधि

CONSTRUCTION OF WALLS

- Good quality building materials and good quality workmanship is required
- Toothed edges should be left on each side of the wall; the tooth projection may be kept ≤ 40 mm to achieve full concrete filling in the teeth space.
- Instead of teething or in addition to teething, horizontal dowels may be used, at the wall-column interface.
- Concrete is to be poured in the tie-columns upon completion of desirable wall height.
- Bricks must be wetted before casting of concrete.

TIE-COLUMNS

दीवार की मोटाई	टाई पीलर के न्यूनतम आकार	
	दीवार के बिचले भाग में	दीवार के कोनों पर
115 mm.	115 mm x 115 mm	230 mm x 230 mm
230 mm	150 mm x 230 mm	230 mm x 230 mm

कमरों के सभी कोनों पर, टाई पीलर में टौर–स्टील की छड़ें			
मकान के प्रकार	मंजिल	टौर–स्टील के खड़े छड़	चूड़ी
B एवं C	चार मंजिल	8 मि.मी. के चार छड़	प्रत्येक मंजिल में उपरी एवं निचली सिरो पर 500 mm तक, 6 mm व्यास की चूड़ी 100 mm की दूरी पर बाकी भाग में 200 mm पर
	पाँच मंजिल	10 मि.मी. के चार छड़	
D एवं E	तीन मंजिल	10 मि.मी. के चार छड़	
	चार मंजिल	12 मि.मी. के चार छड़	

Tie Columns at jambs of windows / doors	
Wall thickness	Minimum size of tie pillar
115 mm	115 mm x 100 mm
230 mm	230 mm x 100 mm

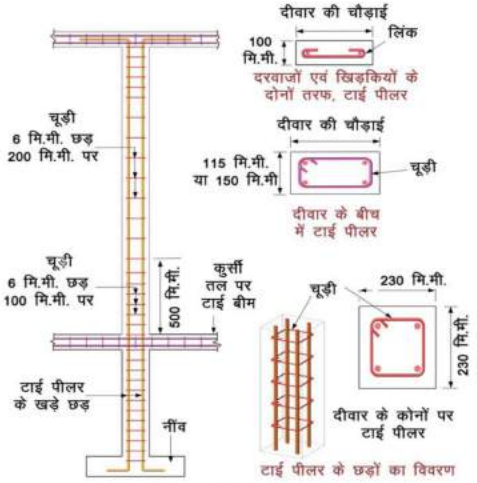
Reinforcement in Tie Columns at jambs		
Type of building	Reinforcements	Ties
B and C	2 nos 8 mm bars	6 mm bar @150 mm
D and E	2 nos 10 mm bars	6 mm bar @150 mm

Vertical bars should be lapped by a minimum of 50 times the longitudinal bar diameter.

TIE COLUMNS

Continued...

Reinforcement for the ground storey *tie-columns* should be assembled before the foundation construction takes place.



टाई पीलर के छड़ों का विवरण

TIE-COLUMN CONSTRUCTION

- Formwork on two sides of the wall.
- Masonry fully wetted before placing concrete.
- Concrete vibrated to fill the teeth space thoroughly.

TIE-BEAMS

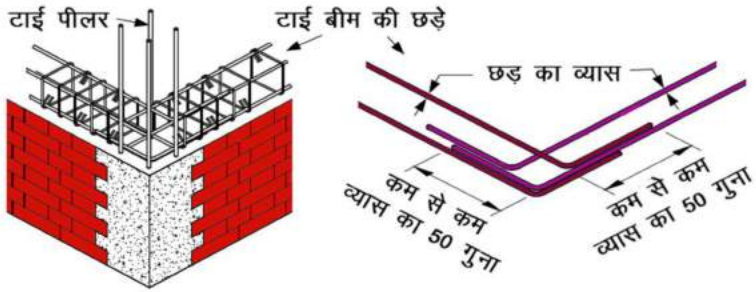
TIE BEAM SIZES	
दीवार की मोटाई	टाई बीम के न्यूनतम आकार
115 mm	115 mm x 100 mm
230 mm	230 mm x 150 mm

REINFORCEMENT IN TIE BEAMS		
मकान के प्रकार	टौर–स्टील क्षैतिज छड़	चूड़ी
B एवं C	8 mm के चार छड़	6 mm छड़ 150 mm पर
D एवं E	10 mm के चार छड़	

- Lintel level bands as per IS 4326
- Stronger lintel for very wide windows

TIE-BEAM & TIE-COLUMN JUNCTION

Proper detailing of the *tie-beam* and *tie-column junction* is a must for satisfactory earthquake performance.



दीवार के जोड़ पर टाई बीम की छड़े

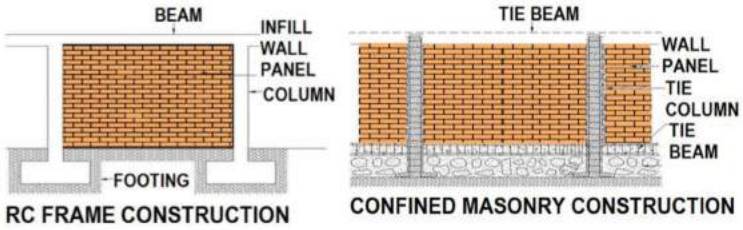
PLINTH CONSTRUCTION

A *plinth band* should be constructed on top of the foundation (as per IS 4326).

Instead of plinth band, *tie beam* will be preferable for proper confinement of masonry panel.

CONFINED MASONRY & RC FRAME

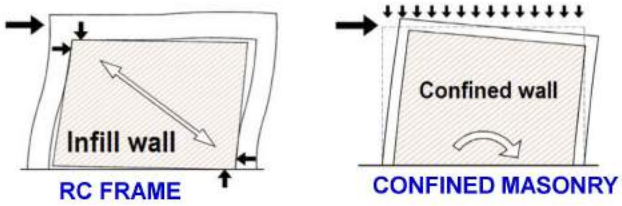
Similarity in Appearance of finished constructions



CONFINED MASONRY & RC FRAME

Differences resisting gravity and lateral loads

- **RC Framed Columns and Beams carry the loads, masonry in-fills are not considered to contribute.**
- **Confined masonry wall panels carry the loads, the confining elements resist tensile forces.**



FAILURE OBSERVED IN CONFINED MASONRY

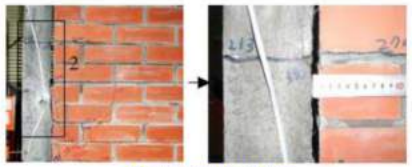
Actual EQ Damage

Shear failure

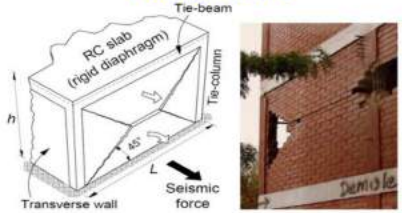
ends of Tie column

Tie column: Bar Buckling

FAILURE OBSERVED IN CONFINED MASONRY



Flexural failure



Out of plane effects in Confined Masonry panels

CONCLUDING REMARKS

Confined masonry buildings, constructed using good quality building units, specified strong mortar and control on quality of construction technology (providing teething in masonry units and wetting of masonry walls before casting of tie-column concrete with proper vibration for compaction), the building shows excellent performance during high intensity earthquakes.

But if the quality of construction is not appropriate, confined masonry buildings may collapse and result in injury, even loss of life due to the collapse of the building.

THANK YOU

(6)

Masonry Buildings: EQ Resistant Design (IS: 4326, IS: 13927), & Confined Masonry

POINTS FOR CONSIDERATION AND DISCUSSION

1. What are the general principles for earthquake resistant design of masonry buildings?
2. Why torsion is produced in masonry buildings?
3. What is limiting height of a masonry building?
4. What do you mean by improper load path?
5. Why Seismic separation gap is needed?
6. What provisions are necessary in a rigidly built stair?
7. What are the ingradients of box type construction of masonry buildings?
8. What is limiting Length and Height of a wall in a masonry building?
9. What will be the size of door and window, in a 3 m long wall in 3 storey masonry building of type E?
10. What will be the size of RCC Band, in a 7 m long wall of a masonry building?
11. Specify the vertical steel at corners, in a 3 storey masonry building in seismic zone V?
12. What precaution will you take, if RCC stiffeners are constructed in masonry walls?
13. What provisions are needed in a double storey masonry building with 125 mm thick wall?
14. What will be minimum thickness of wall of 3 m x 4 m room, in an earthen building?
15. How do you confine a wall, in a confined masonry building?
16. What are the functions of different structural components in confined masonry buildings?
17. What will be maximum spacing of tie columns in confined masonry buildings?
18. Where will you provide tie beams in a confined masonry walls?
19. Define Wall density in the perspective of a confined masonry buildings?
20. How Confined Masonry and RCC frame behave differently under gravity and lateral loads?

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

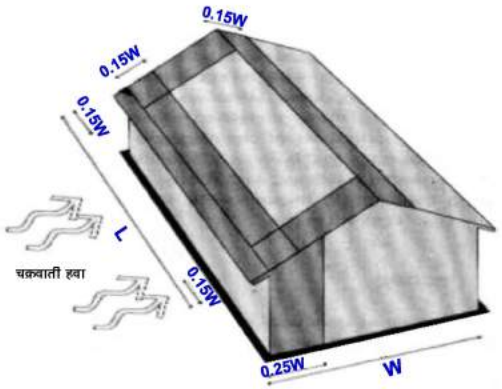
(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(7)
Inclined Roof Buildings,
Bamboo housing,
Hazard Resistant housing

30 min

SAFETY OF
INCLINED ROOF BUILDINGS
AGAINST
CYCLONIC WINDS

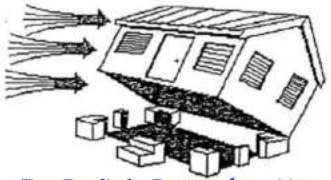
चक्रवाती हवाओं से प्रभाव



- लकड़ी एवं बाँस संरचना के हल्के छत वाले भवन
- कमजोर हो चुके लकड़ी संरचना के ढ़लानछत वाले पुराने भवन
- खुली जगहों पर बने, वृक्षों द्वारा वायु अवरोध विहीन घर

चक्रवाती हवा के कारण मकान के विभिन्न हिस्सों के उपर प्रभाव

प्रबल वायुवेग से घरों को क्षति



नींव–दीवारों के बीच अपर्याप्त संबंध

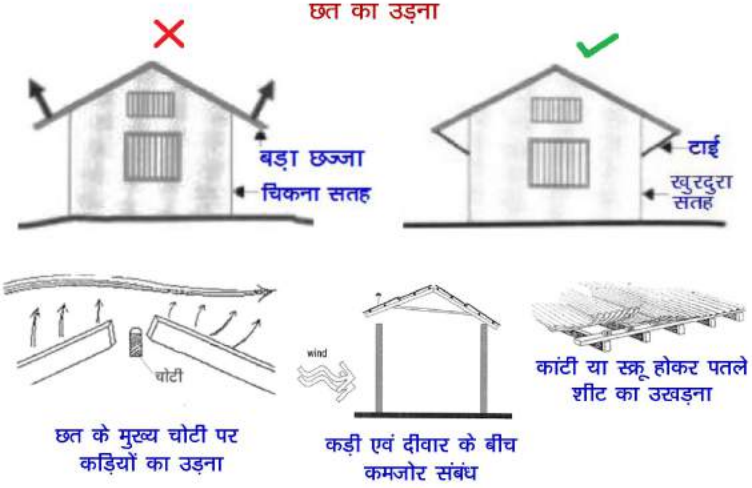
दीवार–छत के बीच अपर्याप्त संबंध

बरामदा का उड़ना

तूफान के बाद भारी बर्षा से घर के सामग्रियों की क्षति

छत के शीट का उड़ना

छत का उड़ना

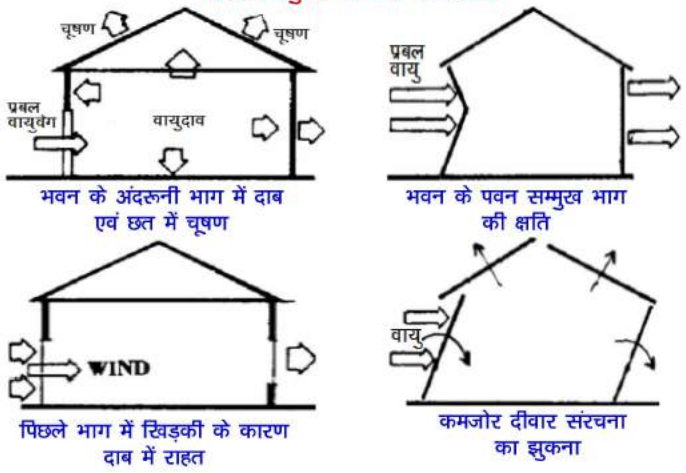


छत के मुख्य चोटी पर
कड़ियों का उड़ना

कड़ी एवं दीवार के बीच
कमजोर संबंध

कांटी या स्क्रू होकर पतले
शीट का उखड़ना

प्रबल वायुवेग से घरों पर प्रभाव



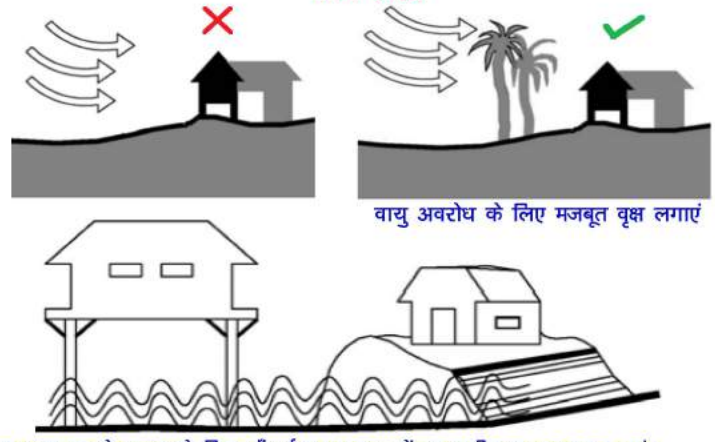
भवन के अंदरूनी भाग में दाब
एवं छत में चूषण

भवन के पवन सम्मुख भाग
की क्षति

पिछले भाग में खिड़की के कारण
दाब में राहत

कमजोर दीवार संरचना
का झुकना

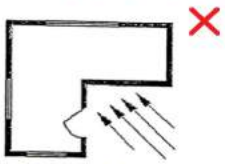
भवन स्थल



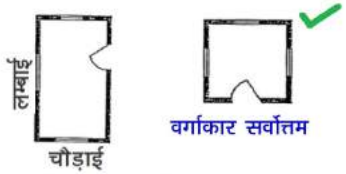
वायु अवरोध के लिए मजबूत वृक्ष लगाएं

जल जमाव से बचाव के लिए, उँचाई पर घर बनाऐं या जमीन भरकर घर बनाएं।

भवनों के आकार



L आकार से आयताकार अच्छा है।



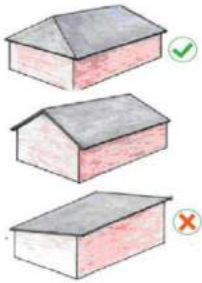
लम्बाई < 3 x चौड़ाई

भवनों के लेआउट

कतार में भवनों के कारण वायु सुरंग का बनना

वायु सुरंग बनने से रोकने के लिए, टेढ़ा मेढ़ा लेआउट रखें।

ढ़ालवाँ छत का आकार

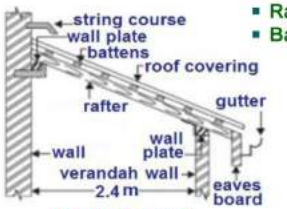


- चारों तरफ ढालवाले छत सर्वोत्तम।
- अगर दो तरफ ढालवाले छत ही बनाने हों तो इसके दोनों तिकोने दीवार को शेष संरचना के साथ दृढता़पूर्वक बांध दें। छत का ढ़लान ज्यादा रखें।
- एक ही तरफ ढालवाले छत वर्जित हैं।

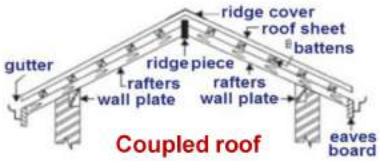
वायु चूषण के चलते छत को उड़ने से बचाने के लिये, छत का झुकाव 22.5 डिग्री से 30 डिग्री

TYPE OF ROOF STRUCTURE

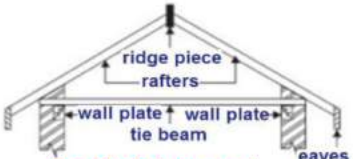
- Single Roof: span < 5
- Rafters at 600 mm to 800 mm spacing
- Battens run over rafters to support tiles



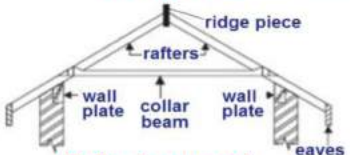
Lean to roof



Coupled roof

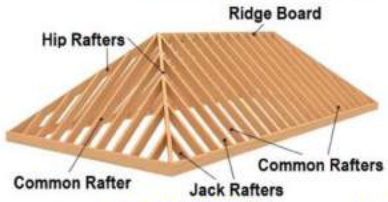


Coupled close roof



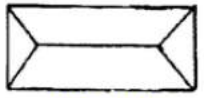
Collar beam roof

STRUCTURE OF HIPPED ROOF

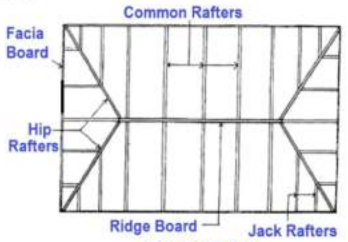


ROOF MEMBERS

ROOF SLOPE



ROOF PLAN

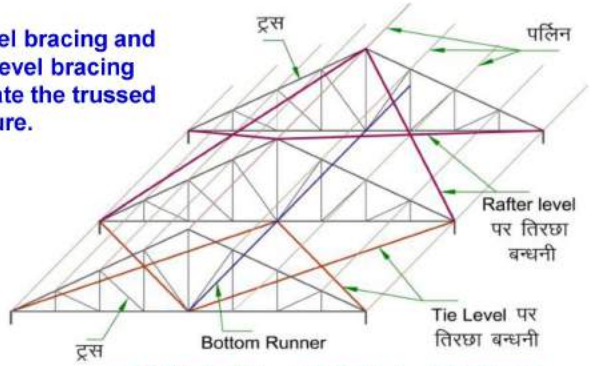


ROOF PLAN

PITCHED ROOFS WITH TRUSSES

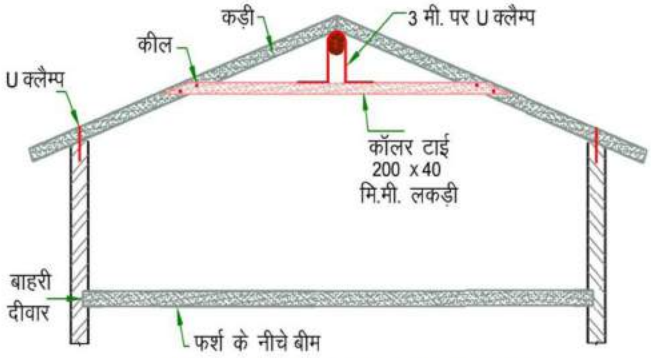
Diagonal bracing of roof trusses

Tie level bracing and rafter level bracing integrate the trussed structure.



ट्रस (कैंची) का Tie level एवं Rafter level पर सम्बन्धन

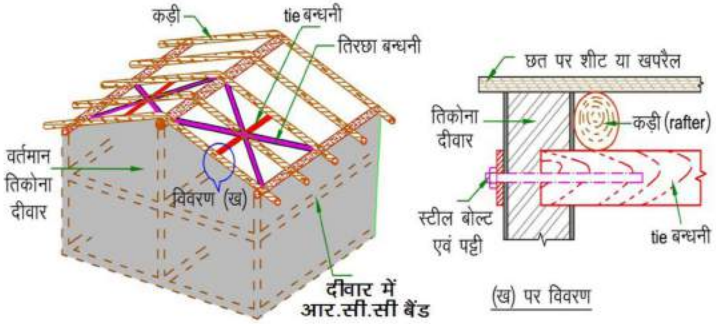
PITCHED ROOFS WITHOUT TRUSSES



Use collar tie with roof rafters to reduce horizontal thrust on walls

PITCHED ROOFS WITHOUT TRUSSES

Roof Rafter Bracings



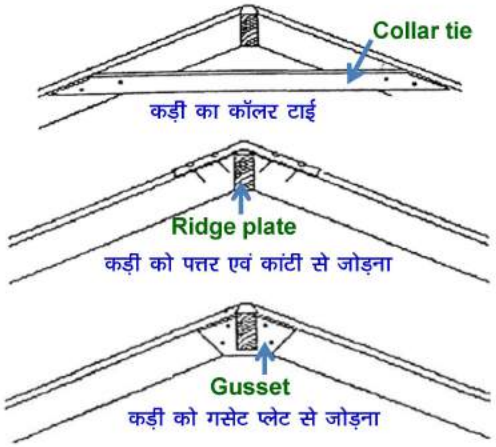
कड़ी पर आधारित ढ़लान वाले छत में बन्धनी

छत एवं दीवार संरचना

- स्टील चादर वाली छतों के संरचना ढ़ाँचे में, बाँस की मुख्य कड़ी 600 मि.मी. की दूरी पर रखें।
- खपरैल के छतों में, मुख्य कड़ी 300 मि.मी. की दूरी पर रखें।
- खपरैल के छतों में तार से टाई लेवेल पर तिरछा बन्धनी
- सबसे निचले पर्लिन को ओलती स्तर के क्षैतिज अंग के साथ कसकर बाँधें।

- छत संरचना का दीवार के साथ संबंधन करें
- मकान के सभी अंगो का एक दूसरे से संबंधन करें
- टाई लेवेल पर, तिकोने दीवार एवं छत संरचना के बीच तिरछा बंधनी

STRENGTHENING RIDGE-RAFTERS JUCTION



ROOF COVERINGS

Roof Cover material for pitched roofs

- Use CGI or cement sheets, Avoid clay tiles
- Avoid loose or heavy roofing units
- Roofing units shall be tied to rafters/purlins

Roof coverings Types

- Thatch
- Clay tiles
- Slates
- Cement sheets
- G.I. sheets

Slates

450 - 600 mm wide, 300 mm long and 4 - 8 mm thick, do not absorb water

Thatch Covering:

- For small spans, village housing
- Thatch thickness 150 -300 mm
- Thatch tied with thin ropes with bamboo batti
- bamboo rafters spaced at 200 mm to 300 mm
- Advantage: cheap, built by semi-skilled worker
- Disadvantages : poor fire resistant, insects attack

ROOF COVERINGS

Clay Tiles

- Locally manufactured various types
- Tiles are supported over battens, Battens are supported by rafters
- Allahabad tiles, Mangalore tiles are excellent inter-locking tiles

Cement Sheets

- Width 1.0 - 1.2 m,
- Length from 1.75 - 3.0 m,
- Fixed to purlins by J-bolts,
- Not thermal resistant
- False ceilings are needed

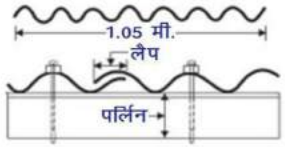
G.I. Sheets

- 1.0 -1.2 m wide & 1.65 m length, Galvanized
- Fixed to steel purlins using J-bolts and washers
- Durable, Fire proof, Lightweight

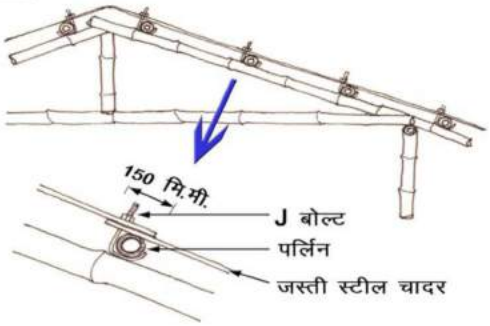
छत का शीट एवं स्क्रू

- 24 गेज यानी 0.4 मि.मी. मोटा शीट का उपयोग करें।
- सामान्य कांटी का उपयोग मत करें।
- हुक एवं स्क्रू गेलवनीकृत होना चाहिए।
- लम्बे स्क्रू या कांटी को पर्लिन के नीचे मोड़ दें।
- बड़े आकार का वाशर या टोपीदार स्क्रू शीट को कटकर उड़ने से बचाता है।
- छत के कोनों, किनारों पर हुक एवं स्क्रू कम दूरी पर रखें।

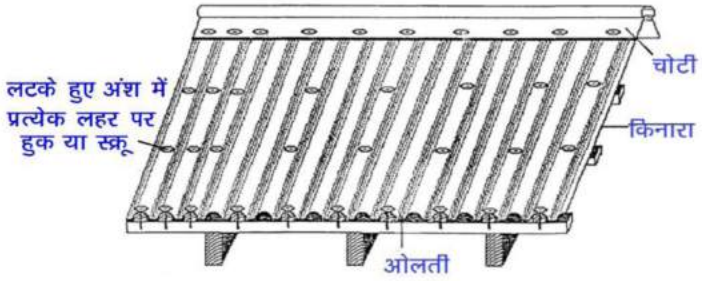
छत के आवरण को उड़ने से बचाने के उपाय



- GI शीट को बोल्ट या पेंच के सहारे पर्लिन के साथ जकड़ दें।
- J बोल्टों की परस्पर दूरी 450 मि.मी. से ज्यादा नहीं होना चाहिए।



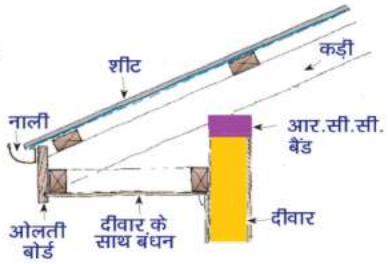
छत के शीट का उड़ने से बचाने के उपाय



चोटी, ओलती एवं लटकन पर प्रति लहर पर शीट को पर्लिन के साथ बाँध दें, शेष में प्रति 2 लहर पर।

कोनों एवं किनारों पर, शीट का पर्लिन के साथ संबंध

छत के कोनों एवं किनारों पर
लोहे का पत्तर से बंधन



लटके शीट का दीवार से बंधन

ROOF TRUSSES

- Fix the trusses or rafters into horizontal RCC bands
- Provide holding down bolts of adequate length
- Purlin to be secured into RCC band at gable end
- Provide diagonal braces in plan at tie level

MAINTENANCE

- सड़े कड़ियों एवं पर्लिन को बदलना
- लोहे के शीट, क्लैम्प, बोल्ट का जंग लगने से बचाव
- ढीले नट, बोल्ट को कसना या बदलना
- अतिरिक्त J या U बोल्ट लगाना
- शीट किनारे के बोल्ट के उपर, लोहे की पट्टी लगाना
- छत के कोनों एवं किनारों की जाँच
- छत के लटके भाग को दीवार के साथ बाँधना
- छत एवं दीवारों में तिरछा बंधनी बनाना

KOSI REHABILITATION

MULTI HAZARD RESISTANT HOUSING

FOR

KOSI FLOOD 2008 AFFECTED PEOPLE

EXISTING BUILDING PRACTICES

Depending on Socio-Economic Condition & Available Building Materials

1) **Rich People**
   Country kiln burnt clay brick
   No EQ Safety

2) **Poor People**
- Bamboo and thatch, Wattle and Daub
- Risky to Flood and high winds
- Use of marchans

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DESIGN CONSTRAINTS

1. Financial resources
   - Max Govt. assistance Rs. 55,000/-
   - Min Plinth area 20m^2
     (Living RM = 14m^2, verandah 6m^2)

2. Must be safe under
   - Earthquake Zone IV and V;
   - Flooding
   - Wind speed 47 m/s

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SITE SOIL CONDITIONS

Safe bearing capacity at 1.5 to 2 m depth
adopted for design of footings

i) ***Silty clay*** with cohesion C = 0.2 – 0.4 range & Φ=6°- 10° range.

6 to 7 t/m2 for strip and 7 to 9 t/m2 for square footing.

ii) ***Silty sand*** with C= 0, & Φ = 27°- 28° range

Safe bearing capacity as 7 – 8 t/m2 for strip and 8 – 9 t/m2 for square footing.

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FLOODING IMPACT ON SOIL & FOUNDATION

- The bearing capacity of the soil gets reduced because of saturated soil condition
- The soil can be eroded under the action of flowing water
- Siltation can take place around the buildings when the flood water recedes away from the site.

EARTHQUAKE IMPACT ON SOIL

- The phenomenon of *soil liquefaction* can take place in Zone IV or Zone V

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SITE SELECTION

- High Ground, above the *normal annual average flood level* in the area.
- Where it is not feasible, action is needed to raise the ground so that the plinth level is at least 300 mm above the *flood* level.

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FOUNDATION AND PLINTH

- Available stiff soil below GL,
  Adopt Wall footing at 75-90 cm depth
- Available cohesive soils (clayey, silty clayey) Adopt *square pedestal piers* at 1.5 m depth
  If scouring depth is more, increase depth for pedestal footings till *silty clay soil* is not reached or use pile foundations

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FOUNDATION AND PLINTH Contd...

- Use reinforced concrete beam at the plinth level to support the super structure wall
- Reinforcement from the piles and piers shall be anchored in the plinth beam
- The distance between two pedestal footings/ piles shall not be more than 1.5-1.8 m.

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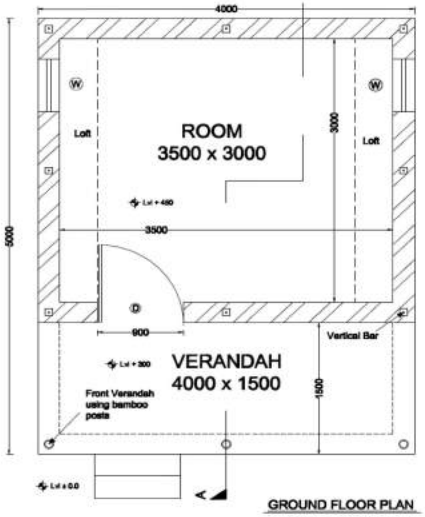
ALTERNATIVE OPTIONS OF BUILDINGS

Detailed Estimate for proposed construction of Mass Housing in Flood affected Areas of Bihar		
sl.	Alternative constructions	Cost (Rs)
	Alternative-A : RCC roof, Brick pedestal foundation, Verandah up to Plinth Level; Area 20 sqm	
Aa	250 mm thick Brick wall in Rat Trap Bond	74,210
Ab	125 mm thick Brick wall	68,981
	Alternative-B : RCC roof , RCC Post foundation in room, Verandah up to Plinth Level; Area 20.64 sqm	
Ba	250 mm thick Brick wall in Rat Trap Bond	81,628
Bb	125 mm thick Brick wall	73,505
	Alternative-C : Bamboo frame CGI sheet roof, Attic floor, Brick pedestal foundation, Verandah up to roof; Area 20.64 sqm	
Ca	250 mm thick Brick wall in Rat Trap Bond	76,603
Cb	125 mm thick Brick wall	73,272
Notes : -	SOR BCD Nov 2009, Cost without Contractor's Profit Flooring, Plaster, Finishing, parapet and stair excluded	

Alternative-A :

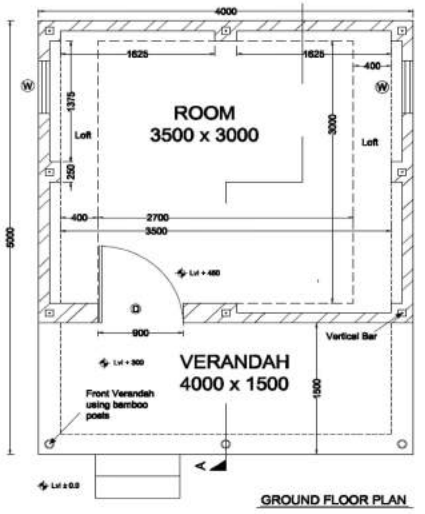
RCC roof, Brick pedestal foundation, Verandah up to Plinth Level; Area 20 sqm

Alternative-Aa :
250 mm thick wall

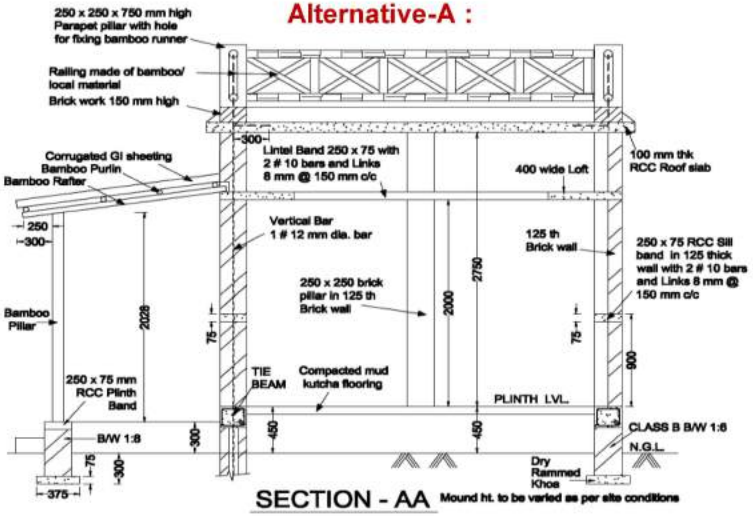


Alternative-A

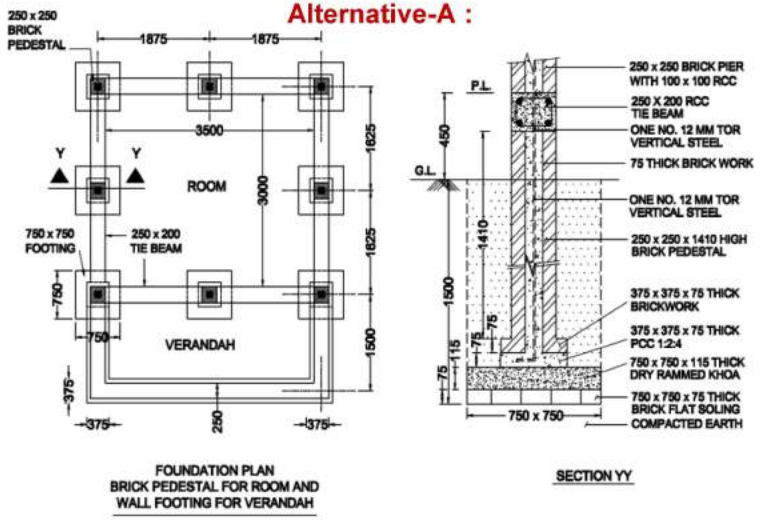
Alternative-Ab :
125 mm thick wall



Alternative-A :

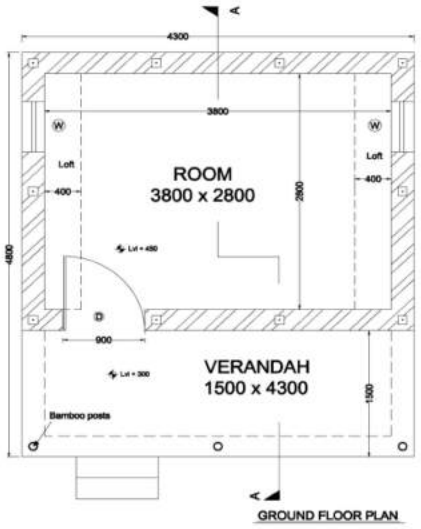


Alternative-A :



Alternative-B :

RCC roof ,
RCC Post Foundation in room,
Verandah up to Plinth Level;
Area 20.64 sqm



Alternative-Ba :

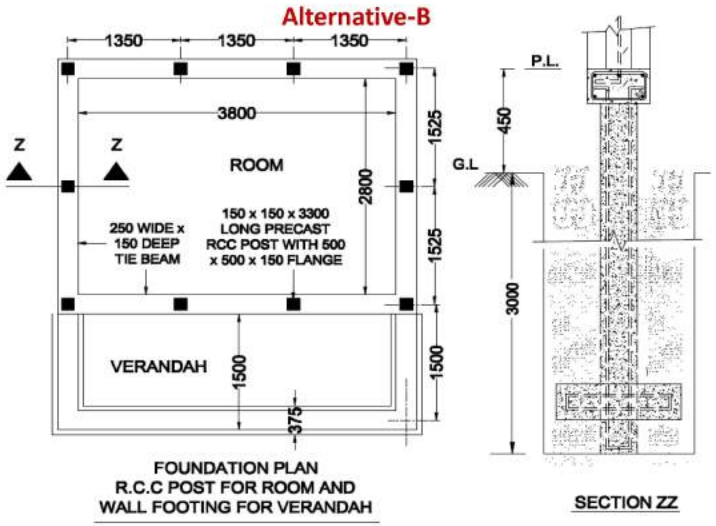
250 mm thick wall

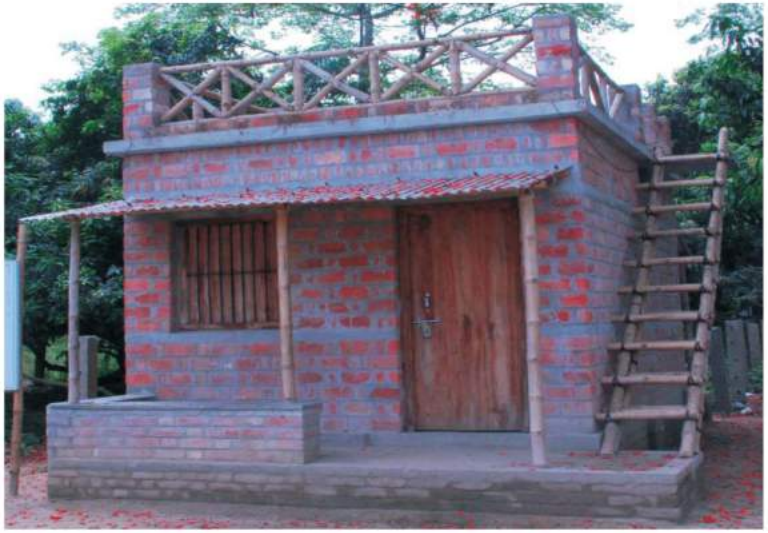
Alternative-B

Alternative-Bb :

125 mm thick wall

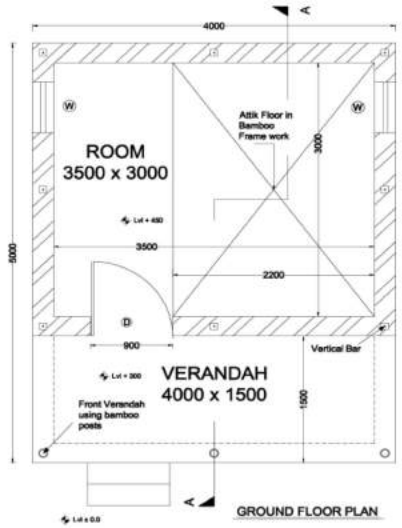
Alternative-B





Alternative-C :

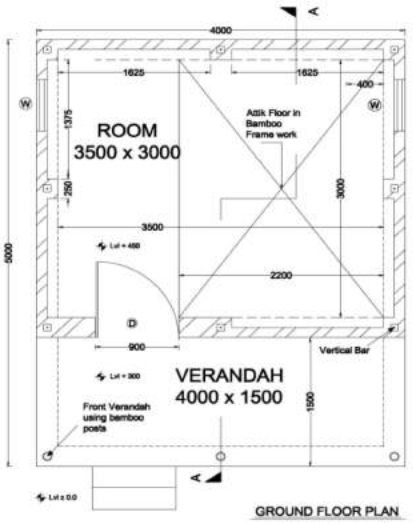
Bamboo frame CGI sheet roof,
Attic floor,
brick pedestal foundation,
Verandah up to roof; Area 20.64 sqm



Alternative-Ca :

250 mm thick wall

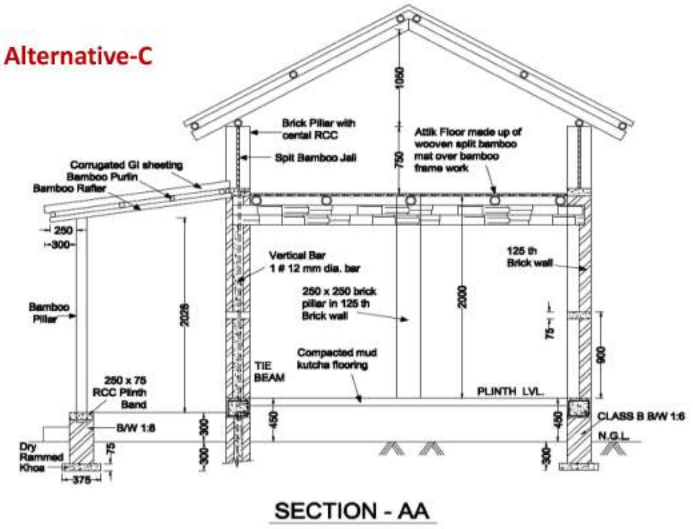
Alternative-C



Alternative-Cb :

250 mm thick wall

Alternative-C



SECTION - AA

SAFETY OF BAMBOO HOUSES AGAINST CYCLONIC WINDS & RAINS

Bamboo species	Description	Culm height	Dia.	Inter nodes	Wall thickness
HAROT 	Tall; grayish green; nodes thickened with a whitish ring above, hairy below; branches from the lower nodes leafless and hard	12-20 m	8-15 cm	20-40 cm	Thick-wall:- about one third of culm diameter
CHAB 	Evergreen; almost un-branched below; white ring below the nodes slightly thickened, lower ones have fibrous roots	7-23 m	5-10 cm	40-70 cm	Thin-walled
MAKHAUR 	Medium sized, much-branched above, straight, green, smooth, not shining, nodes often hairy, lower nodes bearing rootlets.	6-15 m	5-10 cm	25-45 cm	Thick-walled

Chemical Treatment of Bamboo using Boron

For protection from insects attack

Cycle Pump for Pressure injection

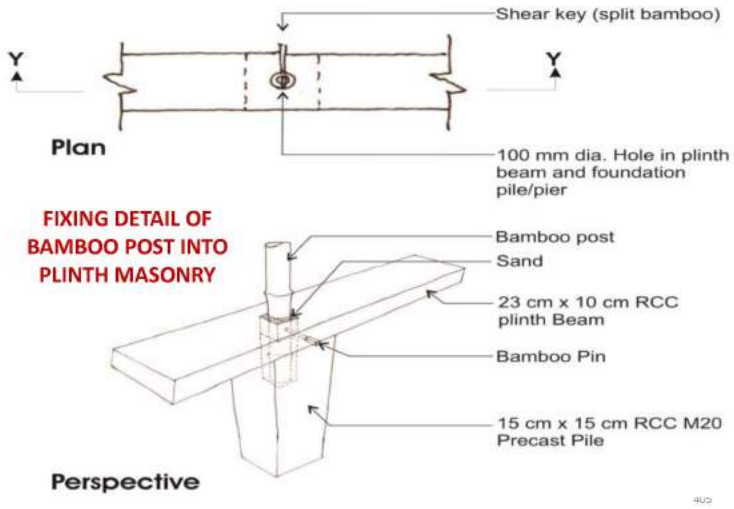
Chemical Treatment

चार घंटे के अंदर कटे बाँसों के जड़ वाले सिरे पर पम्प से दवाव डालकर रासायनिक परिरक्षण

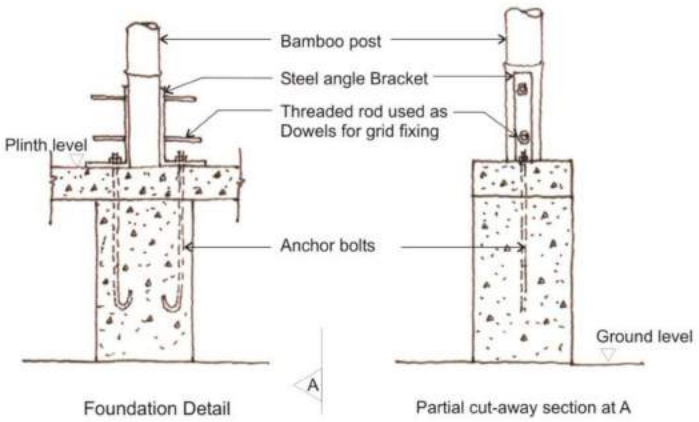
बाँस खम्बे की नमी से सुरक्षा

कुरसी पर ईंट जोड़ाई में गड़े बाँस के खम्बे

- बाँस खम्बा को जमीन में नहीं गाड़ें
- जमीन में **precast** कंक्रीट का खूँटा गाड़ें या ईंट पीलर का आधार बनाऐं
- बाँस खम्बे के निचले सिरे को खूँटा या पीलर से जकड़ दें



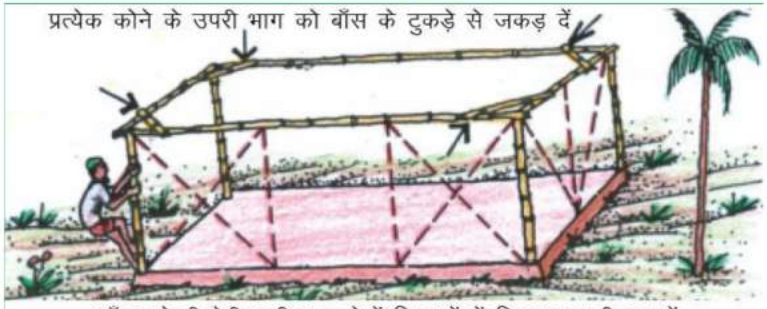
FIXING DETAIL OF BAMBOO POST INTO PLINTH MASONRY



तूफ़ान से वचाव के लिये तिरछा बन्धनीः–

– बाँस के खम्बों के बीच दीवार में

– ओलतीं स्तर पर टाई बाँस के बीच



बाँस को बीचोबीच चीरकर दोनों दिशाओं में तिरछा बन्धनी लगाऐं

बाँस के संरचना ढाँचे के स्थायित्व के लिये
दीवार फलकों में खम्बों के साथ तिरछा बन्धनी का उपयोग

बाँस को बाँधने की सामग्री

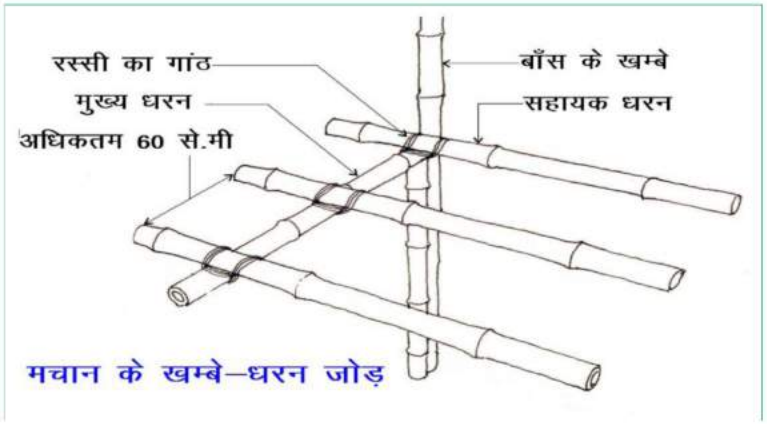
- बाँस एवं बत्तियों में कॉटी मत ठोकें, यह फट जाता है।
- बर्मा से छेद करके, दोनो छोर पर छल्ला लगे बोल्ट का उपयोग करें।
- जूट या नारियल रस्सी के बदले अच्छे प्रकार के नायलन रस्सी अथवा **GI** तार का उपयोग करें।

तिरछा बन्धनी, दीवाल फलक एवं खम्बे के उपरी सिरों को मिलानेवाली बाँस को खम्बे के साथ जकड़ दें।

पर्लिन को कड़ी के साथ और कड़ी को खम्बे के उपरी सिरों को मिलानेवाली बाँस के साथ जकड़ दें।

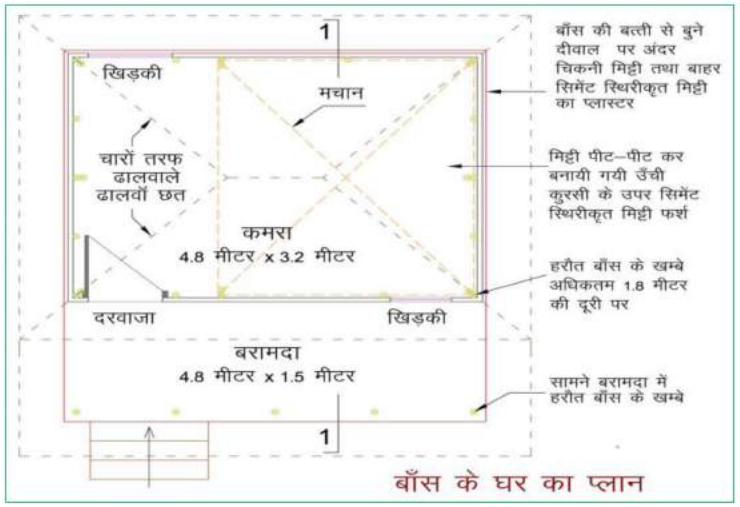
बाँस के ढाँचे का बंधन

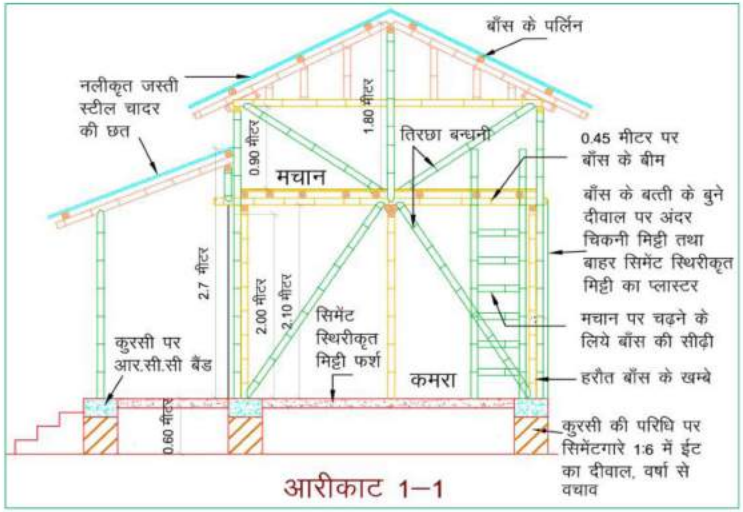
मचान के लिये अतिरिक्त
बाँस के खम्बे खड़ा करें।



बाँस के घर की रूपरेखा

- सरल आयताकार रूपरेखा
- घर के आकार **3 a x 2a**,
- खम्बों की आपसी दूरी, **a = 1.5** से **1.8** मीटर
- द्वारो के आकार सीमित रखें।
- वर्षा से सुरक्षा हेतु कुरसी की परिधि पर सिमेंटगारे 1:6 में दीवार





बाँस से घर निर्माण के आवश्यक विन्दु

- परिरक्षक रासायनिक उपचार **(Chemical preservative)**
- बाँस के खम्बे 1.5 मीटर से 1.8 मीटर की दूरी पर रखें।
- बाँस खम्बे को कंक्रीट खूँटे या ईंट पीलर पर रखें।
- खम्बों के बीच तथा छत संरचना में, तिरछा बन्धनी लगाऐं।
- ढालवाँ छत के नीचे मचान का निर्माण करें।
- नायलन रस्सी अथवा गैलवनीकृत तार का उपयोग करें।
- चारों तरफ ढालवाले छत का निर्माण करें।
- छत संरचना के ढाँचे को दीवार से जकड़ दें।
- **GI Sheet** छत को जे बोल्ट के सहारे कड़ी से जकड़ दें।
- सिमेंट–मिट्टी मिश्रण पीट–पीट कर उँची कुरसी बनाऐं।

CONCLUSION

Any post disaster reconstruction programme provides an opportunity of building-back-better and adoption of disaster resistant technology in all future constructions in the disaster prone areas.

THANK YOU

(7)

Inclined Roof Buildings, Bamboo housing, Hazard Resistant housing

POINTS FOR CONSIDERATION AND DISCUSSION

1. Which portions of an inclined roof are affected most, during cyclonic wind?
2. What are the types of damages to inclined roof buildings, during cyclonic wind?
3. What precautions will you take, during site selection and layout of pitched roof buildings?
4. Which shape of inclined roof is most suitable? Specify the slope of pitched roof?
5. Explain the structure of a hipped roof.
6. How tie level bracing and rafter level bracing improve the behavior of a trussed roof?
7. What are the methods used to integrate the roof rafters, in the pitched buildings without roof trusses?
8. How will you integrate the roof structure with the supporting wall, in a rafter roof building?
9. Which roof covering will you suggest for pitched roof buildings?
10. What are the materials used and precautions taken, while fixing the roof sheets?
11. What was the bearing capacity of open foundation, adopted for footings in Kosi rehabilitation?
12. Name the three types of foundations, suggested for single storey housing.
13. Name the three options taken up, while suggesting housing, for Kosi flood affected people.
14. What option had a minimum cost, while suggesting housing for Kosi flood affected people?
15. What are the common bamboo species available in Bihar?
16. How will you protect bamboo from insects attack.
17. How will you safeguard bamboo post foundation from the ground moisture?
18. How will you improve the resistance of wall structure during cyclonic wind?
19. What are the materials available for jointing bamboos? Which is best?
20. Explain the Shape and size of a bamboo house and specify the spacing of bamboo posts?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(8)

RVS of Masonry Buildings

(DAMAGEABILITY ASSESSMENT OF EXISTING BUILDINGS)

90 min

देखें

- ✓ **IS 13935: 2009- Annex A**
- ✓ चिनाई वाले भवनों की RVS मार्गदर्शिका

DAMAGE GRADES OF MASONRY BUILDINGS

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

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

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

[Restoration]

DAMAGE GRADES OF MASONRY BUILDINGS

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

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

Non-Structural Damage : (moderate)

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

[Restoration]

DAMAGE GRADES OF MASONRY BUILDINGS

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]





DAMAGE GRADES OF MASONRY BUILDINGS

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.

[Restoration with partial Rebuilding / Retrofitting]





DAMAGE GRADES OF MASONRY BUILDINGS

G5 : Structural Damage : (very heavy)

- Total or near total collapse of the building.

[Debris removal & Reconstruction]





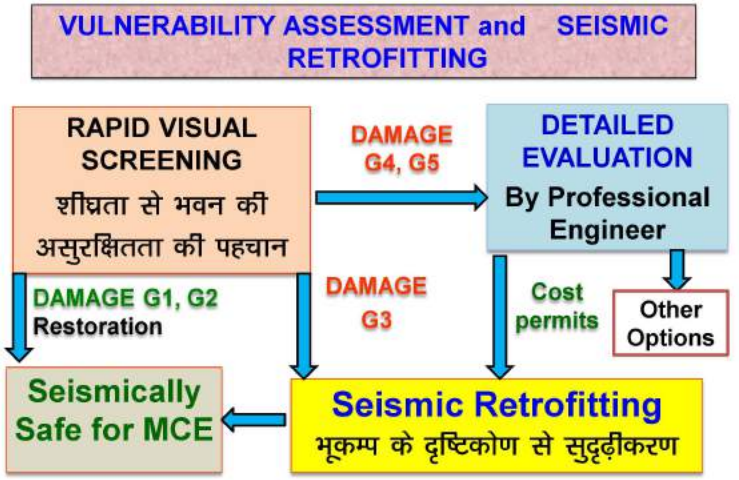
DAMAGE GRADE :
Directly observed after an EQ

DAMAGEABILITY GRADE

Assess Vulnerability of existing building

RAPID VISUAL SCREENING

- शीघ्रता से वर्तमान भवन का निरीक्षण
- भवन के रिकॉर्ड की जानकारी एकत्रित करना
- भूकम्प: **Maximum Considered Earthquake**
- क्षैतिज भूकम्परोधी मुख्य संरचना अंगों की पहचान
- अनियमित आकार प्रकार की पहचान करना
- कमजोर संरचनात्मक अंगों की पहचान करना
- संरचनात्मक गणना की आवश्यकता नहीं
- ✓ भूकम्पीय क्षतिग्रस्तता का आकलन
- ✓ संभावित उन्नयन का सुझाव



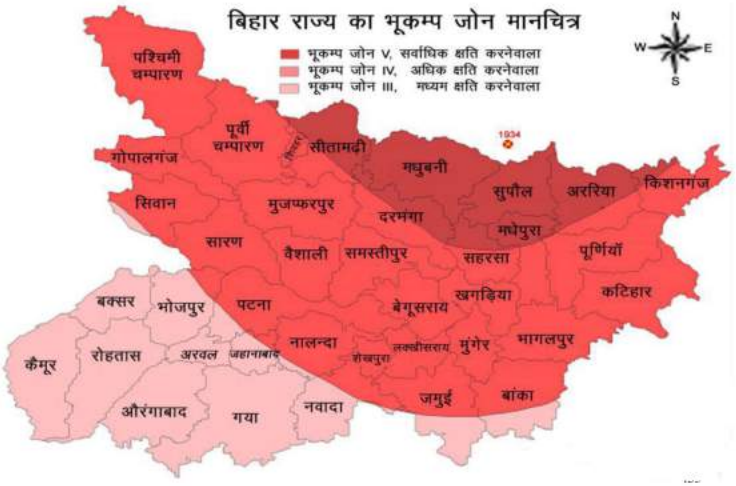
RVS परिणामों का उपयोग

- भवन के भूकम्पीय संरचनात्मक असुरक्षितता का आकलन
- भवन के सामान्य रेट्रोफिटिंग आवश्यकता की पहचान
- समुदायिक भूकम्परोधी पुनर्वास आवश्यकताओं का वर्गीकरण
- भूकम्पीय जोखिम प्रबन्धन कार्यक्रम की रूपरेखा बनाना
- आवासियों के बीच भवन असुरक्षितता की जानकारी बढाना

RVS Guidelines for Masonry Buildings

IS: 13935

433



SEISMIC HAZARD INTENSITIES

वर्तमान भवनों की असुरक्षितता (Vulnerability) भूकम्पीय तीव्रता एवं जोखिम से सम्बंधित है। भूकम्पीय तीव्रता बढने से भूकम्पीय जोखिम बढती है और भवनों की असुरक्षितता बढ जाती है।

भूकम्प जोन	PGA	भूकम्पीय तीव्रता	भूकम्पीय जोखिम
V	0.36g	MSK IX or more	बहुत अधिक
IV	0.24g	MSK VIII	अधिक
III	0.16g	MSK VII	मध्यम

LOAD BEARING MASONRY भवनों के प्रकार

प्रकार	भवन का विवरण
A	गोल पत्थरों के साथ चिनाई; मिट्टी गारे में दोमंजिला घर
A+	मिट्टी गारे में कच्ची ईंट की दीवारें
B	परम्परागत लकड़ी की छतों के साथ UN-REINFORCED BRICK WALLS
B+	चूना के मसाले में UN-REINFORCED BRICK WALLS
C	(क) अच्छे सिमेंट मसाले में, पकी ईंट से निर्मित UN-REINFORCED BRICK WALLS : HORIZONTAL RCC ROOF या HORIZONTAL SEISMIC EAVES BAND वाले ढालवाँ छत के साथ (ख) B की तरह, HORIZONTAL SEISMIC BANDS के साथ
C+	C (क) की तरह, परंतु HORIZONTAL SEISMIC LINTEL BAND के साथ
D	C (क) की तरह, परंतु HORIZONTAL SEISMIC BANDS एवं VERTICAL REINFORCEMENT के साथ अथवा REINFORCED CONFINED MASONRY

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 G3 : most Rest G2 / G1	G5 : few G4 : most Rest G3 / G2	G5 : few Rest G4 / G3
B एवं B+	G3 : few G2 : many Rest G1	G4 : few G3 : most Rest G2	G5 : few G4 : many Rest G3
C एवं C+	G2 : few G1 : many Rest G1 / G0	G3 : few G2 : most Rest G1	G4 : few G3 : many Rest G2
D एवं D+	G1 : few	G2 : few	G3 : few G2 : many Rest G1

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

भवन / संरचना का महत्व : Importance Factor

- महत्वपूर्ण भवन: स्कूल, अस्पताल स्मारक भवन, दूरभाष केंद्र, रेडियो स्टेशन, रेलवे स्टेशन, दमकल केंद्र, बिजलीघर, अतिमहत्वपूर्ण व्यक्तियों के निवास, सामुदायिक हॉल, 1000 से अधिक लोगों वाले कोई भी भवन
- अधिकतम भूकम्प के लिहाज से, IS:1893 (Part-1) – 2002 के अनुसार, भूकम्पीय तीव्रता जोन III IV V

  भूकम्प जोन गुणक 0.16 0.24 0.36

  भूकम्प जोन के एक बढ़ोतरी से, जोन गुणक में करीब 1.5 गुना बढ़ जाता है।
- इसलिए, किसी भूकम्प जोन के महत्वपूर्ण भवनों की क्षतिग्रस्तता, अगले उच्च जोन के लिए जाँची जानी चाहिए।

SPECIAL HAZARDS

इनकी उपस्थिति से भवनों के भूकम्पीय जोखिम बढ़ जाते हैं।

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

SPECIAL HAZARDS

द्रवीकरण (Liquefaction) स्थिति

जमीन के नीचे कम गहराई पर, जलमग्न, समान आकार के कणवाले, विरल, नरम, महीन बालू परत का, मध्यम और उच्च भूकम्प त्वरण में द्रवीकरण हो सकता है, जिससे भवन भूमि में धँस सकता है या झुक सकता है। इस प्रकार की भूमि पर स्थापित भवनों को विशेष मूल्यांकन और उपचार की आवश्यकता होगी।

भूस्खलन (Landslide) प्रवण क्षेत्र

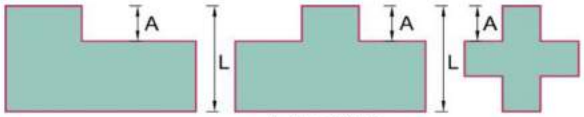
यदि भवन पहाड़ी ढलान पर हो एवं मानसून अथवा भूकम्प में, भूस्खलन खतरा हो, तो, स्थल विशेष की भूवैज्ञानिक एवं भूतकनीकी मूल्यांकन के साथ, भवन की विशेष उपचार की आवश्यकता होगी।

SPECIAL HAZARDS

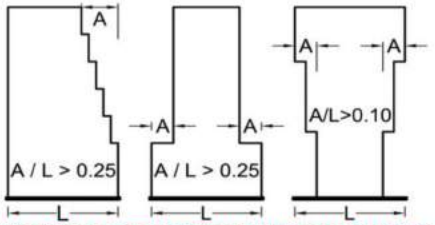
अनियमित भवन : PLAN IRREGULARITY (IS:1893)

- Torsion Irregularity
- Re-entrant Corners
- Diaphragm Discontinuity
- Out of Plane Offsets
- Non – Parallel Systems

इन अनियमित्ताओं के कारण, समग्र क्षतिग्रस्तता में एक ग्रेड की वृद्धि हो सकती है। ऐसे भवनों के लिये, विस्तृत मूल्यांकन या सुदृढ़ीकरण के लिए अनुशंसा की जा सकती है।



PLAN IRREGULARITIES : RE-ENTRANT CORNERS



VERTICAL GEOMETRIC IRREGULARITIES

SPECIAL HAZARDS

अनियमित भवन : VERTICAL IRREGULARITY (IS:1893)

- Mass Irregularity
- Vertical Geometric Irregularity
- In-Plane Discontinuity

यदि इन अनियमित्ताओं में कोई भी विद्यमान हो, तो, भवन को अधिक गंभीर क्षति (ग्रेड 4 से 5 तक) हो सकती है और विस्तृत मूल्यांकन अथवा क्षतिग्रस्तता के एक ग्रेड की वृद्धि की जा सकती है।

SPECIAL HAZARDS

अनियमित गिरनेवाले का खतरे

इससे भवनों की क्षतिग्रस्तता प्रभावित नहीं होती है। परन्तु यदि ऐसे खतरे मौजूद हों, तो, सर्वेक्षण रिर्पोट में, इन खतरों को हटाने की अनुशंसा करना चाहिए।

नींव के नीचे स्थित मिट्टी के प्रकार

सामान्यतः कम दोलन अवधि (T < 0.4 second) वाले भवनों के डिजाइन स्पेक्ट्रा में मिट्टी के प्रकार का कोई प्रभाव नहीं दिखता, जिसमें, लगभग सभी चिनाई भवन आ जाते हैं।

परन्तु, नरम मिट्टी स्थिति में, क्षतिग्रस्तता को एक ग्रेड से बढ़ा देना विवेकपूर्ण होगा।

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

RVS FORM

आँकड़ा संग्रह

- सामान्य जानकारी
- चिनाई भवनों के प्रकार
  - नींव के प्रकार
  - सपाट छत या फर्श
  - ढालदार छत की आंतरिक संरचना
  - ढालदार छत का आच्छादन
  - दीवारों के प्रकार
  - दीवार में गारा / मसाला
  - दीवारों का निर्माण
- भूकम्प सुरक्षा प्रावधानों की जाँच
  - सभी दीवारों में क्षैतिज भूकम्पीय पट्टी
  - दीवारों में ऊर्ध्वाधर प्रबलन की छड़े
- विशेष जोखिम की जाँच
- भवनों के गैर–संरचनात्मक अंग

भूकम्प जोन IV के सभी भवनों एवं जोन III के महत्वपूर्ण भवनों के लिए पूर्वनिर्मित चिनाई वाले भवनों के भूकम्पीय जोखिम आकलन के लिए RVS form

1.0 **सामान्य जानकारी**

1.1 भूकम्प जोन _____

1.2 भवन का नाम _____

1.3 उपयोग आवास □ कार्यालय □ स्कूल □
अस्पताल □ अन्य □

1.4 पता _____
_____ पिन_____

1.5 अन्य पहचान _____

1.6 तलों की संख्या_____

1.7 निर्माण वर्ष_____

1.8 पूर्ण आच्छादित क्षेत्रफल, सभी तलों का (वर्ग मी.)_____

1.9 भूतल पर कुर्सी क्षेत्रफल (वर्ग मी.)_____

1.10 नींव में मिट्टी का प्रकार_____

RVS form continued ....

2.0 चिनाई भवनों के प्रकार

2.1 नींव के प्रकार

2.1.1 दीवार के नीचे. पट्टी आधार हाँ □ नहीं □

2.1.2 पृथक–पृथक् स्तंभ आधार हाँ □ नहीं □

2.1.3 अन्य कोई (वर्णन करें)_____

2.2 सपाट छत या फर्श

2.2.1 लकड़ी की कड़ियों पर मिट्टी भराव हाँ □ नहीं □

2.2.2 इस्पात धरन पर पत्थर के स्लैब हाँ □ नहीं □

2.2.3 जैक मेहराब का छत या फर्ष हाँ □ नहीं □

2.2.4 आर.सी.सी./आर..बी. हाँ □ नहीं □

2.2.5 स्लैब की मोटाई _____

2.2.6 कोई अन्य (वर्णन करें)_____

RVS form continued ....

2.3 ढालदार छत की आंतरिक संरचना

2.3.1 बांस की ट्रस/कड़ी/परलिन हाँ □ नहीं □

2.3.2 लकड़ी की ट्रस/कड़ी /परलिन हाँ □ नहीं □

2.3.3 इस्पात की ट्रस/परलिन हाँ □ नहीं □

2.3.4 कोई अन्य (वर्णन करें)_____

2.4 ढालदार छत का आच्छादन

2.4.1 स्लेट पत्थर

2.4.2 आग में पकाई मिट्टी की टाइल हाँ □ नहीं □

2.4.3 नालीदार जस्ती लोहे की षीट ६ हाँ □ नहीं □

2.4.4 एसबेसटस सीमेंट की षीट हाँ □ नहीं □

2.4.5 रेषेदार षीट हाँ □ नहीं □

2.4.6 कोई अन्य (वर्णन करें)_____

RVS form continued ....

2.5 दीवारों के प्रकार

2.5.1 मिट्टी गारे की दीवारें हाँ □ नहीं □

2.5.2 कच्ची ईंट की दीवारें हाँ □ नहीं □

2.5.3 बांस के चचरी की दीवारें हाँ □ नहीं □

2.5.4 लकड़ी की दीवारें हाँ □ नहीं □

2.5.5 अनगढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.6 गढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.7 पकी ईंटों की चिनाई हाँ □ नहीं □

2.5.8 सीमेंट कंक्रीट ब्लॉक की चिनाई हाँ □ नहीं □

2.5.9 दीवार की मोटाई _____

2.5.10 कोई अन्य (वर्णन करें)_____

RVS form continued ....

2.6 दीवार में गारा / मसाला

2.6.1 मिट्टी का गारा हाँ □ नहीं □

2.6.2 चूने का मसाला हाँ □ नहीं □

2.6.3 सीमेंट का मसाला हाँ □ नहीं □

2.7 दीवारों का निर्माण *

2.7.1 दो आड़ी दीवारों के बीच, दीवार की लम्बाई, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.2 दीवारों में द्वार, दरवाजा एवं खिड़की के खुले भाग, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.3 दीवार की ऊँचाई और मोटाई का अनुपात, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.4 पत्थर की दीवारों की मोटाई में 'आर–पार पत्थर' तथा कोनों पर लंबे पत्थर दिए गए हैं? हाँ □ नहीं □

* भारतीय मानक **IS:4326** एवं **IS:13828** देखें।

RVS form continued ....

3.0 भूकम्प सुरक्षा प्रावधानों की जाँच *

3.1 अंदरूनी एवं बाहरी, सभी दीवारों में क्षैतिज भूकम्पीय पट्टी

3.1.1 कुर्सी स्तर पर हाँ □ नहीं □

3.1.2 खिड़की के निचले स्तर पर हाँ □ नहीं □

3.1.3 लिंटल (सरदल) स्तर पर हाँ □ नहीं □

3.1.4 सपाट फर्श/छत के निचले स्तर पर हाँ □ नहीं □

3.1.5 ढालवाँ छतों के ओलती स्तर पर हाँ □ नहीं □

3.1.6 तिकोने दीवार पर ढ़ालदार पट्टी हाँ □ नहीं □

3.1.7 रिज दीवार के उपर हाँ □ नहीं □

3.2 दीवारों में ऊर्ध्वाधर प्रबलन की छड़े

3.2.1 कमरों के कोनो पर हाँ □ नहीं □

3.2.2 दीवारो के **T**–जोड़ों पर हाँ □ नहीं □

3.2.3 दरवाजों और खिड़कियों के पाखों पर हाँ □ नहीं □

* भारतीय मानक **IS:4326** एवं **IS:13828** देखें।

RVS form continued ....

4.0 विशेष जोखिम की जाँच

4.1 उच्च जलस्तर (भूतल से 3 मी. के अंदर) एवं बलुआही मिट्टी हो, तो, सम्भावित द्रवीकरण भूस्थल हाँ □ नहीं □

4.2 भवन में गंभीर ऊर्ध्वाधर अनियमितता हाँ □ नहीं □

4.3 भवन में गंभीर प्लान अनियमितता हाँ □ नहीं □

4.4 भूस्खलन प्रवण स्थल हाँ □ नहीं □

RVS form continued ....

5.0 भवनों के गैर–संरचनात्मक अंग

गैर–संरचनात्मक अंग मौजूद हैं और भूकम्प के विरूद्ध स्थिर हैं ?

5.1 कमरे ईंट या लकड़ी की पतले दीवार से विभाजित है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.2 बाहरी सतह पर सजावटी **facade** का आच्छादन है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.3 फाल्स सिलिंग लगे है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.4 ईंटों की मुंड़ेर/प्लांटर्स बने हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.5 छतों पर चिमनियां दी गई हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.6 छत पर आर.सी.सी./चिनाई के पानीटैंक है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.7 संकेत/प्रदर्षन बोर्ड आदि लगे हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

6.0 कुछ या कई चिनाई भवनों में संभावित क्षतिग्रस्तता

चिनाई **भवनों के प्रकार** (तालिका 1 देखें)	A	B	B+	C	C+	D
भूकम्प जोन IV में **क्षतिग्रस्तता ग्रेड**, अधिक तीव्रता (तालिका–2 देखें)	G5	G4	G3	G3	G2	G2
नोट : सर्वेक्षक भवन के प्रकार का पहचान कर पेन से गोल बनाकर घेर देंगे और तदनुरूप क्षतिग्रस्तता ग्रेड को भी घेर देंगे।						

चिनाई भवनों के क्षतिग्रस्तता ग्रेड के बारे में आवश्यक नोट

- सामान्य आवासीय भवन : **50%** वाला ग्रेड
- विद्यालय एवं अस्पताल भवन : उच्चतम ग्रेड
- महत्वपूर्ण भवन : अगला भूकम्प जोन
- भूकम्प जोन V एवं IV में, VERTICAL IRREGULARITY वाले भवन :
  यदि विशेष रूप से निरूपित नहीं हों : एक ग्रेड ज्यादा क्षति
- जोन V, IV एवं III मे स्थित IRREGULAR PLAN वाले भवन :
  : एक ग्रेड ज्यादा क्षति
- IRREGULAR PLAN एवं G4 या G5 : पुर्नमूल्यांकन
- A एवं A+ प्रकार के दो मंजिल : एक ग्रेड ज्यादा क्षति
- B, C एवं D प्रकार के तीन मंजिल : एक ग्रेड ज्यादा क्षति
- नरम मिट्टी पर नींव : एक ग्रेड ज्यादा क्षति
- द्रवीकरण अथवा भूस्खलन प्रवण स्थल : विशेष मूल्यांकन

7.0 मूल्यांकन के दौरान की अनुशंसा

यदि क्षतिग्रस्तता ग्रेड है :

- **G1/G2** : भवन को भूकम्पीय दृष्टि से सुरक्षित माना जा सकता है।
- **G3** : भवन के ढ़हने की संभावना नहीं होगी, लेकिन यह मध्यम से भारी क्षति हो सकती है। ऐसे मामले में, भवन के रेट्रोफिटिंग (सुदृढ़ीकरण) की सलाह दी जा सकती है।
- **G4/G5** : भवन असुरक्षित है, इसे पुनः मूल्यांकन और उसके बाद रेट्रोफिटिंग की आवश्यकता होगी।

यदि कोई जोखिम हो :

- विशेष खतरा (कंडिका 4.0) पाये जाने पर उसे रोका या हटाया जाना चाहिए।
- यदि गैर–संरचनात्मक अस्थिर अंग (कंडिका 5.0) मौजूद हो तो इसे हटा देना चाहिए या स्थिर कर देना चाहिए।
- यदि दीवारों के निर्माण (कंडिका 2.7) कोड के अनुरूप नहीं हों, तो, गम्भीर क्षति होंगे अतएव, रेट्रोफिटिंग की आवश्यकता होगी।

8.0 आरीकाट के साथ, निर्मित भवन का रेखाचित्र या आरेखन तथा भवन का फोटो संलग्न करें।

लम्बाई, चौड़ाई एवं आरीकाट के साथ भवन का रेखाचित्र

भवन का फोटो

Thank You

(8)

RVS of masonry buildings

POINTS FOR CONSIDERATION AND DISCUSSION

1. Define Damage Grades (G1, G2, G3, G4 and G5) for masonry buildings.
2. Differentiate between damage grade and damageability grade.
3. Narrate the activities taken up during Rapid Visual Screening.
4. Explain the types of load bearing masonry buildings, specified for RVS surveys.
5. How will you find damageability grade from the specified seismic zone and building type?
6. How to incorporate the effect of Importance Factor in RVS surveys?
7. How the damageability grades are increased in case of different Special hazards?
8. What are the action taken by surveyors during RVS surveys?
9. Whick equipments help the surveyors, while performing RVS surveys?
10. Does falling hazard affect the damageability grade of a building?
11. Specify your recommendations for different damageability grades of masonry buildings.
12. Which type of sketches and phographs will be suggest for RVS surveys?

(9)

Practical RVS of a masonry building

POINTS FOR CONSIDERATION AND DISCUSSION

1. Participants will find out damageability grade of an existing masonry building after performing Rapid Visual Screening survey.
2. Participants will present the findings of survey, explain the reason for the damageability grade specified by them and their recommendations.

चिनाई वाले भवनों की RVS मार्गदर्शिका

(अस्पतालों, विद्यालयों एवं आवासों के भूकम्पीय क्षतिग्रस्तता का आकलन)

प्रो.. ए. एस. आर्य द्वारा विकसित विधि एवं मार्गदर्शन

1. प्रस्तावना

1.1 भूकम्पीय मूल्यांकन की आवश्यकता

वर्तमान चिनाई भवन, कई कारणों से, भूकम्परोधी कोड के प्रावधानों का अनुपालन नहीं करते, जैसे कि :–

i) कोड के आने से पहले ही भवन का निर्माण किया जा चुका हो, जिससे, भूकम्परोधी निरूपण नहीं किया गया हो, अथवा कोड के आने के वावजूद इसके प्रावधानों का उपयोग नहीं किया गया हो।

ii) प्रारम्भ में, कोड के अनूसार, यदि भूकम्परोधी निर्माण किया भी गया हो, तो भी, बाद में कोड के संशोधन के अनुरूप, भूकम्प प्रतिरोध की बढ़ी हुई आवश्यकता का समावेश नहीं हो पाया हो।

iii) भवन का उपयोग बदल गया हो, जिसमें अब भूकम्प सुरक्षा के उच्च स्तर की आवश्यकता हो।

iv) वर्षो से, उचित रखरखाव के अभाव में, भवन की स्थिति खराब हो गयी हो।

1.2 मूल्यांकन के चरण

वर्तमान भवन के लिये, भूकम्परोध मूल्यांकन के निम्नलिखित चरण हैं :–

पहला : RAPID VISUAL SCREENING (RVS) प्रक्रिया द्वारा एक त्वरित आकलन। इस प्रक्रिया में, भवन के कमजोर एवं असुरक्षित अंगों की पहचान के लिए, शीघ्रता से भवन का निरीक्षण और भवन के स्वामी, निर्माण विभाग, एवं रखरखाव कर्मचारी से भवनों रिकॉर्ड की जानकारी एकत्रित करना शामिल है।

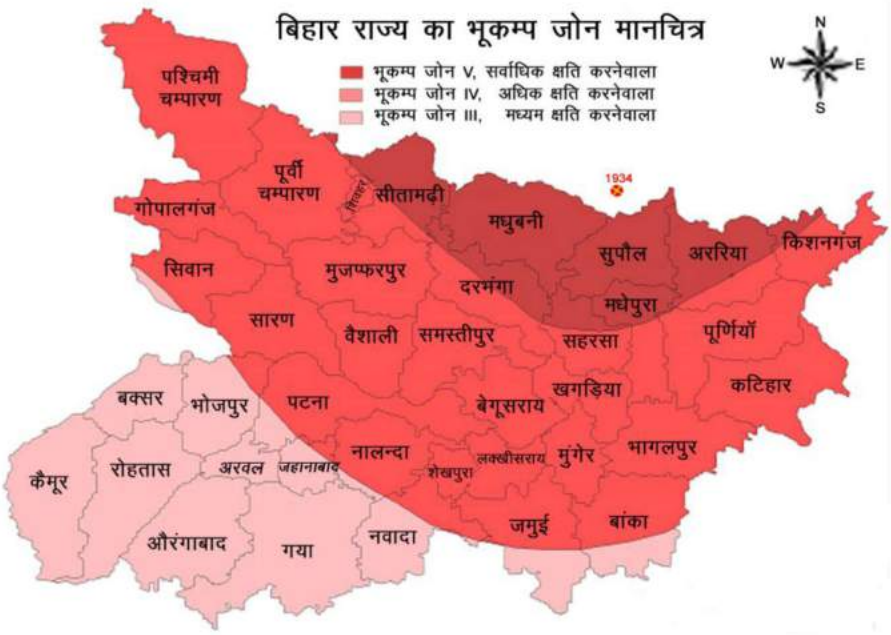
दूसरा : यदि भवन की पहचान कमजोर या असुरक्षित के रूप में होती है, तो, अगला कदम, भवन निमाण की कमियों से सम्बंधित डेटा प्राप्त कर, विस्तृत मूल्यांकन करने की होगी, जिससे, भूकम्परोधी रेट्रोफिटिंग (सुदृढ़ीकरण या मजबूतीकरण) द्वारा भवन का उपचार किया जा सके।

1.3 मार्गदर्थन का उद्येष्य

इस मार्गदर्शिका का उद्येश्य बिहार के जिलों में विभिन्न प्रकार के बहुत सारे चिनाई भवनों के RVS प्रक्रिया को सूत्रबद्ध करना है, जिससे भवन स्थल के भूकम्प जोन के लिये उल्लेखित भूकम्प तीव्रता में, संभावित पतन या क्षतिग्रस्तता ग्रेड के बारे में प्रारंभिक आकलन किया जा सके।

2. भूकम्प जोन

सम्भावित भूकम्प तीव्रता के आधार पर बिहार को तीन भूकम्प जोन में बाँटा गया है। भूकम्प जोन बगल के चित्र में दर्शाया गया है।



3. RVS प्रक्रिया

3.1 RVS **प्रक्रिया का आधार**

(i) कोड आधारित भूकम्पीय तीव्रता जोन

(ii) भवनों के प्रकार

(iii) क्षतिग्रस्तता ग्रेड (पूर्व भूकम्पों में क्षति तथा MSK/यूरोपीय मैक्रो तीव्रता स्केल में परिभाषित)

3.2 RVS **परिणामों का उपयोग**

मौजूदा भवनों के भूकम्पीय मूल्यांकन और संभावित उन्नयन के संबंध में, इस प्रक्रिया का मुख्य उपयोग है:

(i) किसी मौजूदा भवन को भूकम्पीय असुरक्षा की मूल्यांकन के लिए, अग्रतर आकलन की आवश्यकता है या नहीं यह पहचान करना।

(ii) निरूपण हेतु निदेशित भूकंपीय तीव्रता के दौरान, मौजूदा भवनों के भूकम्पीय क्षतिग्रस्ता (संरचनात्मक असुरक्षा) का आकलन।

(iii) भवन के गैर–सरंचनात्मक अंगों की क्षतिग्रस्तता तथा उनके स्थिरीकरण की आवश्यकता का आकलन।

3.3 RVS Form **में भूकम्पीय जोखिम** (hazard) **पर विचार**

तीन स्तरों पर भूकम्पीय जोखिम के तीव्रता का विचार किया जा रहा है जो कि निम्नलिखित है :–

भूकम्प जोन	MSK तीव्रता	भूकम्पीय जोखिम
V	IX या अधिक	बहुत अधिक
IV	VIII	अधिक
III	VII	मध्यम

जब, भूकम्पीय जोखिम की एक विशेष तीव्रता घटित होती है, तो, विभिन्न प्रकार के भवन में निहित विशेषताओं के अनुरूप, क्षति के विभिन्न स्तर प्रकट हो जाते हैं।

3.4 RVS **प्रक्रिया में भवनों के प्रकार पर विचार**

भारत के शहरी और ग्रामीण क्षेत्रों में, अनेकों प्रकार के भवन निर्माण विधियॉ और निर्माण सामग्रियों का उपयोग किया जाता है (**त्वरित.2. के तालिका–1**, देखें)। निर्माण सामग्रियॉ हैं, जैसे कि, स्थानीय सामग्री : जैसे मृदा, बांस एवं लकड़ी; अर्द्ध इंजीनियरीकृत सामग्री : जैसे पकी ईंटें और विभिन्न गढ़े पत्थर तथा इंजीनियरकृत सामग्री : जैसे कंक्रीट ब्लाकॅ। भवन निर्माण सामग्री और निर्माण तकनीक की चुनाव पर, विभिन्न प्रकार के भवन की भूकम्पीय असुरक्षा निर्भर करती है। आमतौर पर, इंजीनियरिंग तकनीकि के बिना, स्थानीय सामग्री के उपयोग में, बहुत ज्यादा असुरक्षा है और व्यवसायी कौशल के साथ, इंजीनियरी सामग्री के उपयोग करने में, सबसे कम है।

किसी एक प्रकार के भवन की बुनियादी असुरक्षितता, उस प्रकार के भवन की अपेक्षित औसत भूकम्पीय प्रदर्शन पर, निर्भर करती है। **त्वरित.2. के तालिका–1 में,** सभी भवनों को टाइप **A** से लेकर टाइप **D** तक विभाजित किया गया है, जो कि यूरोपीय मैक्रो भूकम्पीय स्केल (EMS-98) अनुशंसा पर आधारित है। टाइप **A** के भवनों में सबसे ज्यादा भूकम्पीय असुरक्षा है, जबकि टाइप **D** के भवनों में सबसे कम। हालॉकि, किसी भी प्रकार के भवन की अपनी असुरक्षितता, बुनियादी परिभाषित टाइप से अलग हो सकती है क्योंकि भवन की अवस्था, भूकम्परोधी अंगों की उपस्थिति, वास्तुविदीय विशेषताऐं, तलों की संख्या आदि पर भी असुरक्षितता निर्भर करती है। इसलिए यह संभव है कि, भूकम्प के दौरान, भवन के सम्भावित प्रदर्शन को प्रभावित करने वाले कारकों को ध्यान में रखते हुए, प्रत्येक प्रकार की क्षतिग्रस्तता सीमा प्रशस्त की जाय। अतएव, भवन के प्रकार में कुछ विभिन्नता, यथा : **A+**, **B+**, **C+**, **D+** के रूप में, लेखक द्वारा परिभाषित किये गये हैं। भवन की मजबूती पर भूकंप तीव्रता के प्रभाव को घ्यान में रखकर, भवनों की सम्भावित क्षति को विभिन्न ग्रेड में वर्गीकृत किया गया है।

3.5 **क्षतिग्रस्तता ग्रेड**

MSK और यूरोपीयन तीव्रता स्केल में, **G1** से **G5** तक, क्षतिग्रस्तता के पांच ग्रेड का उल्लेख है जो, चिनाई भवनों के लिए, **त्वरित.3. के तालिका–2 में,** में वर्णित है।

3.6 भूकम्पीय तीव्रता, भवनों के प्रकार और क्षतिग्रस्तता ग्रेड में सम्बंध

कंडिका 3.3 में, भूकम्पीय जोखिम जोन में वर्णित, भूकम्पीय तीव्रता घटित होने पर, चिनाई भवनों का सम्भावित प्रदर्शन के संबंध में, **त्वरित.4. का तालिका–3** मार्गदर्शन प्रदान करती है। भवन सर्वेक्षण में, क्षति के ग्रेड की पहचान के लिए, RVS फॉर्म सम्पादित करने में, इस जानकारी का उपयोग किया गया है।
भूकम्पीय सुदृढ़ीकरण की आवश्यकता को जानने के लिए भी इसका उपयोग किया जा सकता है एवं साधारण भवनों के लिए सरल सुदृढ़ीकरण तकनीक की सलाह देने के लिये, जहाँ, खर्च के दृष्टिकोण से अधिक विस्तृत मूल्यांकन व्यवहार्य नहीं हो।
यूरोपीयन तीव्रता स्केल में, संकेतिक मात्राऐं यथाः **कुछ**, **कई** और **बहुत**, निम्न प्रकार से परिभाषित हैं :–
कुछ : (15 ± 5) % से कम; **कई** : (15 ± 5) से (55 ± 5) % के बीच; **बहुत** : (55 ± 5) से 100 % के बीच।

MSK तीव्रता स्केल के अनुसार, इन संकेतिक मात्राओं का औसत मान इस प्रकार लिया जा सकता है –
कुछ : लगभग 5 %; **कई** : लगभग 50 %; **बहुत** : लगभग 75 %
त्वरित.4. का तालिका–3 सामान्यतः, MSK विवरण पर आधारित है।

3.7 RVS सर्वेक्षण फॉर्म – विशेष बिंदु

प्रत्येक भूकम्पीय जोखिम तीव्रता जोन के लिए, अलग RVS सर्वेक्षण फॉर्म बनाया गया है। टाइप **A** से लेकर टाइप **D** तक भवनों के **प्रकार एवं G1 से G5 तक क्षतिग्रस्तता** ग्रेड ऊपर वर्णित है। इसके अलावे, फॉर्म में, निम्नलिखित कुछ मुख्य परिस्थितियों को शामिल किया गया है :–

3.8 भवन / संरचना का महत्व

अधिकतर भूकम्प कोड में, भवन के **महत्व** का गुणक (importance factor, I) परिभाषित किया गया है जो कि भवनों और संरचनाओं की मजबूती में वृद्धि की आवश्यकता दर्शाता हैं। महत्वपूर्ण भवनों की श्रेणी में शामिल संरचनाओं में स्कूल और अस्पताल के भवन आते हैं। अन्य महत्वपूर्ण भवन हैं, यथा : स्मारक भवन; आपातकालीन संचार भवन जैसे– दूरभाष केंद्र, टेलीविजन एवं रेडियो स्टेशन; जीवन रेखा भवन जैसे– रेलवे स्टेशन, दमकल केंद्र; बड़े सामुदायिक हॉल जैसे– सिनेमाघर, सभा भवन और भूमिगत रेल मार्ग स्टेशन; बिजलीघर; अतिमहत्वपूर्ण व्यक्तियों के निवास और आपातकाल में सहायक महत्वपूर्ण व्यक्तियों के निवास। दिन या रात में, किसी भी समय, 1000 से अधिक लोगों वाले किसी भी भवन को RVS के लिए, महत्वपूर्ण रूप में माना जा सकता है।
इन महत्वपूर्ण भवनों के लिए, I का मान, विभिन्न संहिताओं में उल्लिखित है। IS:1893 (Part-1) – 2002 के अनुसार I का मान 1.5 लेना है, जिससे महत्वपूर्ण भवनों के निरूपण में भूकम्पीय बल में 1.5 गुणा वृद्धि हो जाती है।
अधिकतम भूकम्प के लिहाज से, IS:1893 (Part-1) – 2002 के अनुसार, विभिन्न भूकम्प जोन गुणक निम्नलिखित है :–

भूकम्पीय तीव्रता जोन	III	IV	V
भूकम्प जोन गुणक	0.16	0.24	0.36

यह गौर किया जा सकता है कि भूकम्प जोन के एक बढ़ोतरी से, जोन गुणक में करीब 1.5 गुना बढ़ जाता है। इसलिए, यह कहा जा सकता है कि, किसी भूकम्प जोन के महत्वपूर्ण भवनों की क्षतिग्रस्तता, अगले उच्च जोन के लिए जाँची जानी चाहिए। RVS के लिए, **कंडिका 3.3** में दर्शाये गये, जोन V, IV और III के अनुसार भूकम्प जोखिम माना जा सकता है।

3.9 भूकम्पीय जोखिम बढ़ानेवाले, भवन के कारक/लक्षण

कुछ विशेष खतरनाक स्थितियॉ विचार योग्य हैं:–

3.9.1 द्रवीकरण स्थिति

जमीन के नीचे कम गहराई पर जलमग्न, समान आकार के कणवाले विरल नरम महीन बालू परत का, मध्यम और उच्च भूकम्प त्वरण में द्रवीकरण हो सकता है, जिससे भवन भूमि में धँस सकता है या झुक सकता है। इस प्रकार की भूमि पर स्थापित भवनों को विशेष मूल्यांकन और उपचार की आवश्यकता होगी।

3.9.2 भूस्खलन प्रवण क्षेत्र

यदि भवन पहाड़ी ढलान पर हो एवं मानसून अथवा भूकम्प में, भूस्खलन या पत्थरों के गिरने का खतरा हो, तो, स्थल की विशेष भूवैज्ञानिक एवं भूतकनीकी मूल्यांकन के साथ, भवन की विशेष उपचार की आवश्यकता होगी।

3.9.3 अनियमित भवनः

भवन संहिताओं में, भवनों की अनियमितताऐं निम्नलिखित उप शीर्षों में परिभाषित हैंः–

i. **प्लान अनियमितता** (देखें, **त्वरित.5. का चित्र–1**)

इन्हें सामान्यतः निम्न रूप से परिभाषित किया जाता हैः–

a) ऐंठन उत्पन्न करनेवाली अनियमितताऐं (Torsion Irregularity)
b) भवन के बाहरी भाग पर पुनः प्रवेशी कोना (Re-entrant Corners)
c) किसी मंजिल के छत में, बीच में खुली जगह (Diaphragm Discontinuity)
d) उर्ध्वाधर दिशा में भूकम्परोधी अवयव लगातार नहीं (Out of Plane Offsets)
e) भूकम्परोधी अवयव क्षैतिज अक्षों के असमानान्तर (Non – Parallel Systems)

भवन के प्लान की ज्यामितीय अनियमितताओं को, **चित्र–1** द्वारा आसानी से पहचाना जा सकता है। इन अनियमित्ताओं के कारण, समग्र क्षतिग्रस्तता में एक ग्रेड की वृद्धि हो सकती है। (यथा, पुनः प्रवेशी कोना के कारण, क्षतिग्रस्तता ग्रेड में वृद्धि)। ऐसे भवनों के लिये, विस्तृत मूल्यांकन या सुदृढ़ीकरण के लिए अनुशंसा की जा सकती है।

ii. **ऊर्ध्वाधर अनियमितता**

चिनाई भवनों में, निम्नलिखित ऊर्ध्वाधर अनियमितता देखी जा सकती है (देखें, **त्वरित.5. का चित्र–2**)

a) निकटस्थ मंजिलों के वजन में भारी असमानता (Mass Irregularity)
b) भूकम्परोधी खड़े अंग के क्षैतिज माप में भारी परिवर्तन (Vertical Geometric Irregularity)
c) मंजिलों पर भूकम्परोधी खड़े अंगों की अनिरन्तरता (In-Plane Discontinuity)

यदि इन अनियमित्ताओं में कोई भी विद्यमान हो, तो, भवन को अधिक गंभीर क्षति (ग्रेड 4 से 5 तक) हो सकती है और विस्तृत मूल्यांकन अथवा क्षतिग्रस्तता के एक ग्रेड की वृद्धि की अनुशंसा की जा सकती है।

3.9.4 गिरनेवाले का खतरे

विशेषकर तीव्र भूकम्प तीव्रता क्षेत्रों में, यदि ऐसे खतरे मौजूद हों, तो, सर्वेक्षण रिर्पोट की अनुशंसा में, इन खतरों को हटाने का जिक्र होना चाहिए।

3.10 नींव के नींचे स्थित मिट्टी के प्रकार

सामान्यतः भूकम्परोधी भवन संहिताऐं तीन प्रकार की मिट्टी परिभाषित करती हैः– कठोर, मध्यम और नरम। कम दोलन अवधि (T < 0.4 second) वाले भवनों के डिजाइन स्पेक्ट्रा में मिट्टी के प्रकार का कोई प्रभाव नहीं दिखता, जिसमें, लगभग सभी चिनाई भवन आ जाते हैं। इसलिए, चिनाई भवनों में मिट्टी के प्रकार का प्रभाव बहुत महत्वपूर्ण नहीं है। परंतु नरम मिट्टी स्थिति में, क्षतिग्रस्तता को एक ग्रेड से बढ़ा देना विवेकपूर्ण होगा।

4. RVS फॉर्म एवं आँकड़ा संग्रह

उपरोक्त दिशा निर्देशों का उपयोग करते हुए, विभिन्न भूकम्पीय जोन के लिए, RVS फॉर्म विकसित किये गये हैं। शीघ्रता से भवन सर्वेक्षण कर, RVS फॉर्म में भवन के आँकड़े एकत्रित किए जाते हैं तथा **तालिका–1** की सहायता से भवन के प्रकार की पहचान करते हैं। **तालिका–2** एवं **तालिका–3** की सहायता से, भूकम्पीय क्षेत्र की जोखिम तीव्रता के अनुरूप क्षतिग्रस्तता ग्रेड निर्धारित करते हैं। RVS फॉर्म की उचित तालिका में, भवन के प्रकार को, पेन से गोल बनाकर घेर देते हैं और तदनुरूप क्षतिग्रस्तता ग्रेड को भी घेर देते हैं।

RVS प्रक्रिया को समझने के लिए, एक ''त्वरित गाइड'' विकसित किया गया है, जिसमें सभी संदर्भ तालिकाऐं और नोट प्रस्तुत है। सम्बंधित भूकम्प जोन का RVS फॉर्म और RVS कार्य के दौरान मार्गदर्शन हेतु ''त्वरित गाइड'', सर्वेक्षक को अपने साथ ले जाना चाहिए।

RVS फॉर्म उपयोग करने हेतु त्वरित गाइड

त्वरित.1. सर्वेक्षक के साथ उपकरण:

1) डिजिटल कैमरा
2) मापी हेतु टेप
3) क्लिप के साथ सख्त पाटी
4) पेन (काला), पेंसिल, रबड़
5) पर्याप्त संख्या में RVS फॉर्म
6) RVS मार्गदर्शिका की एक प्रति
7) त्वरित गाइड (बार–बार उपयोग हेतु लेमिनेशन करा लें)

त्वरित.2. चिनाई की भारवाहक दीवार वाले भवन : तालिका 1: भवनों के प्रकार

प्रकार	भवन का विवरण
A	(क) जमीन पर उथला नीव के साथ मिट्टी गारे में निर्मित दीवारें
A+	(ख) सामान्य ढ़ालवाँ लकड़ी की छत के साथ, मिट्टी के गारे में अथवा बिना मसाला के, अनगढ़े (क्षेत्रीय) पत्थर की दीवारें (ग) पर्याप्त 'आर–पार पत्थर' के बिना अनगढ़े पत्थरों की रद्दारहित चिनाई (घ) गोल पत्थरों के साथ चिनाई (ड़) मिट्टी गारे में कच्ची ईंट की दीवारें
B	'आर–पार पत्थरों' एवं कोनों पर लम्बे पत्थरों के साथ, अर्द्ध गढ़े (या अनगढ़े) पत्थरों की रद्दा में चिनाई; परम्परागत लकड़ी की छतों के साथ, अप्रबलित ईंट की दीवारें; मिट्टी गारे या चूना के कमजोर मसाले में, अप्रबलित सिमेंट कंक्रीट ब्लॉक की दीवारें
B+	(क) लकड़ी के खड़े पीलरों या लकड़ी के क्षैतिज अंगों या लकड़ी के भूकंपीय बैंड (IS: 13828)* के साथ, मिट्टी गारे में अप्रबलित ईंटों की चिनाई (ख) चूना के मसाले में, अप्रबलित ईंटों की चिनाई
C	(क) सपाट आर.सी.सी. फर्श/छत अथवा ओलती स्तर पर क्षैतिज बन्धनी या भूकम्पीय पट्टियों वाले ढालवाँ छत के साथ; पूर्णतः गढ़े पत्थरों या सिमेंट कंक्रीट ब्लॉक अथवा अच्छे सिमेंट मसाले में, पकी ईंट से निर्मित अप्रबलित चिनाई की दीवारें (ख) B+ की तरह, क्षैतिज भूकम्पीय पट्टियों (IS: 13828)* के साथ
C+	C (क) की तरह, परन्तु दरवाजों और खिड़कियों के लिंटल स्तर पर क्षैतिज भूकम्पीय पट्टियों (IS: 4326)* के साथ
D	C (क) की तरह निर्मित, परंतु क्षैतिज भूकम्पीय पट्टियों और खड़े छड़ों इत्यादि (IS: 4326)* के साथ प्रबलित चिनाई अथवा क्षैतिज और ऊर्ध्वाधर आर.सी.सी. अंगों द्वारा प्रबलित परिबन्धित चिनाई
D+	पकी ईंटों से चिनाई की गयी प्रबलित दीवारें

IS:13828-1993, "Improving Earthquake Resistance of Low Strength Masonry Buildings --- Guidelines".
IS:4326-1993, "Earthquake Resistant Design and Construction of Buildings – Code of Practice BIS 2005

त्वरित.3. क्षतिग्रस्तता ग्रेड : तालिका 2: चिनाई भवनों के क्षतिग्रस्तता ग्रेड की परिभाषा

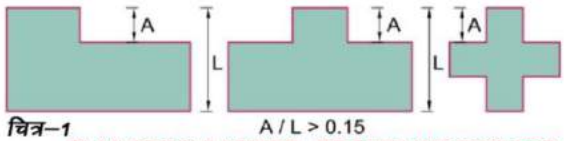
ग्रेड	विवरण
G1	**नगण्य से हल्की क्षति (संरचनात्मक क्षति नहीं, हल्की गैर–संरचनात्मक क्षति)** **संरचनात्मकः** इने गिने दीवारों में बारीक दरार **गैर–संरचनात्मकः** केवल प्लास्टर के छोटे टुकड़ों का गिरना। कुछेक स्थानों पर भवनों के ऊपरी हिस्सों से ढ़ीले–ढ़ाले अंशों का गिरना।
G2	**मध्यम क्षति (हल्की संरचनात्मक क्षति, मध्यम गैर– संरचनात्मक क्षति)** **संरचनात्मकः** बहुतों दीवारों में दरारें, आर.सी.सी. स्लैब एवं एसबेसटस शीट में बारीक दरारें **गैर–संरचनात्मकः** प्लास्टर के बड़े–बड़े टुकड़ों का गिरना, छतों पर धुंआ चिमनियों का आंशिक पतन, मुंड़ेर और छज्जों की क्षति, करीब 10 प्रतिशत छत की टाइल का बिखरना, ढ़ालवाँ छतों की अंदरूनी संरचना की मामूली क्षति।
G3	**भारी क्षति (मध्यम संरचनात्मक क्षति, भारी गैर–संरचनात्मक क्षति)** **संरचनात्मकः** ज्यादातर दीवारों में व्यापक बड़ी दरारें, स्तंभ और पीलर में विस्तृत दरारें। **गैर–संरचनात्मकः** छत टाइल का अलग हो जाना, छत पर चिमनियों का जड़ से टूटना, पृथक गैर–संरचनात्मक अंगों (विभाजक दीवारें तिकोनें दीवारें) की विफलता
G4	**बहुत भारी क्षति (भारी संरचनात्मक क्षति, बहुत भारी गैर–संरचनात्मक क्षति)** **संरचनात्मकः** दीवारों की गंभीर विफलता (दीवारों में गैप), अंदरूनी दीवारों का ढ़हना, फर्शों और छतों की आंशिक संरचनात्मक विफलता
G5	**विनाश (बहुत भारी संरचनात्मक क्षति)** : कुल या तकरीबन पूर्ण रूप से भवन का ढ़हना

त्वरित.4. भवन के प्रकार, भूकम्प जोन तीव्रता तथा क्षतिग्रस्तता ग्रेड में सम्बंध

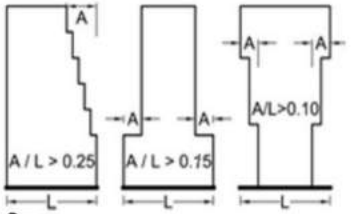
तालिका 3: चिनाई भवनों के क्षतिग्रस्तता ग्रेड का आकलन

भवन का प्रकार	मध्यम भूकम्पीय तीव्रता (MSK VII)	उच्च भूकम्पीय तीव्रता (MSK VIII)	बहुत उच्च भूकम्पीय तीव्रता (MSK IX या अधिक)
A एवं **A+**	बहुत ग्रेड 3 के कुछ ग्रेड 4 के (बाकी ग्रेड 2 या 1 के)	बहुत ग्रेड 4 के कुछ ग्रेड 5 के (बाकी ग्रेड 3 या 2 के)	कई ग्रेड 5 के (बाकी ग्रेड 4 या 3 के)
B एवं **B+**	कई ग्रेड 2 के कुछ ग्रेड 3 के (बाकी ग्रेड 1 के)	बहुत ग्रेड 3 के कुछ ग्रेड 4 के (बाकी ग्रेड 2 के)	कई ग्रेड 4 के कुछ ग्रेड 5 के (बाकी ग्रेड 3 के)
C एवं **C+**	कई ग्रेड 1 के कुछ ग्रेड 2 के (बाकी ग्रेड 1 या 0 के)	बहुत ग्रेड 2 के कुछ ग्रेड 3 के (बाकी ग्रेड 1 के)	कई ग्रेड 3 के कुछ ग्रेड 4 के (बाकी ग्रेड 2 के)
D एवं **D+**	कुछ ग्रेड 1 के	कुछ ग्रेड 2 के	कई ग्रेड 2 के कुछ ग्रेड 3 के (बाकी ग्रेड 1 के)

त्वरित.5. प्लान में अनियमितता (चित्र 1) ऊर्ध्वाधर अनियमितता (चित्र 2)



चित्र–1
PLAN IRREGULARITIES : RE-ENTRANT CORNERS



चित्र–2
VERTICAL GEOMETIC IRREGULARITIES

त्वरित.6. दीवारों में क्षैतिज भूकम्पीय आर.सी.सी. पट्टी सभी बाहरी एवं अंदरूनी दीवारों में आवश्यक है।

प्रत्येक मकान में, लिंटल (सरदल) स्तर पर एवं कुरसी स्तर पर, पट्टी आवश्यक है। जहाँ कुर्सी स्तर पर आर.सी.सी बीम दिया गया हो, वहाँ कुरसी स्तर पर पट्टी आवश्यक नहीं है। पूर्वनिर्मित (पहले ही ढ़ालकर तैयार किये गये) आर.सी.सी बीम (या तख्ता) से जोड़कर बनाये गये छतों में तथा ढलान वाले मकानों में, छत के निचले स्तर पर (ओलती पर) छत पट्टी आवश्यक है। एक या दो तरफ ढलान वाले मकानों में त्रिभुजाकार ओरी पर ढ़ालदार गेबल पट्टी आवश्यक है। सपाट आर. सी.सी. या आर. बी. छतवाले मकानों में, जहाँ छत दीवार के उपर, दीवार के 2/3 मोटाई तक चढ़ती हो, छत पट्टी आवश्यक नहीं है।

दीवारों में ऊर्ध्वाधर प्रबलन की छड़े

प्रत्येक मकान में, सभी कमरों के कोनों पर, कंक्रीट के अंदर टौर–स्टील के छड़ आवश्यक है।

भूकम्प जोन V में, एक मीटर से बड़े दरवाजों एवं खिड़कियों के दोनों तरफ, भूकम्प जोन IV में 2.5 मीटर से बड़े द्वारों के दोनों तरफ, कंक्रीट के अंदर टौर–स्टील के छड़ खड़ा करना चाहिए एवं खिड़की के निचले स्तर पर सिल्ल बैंड आवश्यक है।

त्वरित.7. क्षतिग्रस्तता ग्रेड के बारे में आवश्यक नोट

1) MSK तीव्रता स्केल के अनुसार, कुछ, कई एवं बहुतों का औसत मान इस प्रकार लिया जाय :–
   कुछ : लगभग 5 %; **कई** : लगभग 50 %; **बहुत** : लगभग 75 %
2) सामान्य आवासीय भवन का क्षतिग्रस्तता ग्रेड निर्धारित करते समय, '' कई '' के लिये दर्शाया गया ग्रेड चुना जाय।
3) विद्यालय एवं अस्पताल भवनों के क्षतिग्रस्तता ग्रेड निर्धारित करते समय, अगर '' कुछ '' क्षति दर्शाया जा रहा हो, तब भी, उच्चतम ग्रेड ही चुना जाय। साथ ही, महत्वपूर्ण भवन होने के कारण, अगले भूकम्पीय तीव्रता जोन को चुना जाय।
4) ऊर्ध्वाधर अनियमितता वाले भवनों को, यदि विशेष रूप से निरूपित नहीं किया गया हो, तो, उच्च भूकम्पीय तीव्रता एवं बहुत उच्च भूकम्पीय तीव्रता (MSK VIII and IX or more) में एक ग्रेड ज्यादा क्षति हो सकती है।
5) प्लान अनियमितता वाले भवनों को, मध्यम, उच्च एवं बहुत उच्च भूकम्पीय तीव्रता (MSK VII, VIII and IX or more) में एक ग्रेड ज्यादा क्षति हो सकती है। यदि क्षतिग्रस्तता ग्रेड G4 या ज्यादा हो, तो, सर्वेक्षक पुनर्मूल्यांकन की अनुशंसा कर सकते हैं।
6) (i) A एवं A+ प्रकार के दो मंजिल उँचे चिनाई भवन की एक ग्रेड ज्यादा क्षति हो सकती है।
   (il) B, C एवं D प्रकार के तीन मंजिल उँचे चिनाई भवन की एक ग्रेड ज्यादा क्षति हो सकती है।
7) नरम मिट्टी पर आधारित नींव वाले चिनाई भवन की एक ग्रेड ज्यादा क्षति हो सकती है।
8) भूकम्पीय सुरक्षा के लिये, द्रवीकरण अथवा भूस्खलन प्रवण स्थल पर स्थित भवनों की विशेष मूल्यांकन का आवश्यकता है।

भूकम्प जोन V के सभी भवनों एवं जोन IV के महत्वपूर्ण भवनों के लिए

पूर्वनिर्मित चिनाई वाले भवनों के भूकम्पीय जोखिम आकलन के लिए RVS form (पद्मश्री डा. ए. एस. आर्य द्वारा)

1.0 सामान्य जानकारी

1.1 भूकम्प जोन _____

1.2 भवन का नाम _____

1.3 उपयोग आवास □ कार्यालय □ स्कूल □ अस्पताल □ अन्य □

1.4 पता _____ _____ पिन _____

1.5 अन्य पहचान _____

1.6 तलों की संख्या _____

1.7 निर्माण वर्ष _____

1.8 पूर्ण आच्छादित क्षेत्रफल, सभी तलों का (वर्ग मी.) _____

1.9 भूतल पर कुर्सी क्षेत्रफल (वर्ग मी.) _____

1.10 नींव में मिट्टी का प्रकार _____

2.0 चिनाई भवनों के प्रकार

2.1 नींव के प्रकार

2.1.1 दीवार के नीचे. पट्टी आधार हाँ □ नहीं □

2.1.2 पृथक–पृथक् स्तंभ आधार हाँ □ नहीं □

2.1.3 अन्य कोई (वर्णन करें) _____

2.2 सपाट छत या फर्श

2.2.1 लकड़ी की कड़ियों पर मिट्टी भराव हाँ □ नहीं □

2.2.2 इस्पात धरन पर पत्थर के स्लैब हाँ □ नहीं □

2.2.3 जैक मेहराब का छत या फर्श हाँ □ नहीं □

2.2.4 आर.सी.सी./आर..बी. हाँ □ नहीं □

2.2.5 स्लैब की मोटाई _____

2.2.6 कोई अन्य (वर्णन करें) _____

2.3 ढालदार छत की आंतरिक संरचना

2.3.1 बांस की ट्रस/कड़ी/परलिन हाँ □ नहीं □

2.3.2 लकड़ी की ट्रस/कड़ी /परलिन हाँ □ नहीं □

2.3.3 इस्पात की ट्रस/परलिन हाँ □ नहीं □

2.3.4 कोई अन्य (वर्णन करें) _____

2.4 ढालदार छत का आच्छादन

2.4.1 स्लेट पत्थर

2.4.2 आग में पकाई मिट्टी की टाइल हाँ □ नहीं □

2.4.3 नालीदार जस्ती लोहे की शीट हाँ □ नहीं □

2.4.4 एसबेसटस सीमेंट की शीट हाँ □ नहीं □

2.4.5 रेशेदार शीट हाँ □ नहीं □

2.4.6 कोई अन्य (वर्णन करें) _____

2.5 दीवारों के प्रकार

2.5.1 मिट्टी गारे की दीवारें हाँ □ नहीं □

2.5.2 कच्ची ईंट की दीवारें हाँ □ नहीं □

2.5.3 बांस के चचरी की दीवारें हाँ □ नहीं □

2.5.4 लकड़ी की दीवारें हाँ □ नहीं □

2.5.5 अनगढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.6 गढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.7 पकी ईंटों की चिनाई हाँ □ नहीं □

2.5.8 सीमेंट कंक्रीट ब्लॉक की चिनाई हाँ □ नहीं □

2.5.9 दीवार की मोटाई _____

2.5.10 कोई अन्य (वर्णन करें) _____

2.6 दीवार में गारा / मसाला

2.6.1 मिट्टी का गारा हाँ □ नहीं □

2.6.2 चूने का मसाला हाँ □ नहीं □

2.6.3 सीमेंट का मसाला हाँ □ नहीं □

2.7 दीवारों का निर्माण *

2.7.1 दो आड़ी दीवारों के बीच, दीवार की लम्बाई, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.2 दीवारों में द्वार, दरवाजा एवं खिड़की के खुले भाग, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.3 दीवार की ऊँचाई और मोटाई का अनुपात, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.4 पत्थर की दीवारों की मोटाई में 'आर–पार पत्थर' तथा कोनों पर लंबे पत्थर दिए गए हैं? हाँ □ नहीं □

3.0 भूकम्प सुरक्षा प्रावधानों की जाँच *

3.1 अंदरूनी एवं बाहरी, सभी दीवारों में क्षैतिज भूकम्पीय पट्टी

3.1.1 कुर्सी स्तर पर हाँ □ नहीं □

3.1.2 खिड़की के निचले स्तर पर हाँ □ नहीं □

3.1.3 लिंटल (सरदल) स्तर पर हाँ □ नहीं □

3.1.4 सपाट फर्श/छत के निचले स्तर पर हाँ □ नहीं □

3.1.5 ढालवाँ छतों के ओलती स्तर पर हाँ □ नहीं □

3.1.6 तिकोने दीवार पर ढ़ालदार पट्टी हाँ □ नहीं □

3.1.7 रिज दीवार के उपर हाँ □ नहीं □

3.2 दीवारों में ऊर्ध्वाधर प्रबलन की छड़े

3.2.1 कमरों के कोनो पर हाँ □ नहीं □

3.2.2 दीवारो के T–जोड़ों पर हाँ □ नहीं □

3.2.3 दरवाजों और खिड़कियों के पाखों पर हाँ □ नहीं □

* इस हेतु भारतीय मानक IS:4326 एवं IS:13828 देखें।

4.0 विशेष जोखिम की जाँच

4.1 उच्च जलस्तर (भूतल से 3 मी. के अंदर) एवं बलुआही मिट्टी हो, तो, सम्भावित द्रवीकरण भूस्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.2 भवन में गंभीर ऊर्ध्वाधर अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.3 भवन में गंभीर प्लान अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 1 ग्रेड से, अधिकतम G4 तक बढ़ा दें)

4.4 भूस्खलन प्रवण स्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता ग्रेड G5 हो सकता है)

5.0 भवनों के गैर–संरचनात्मक अंग

गैर–संरचनात्मक अंग मौजूद हैं और भूकम्प के विरूद्ध स्थिर हैं ?

5.1 कमरे ईंट या लकड़ी की पतले दीवार से विभाजित हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.2 बाहरी सतह पर सजावटी facade का आच्छादन है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.3 फाल्स सिलिंग लगे है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.4 ईंटों की मुंड़ेर/प्लांटर्स बने हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.5 छतों पर चिमनियां दी गई हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.6 छत पर आर.सी.सी./चिनाई के पानीटैंक है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.7 संकेत/प्रदर्शन बोर्ड आदि लगे हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

6.0 कुछ या कई चिनाई भवनों में संभावित क्षतिग्रस्तता

चिनाई **भवनों के प्रकार** (तालिका 1 देखें)	**A**	**A+**	**B**	**B+**	**C**	**C+**	**D**
भूकम्प जोन V में **क्षतिग्रस्तता ग्रेड**, बहुत अधिक तीव्रता (तालिका–2 देखें)	**G5**	**G5**	**G5**	**G4**	**G4**	**G3**	**G3**
नोट : + चिन्ह थोड़ा बढ़ा हुआ शक्ति यानी थोड़ा कम क्षतिग्रस्तता दर्शाता है। साथ ही, एक स्थल पर, एक ही प्रकार के भवनों के लिये, उपर दर्शाये गये सम्भावित क्षतिग्रस्तता को 1 ग्रेड से कम किया जा सकता है। सर्वेक्षक भवन के प्रकार का पहचान कर पेन से गोल बनाकर घेर देंगे और तदनुरूप क्षतिग्रस्तता ग्रेड को भी घेर देंगे।							

7.0 मूल्यांकन के दौरान की अनुशंसा

यदि क्षतिग्रस्तता ग्रेड है :

- G1/G2 : भवन को भूकम्पीय दृष्टि से सुरक्षित माना जा सकता है।
- G3 : भवन के ढ़हने की संभावना नहीं होगी, लेकिन यह मध्यम से भारी क्षति हो सकती है। ऐसे मामले में, भवन के रेट्रोफिटिंग (सुदृढ़ीकरण) की सलाह दी जा सकती है।
- G4/G5 : भवन असुरक्षित है, इसे पुनः मूल्यांकन और उसके बाद रेट्रोफिटिंग की आवश्यकता होगी।

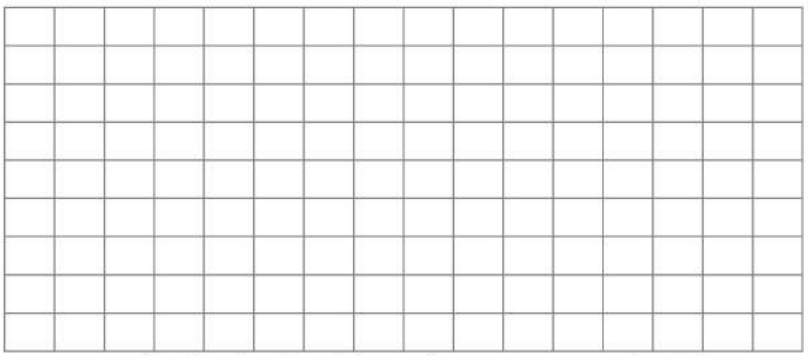
यदि कोई जोखिम हो :

- विशेष खतरा (कंडिका 4.0) पाये जाने पर उसे रोका या हटाया जाना चाहिए।
- यदि गैर–संरचनात्मक अस्थिर अंग (कंडिका 5.0) मौजूद हो तो इसे हटा देना चाहिए या स्थिर कर देना चाहिए।
- यदि दीवारों के निर्माण (कंडिका 2.7) कोड के अनुरूप नहीं हों, तो, गम्भीर क्षति होंगे अतएव, रेट्रोफिटिंग की आवश्यकता होगी।

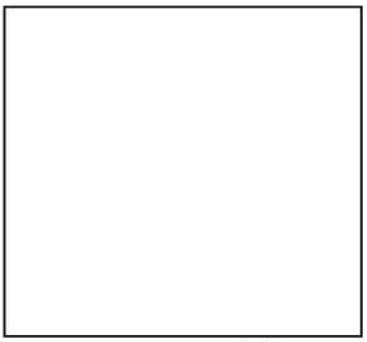
नोटः

1) 5.0 का आकलन भवन के क्षतिग्रस्तता ग्रेड को प्रभावित नहीं करता, बल्कि अस्थिर गैर–संरचनात्मक अंग आवासियों को हानि पहुँचा सकता है।
2) संक्षिप्त रूपः RVS: Rapid Visual Screening, आर.सी.सी.: प्रबलित सिमेंट कंक्रीट, आर..बी.: प्रबलित ईंट

8.0 आरीकाट के साथ, निर्मित भवन का रेखाचित्र या आरेखन तथा भवन का फोटो संलग्न करें।



लम्बाई, चौड़ाई एवं आरीकाट के साथ भवन का रेखाचित्र



भवन का फोटो

सर्वेक्षक का हस्ताक्षरः _____

नामः _____

कार्यपालक अभियन्ता का हस्ताक्षरः _____

सर्वेक्षण की तिथिः _____

भूकम्प जोन IV के सभी भवनों एवं जोन III के महत्वपूर्ण भवनों के लिए

पूर्वनिर्मित चिनाई वाले भवनों के भूकम्पीय जोखिम आकलन के लिए RVS form (पद्मश्री डा. ए. एस. आर्य द्वारा)

1.0 सामान्य जानकारी

1.1 भूकम्प जोन _____

1.2 भवन का नाम _____

1.3 उपयोग आवास □ कार्यालय □ स्कूल □ अस्पताल □ अन्य □

1.4 पता _____

_____ पिन _____

1.5 अन्य पहचान _____

1.6 तलों की संख्या _____

1.7 निर्माण वर्ष _____

1.8 पूर्ण आच्छादित क्षेत्रफल, सभी तलों का (वर्ग मी.) _____

1.9 भूतल पर कुर्सी क्षेत्रफल (वर्ग मी.) _____

1.10 नींव में मिट्टी का प्रकार _____

2.0 चिनाई भवनों के प्रकार

2.1 नींव के प्रकार

2.1.1 दीवार के नीचे. पट्टी आधार हाँ □ नहीं □

2.1.2 पृथक–पृथक् स्तंभ आधार हाँ □ नहीं □

2.1.3 अन्य कोई (वर्णन करें) _____

2.2 सपाट छत या फर्श

2.2.1 लकड़ी की कड़ियों पर मिट्टी भराव हाँ □ नहीं □

2.2.2 इस्पात धरन पर पत्थर के स्लैब हाँ □ नहीं □

2.2.3 जैक मेहराब का छत या फर्श हाँ □ नहीं □

2.2.4 आर.सी.सी./आर..बी. हाँ □ नहीं □

2.2.5 स्लैब की मोटाई _____

2.2.6 कोई अन्य (वर्णन करें) _____

2.3 ढालदार छत की आंतरिक संरचना

2.3.1 बांस की ट्रस/कड़ी/परलिन हाँ □ नहीं □

2.3.2 लकड़ी की ट्रस/कड़ी /परलिन हाँ □ नहीं □

2.3.3 इस्पात की ट्रस/परलिन हाँ □ नहीं □

2.3.4 कोई अन्य (वर्णन करें) _____

2.4 ढालदार छत का आच्छादन

2.4.1 स्लेट पत्थर

2.4.2 आग में पकाई मिट्टी की टाइल हाँ □ नहीं □

2.4.3 नालीदार जस्ती लोहे की शीट हाँ □ नहीं □

2.4.4 एसबेसटस सीमेंट की शीट हाँ □ नहीं □

2.4.5 रेशेदार शीट हाँ □ नहीं □

2.4.6 कोई अन्य (वर्णन करें) _____

2.5 दीवारों के प्रकार

2.5.1 मिट्टी गारे की दीवारें हाँ □ नहीं □

2.5.2 कच्ची ईंट की दीवारें हाँ □ नहीं □

2.5.3 बांस के चचरी की दीवारें हाँ □ नहीं □

2.5.4 लकड़ी की दीवारें हाँ □ नहीं □

2.5.5 अनगढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.6 गढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.7 पकी ईंटों की चिनाई हाँ □ नहीं □

2.5.8 सीमेंट कंक्रीट ब्लॉक की चिनाई हाँ □ नहीं □

2.5.9 दीवार की मोटाई _____

2.5.10 कोई अन्य (वर्णन करें) _____

2.6 दीवार में गारा / मसाला

2.6.1 मिट्टी का गारा हाँ □ नहीं □

2.6.2 चूने का मसाला हाँ □ नहीं □

2.6.3 सीमेंट का मसाला हाँ □ नहीं □

2.7 दीवारों का निर्माण *

2.7.1 दो आड़ी दीवारों के बीच, दीवार की लम्बाई, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.2 दीवारों में द्वार, दरवाजा एवं खिड़की के खुले भाग, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.3 दीवार की ऊँचाई और मोटाई का अनुपात, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.4 पत्थर की दीवारों की मोटाई में 'आर–पार पत्थर' तथा कोनों पर लंबे पत्थर दिए गए हैं? हाँ □ नहीं □

3.0 भूकम्प सुरक्षा प्रावधानों की जाँच *

3.1 अंदरूनी एवं बाहरी, सभी दीवारों में क्षैतिज भूकम्पीय पट्टी

3.1.1 कुर्सी स्तर पर हाँ □ नहीं □

3.1.2 खिड़की के निचले स्तर पर हाँ □ नहीं □

3.1.3 लिंटल (सरदल) स्तर पर हाँ □ नहीं □

3.1.4 सपाट फर्श/छत के निचले स्तर पर हाँ □ नहीं □

3.1.5 ढालवाँ छतों के ओलती स्तर पर हाँ □ नहीं □

3.1.6 तिकोने दीवार पर ढ़ालदार पट्टी हाँ □ नहीं □

3.1.7 रिज दीवार के उपर हाँ □ नहीं □

3.2 दीवारों में ऊर्ध्वाधर प्रबलन की छड़े

3.2.1 कमरों के कोनो पर हाँ □ नहीं □

3.2.2 दीवारो के T–जोड़ों पर हाँ □ नहीं □

3.2.3 दरवाजों और खिड़कियों के पाखों पर हाँ □ नहीं □

* इस हेतु भारतीय मानक IS:4326 एवं IS:13828 देखें।

4.0 विशेष जोखिम की जाँच

4.1 उच्च जलस्तर (भूतल से 3 मी. के अंदर) एवं बलुआही मिट्टी हो, तो, सम्भावित द्रवीकरण भूस्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.2 भवन में गंभीर ऊर्ध्वाधर अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.3 भवन में गंभीर प्लान अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 1 ग्रेड से, अधिकतम G4 तक बढ़ा दें)

4.4 भूस्खलन प्रवण स्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता ग्रेड G5 हो सकता है)

5.0 भवनों के गैर–संरचनात्मक अंग

गैर–संरचनात्मक अंग मौजूद हैं और भूकम्प के विरूद्ध स्थिर हैं ?

5.1 कमरे ईंट या लकड़ी की पतले दीवार से विभाजित हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.2 बाहरी सतह पर सजावटी facade का आच्छादन है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.3 फाल्स सिलिंग लगे है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.4 ईंटों की मुंड़ेर/प्लांटर्स बने हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.5 छतों पर चिमनियां दी गई हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.6 छत पर आर.सी.सी./चिनाई के पानीटैंक है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.7 संकेत/प्रदर्शन बोर्ड आदि लगे हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

6.0 कुछ या कई चिनाई भवनों में संभावित क्षतिग्रस्तता

चिनाई **भवनों के प्रकार** (तालिका 1 देखें)	**A**	**B**	**B+**	**C**	**C+**	**D**
भूकम्प जोन IV में **क्षतिग्रस्तता ग्रेड**, अधिक तीव्रता (तालिका–2 देखें)	**G5**	**G4**	**G3**	**G2**	**G2**	**G2**
नोट : + चिन्ह थोड़ा बढ़ा हुआ शक्ति यानी थोड़ा कम क्षतिग्रस्तता दर्शाता है। साथ ही, एक स्थल पर, एक ही प्रकार के भवनों के लिये, उपर दर्शाये गये सम्भावित क्षतिग्रस्तता को 1 ग्रेड से कम किया जा सकता है। सर्वेक्षक भवन के प्रकार का पहचान कर पेन से गोल बनाकर घेर देंगे और तदनुरूप क्षतिग्रस्तता ग्रेड को भी घेर देंगे।						

7.0 मूल्यांकन के दौरान की अनुशंसा

यदि क्षतिग्रस्तता ग्रेड है :

- G1/G2 : भवन को भूकम्पीय दृष्टि से सुरक्षित माना जा सकता है।
- G3 : भवन के ढ़हने की संभावना नहीं होगी, लेकिन यह मध्यम से भारी क्षति हो सकती है। ऐसे मामले में, भवन के रेट्रोफिटिंग (सुदृढ़ीकरण) की सलाह दी जा सकती है।
- G4/G5 : भवन असुरक्षित है, इसे पुनः मूल्यांकन और उसके बाद रेट्रोफिटिंग की आवश्यकता होगी।

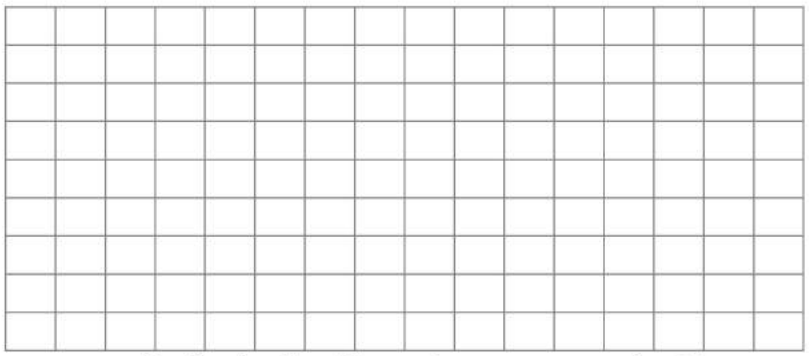
यदि कोई जोखिम हो :

- विशेष खतरा (कंडिका 4.0) पाये जाने पर उसे रोका या हटाया जाना चाहिए।
- यदि गैर–संरचनात्मक अस्थिर अंग (कंडिका 5.0) मौजूद हो तो इसे हटा देना चाहिए या स्थिर कर देना चाहिए।
- यदि दीवारों के निर्माण (कंडिका 2.7) कोड के अनुरूप नहीं हों, तो, गम्भीर क्षति होंगे अतएव, रेट्रोफिटिंग की आवश्यकता होगी।

नोटः

1) 5.0 का आकलन भवन के क्षतिग्रस्तता ग्रेड को प्रभावित नहीं करता, बल्कि अस्थिर गैर–संरचनात्मक अंग आवासियों को हानि पहुँचा सकता है।
2) संक्षिप्त रूपः RVS: Rapid Visual Screening, आर.सी.सी.: प्रबलित सिमेंट कंक्रीट, आर..बी.: प्रबलित ईंट

8.0 आरीकाट के साथ, निर्मित भवन का रेखाचित्र या आरेखन तथा भवन का फोटो संलग्न करें।



लम्बाई, चौड़ाई एवं आरीकाट के साथ भवन का रेखाचित्र

भवन का फोटो

सर्वेक्षक का हस्ताक्षरः _____

नामः _____

कार्यपालक अभियन्ता का हस्ताक्षरः _____

सर्वेक्षण की तिथिः _____

भूकम्प जोन III के सभी भवनों एवं जोन II के महत्वपूर्ण भवनों के लिए

पूर्वनिर्मित चिनाई वाले भवनों के भूकम्पीय जोखिम आकलन के लिए RVS form (पद्मश्री डा. ए. एस. आर्य द्वारा)

1.0 सामान्य जानकारी

1.1 भूकम्प जोन _____

1.2 भवन का नाम _____

1.3 उपयोग आवास □ कार्यालय □ स्कूल □ अस्पताल □ अन्य □

1.4 पता _____ _____ पिन_____

1.5 अन्य पहचान _____

1.6 तलों की संख्या_____

1.7 निर्माण वर्ष_____

1.8 पूर्ण आच्छादित क्षेत्रफल, सभी तलों का (वर्ग मी.)_____

1.9 भूतल पर कुर्सी क्षेत्रफल (वर्ग मी.)_____

1.10 नींव में मिट्टी का प्रकार_____

2.0 चिनाई भवनों के प्रकार

2.1 नींव के प्रकार

2.1.1 दीवार के नीचे. पट्टी आधार हाँ □ नहीं □

2.1.2 पृथक–पृथक् स्तंभ आधार हाँ □ नहीं □

2.1.3 अन्य कोई (वर्णन करें)_____

2.2 सपाट छत या फर्श

2.2.1 लकड़ी की कड़ियों पर मिट्टी भराव हाँ □ नहीं □

2.2.2 इस्पात धरन पर पत्थर के स्लैब हाँ □ नहीं □

2.2.3 जैक मेहराब का छत या फर्श हाँ □ नहीं □

2.2.4 आर.सी.सी./आर..बी. हाँ □ नहीं □

2.2.5 स्लैब की मोटाई _____

2.2.6 कोई अन्य (वर्णन करें)_____

2.3 ढालदार छत की आंतरिक संरचना

2.3.1 बांस की ट्रस/कड़ी/परलिन हाँ □ नहीं □

2.3.2 लकड़ी की ट्रस/कड़ी /परलिन हाँ □ नहीं □

2.3.3 इस्पात की ट्रस/परलिन हाँ □ नहीं □

2.3.4 कोई अन्य (वर्णन करें)_____

2.4 ढालदार छत का आच्छादन

2.4.1 स्लेट पत्थर

2.4.2 आग में पकाई मिट्टी की टाइल हाँ □ नहीं □

2.4.3 नालीदार जस्ती लोहे की शीट हाँ □ नहीं □

2.4.4 एसबेसटस सीमेंट की शीट हाँ □ नहीं □

2.4.5 रेशेदार शीट हाँ □ नहीं □

2.4.6 कोई अन्य (वर्णन करें)_____

2.5 दीवारों के प्रकार

2.5.1 मिट्टी गारे की दीवारें हाँ □ नहीं □

2.5.2 कच्ची ईंट की दीवारें हाँ □ नहीं □

2.5.3 बांस के चचरी की दीवारें हाँ □ नहीं □

2.5.4 लकड़ी की दीवारें हाँ □ नहीं □

2.5.5 अनगढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.6 गढ़े पत्थरों की चिनाई हाँ □ नहीं □

2.5.7 पकी ईंटों की चिनाई हाँ □ नहीं □

2.5.8 सीमेंट कंक्रीट ब्लॉक की चिनाई हाँ □ नहीं □

2.5.9 दीवार की मोटाई _____

2.5.10 कोई अन्य (वर्णन करें)_____

2.6 दीवार में गारा / मसाला

2.6.1 मिट्टी का गारा हाँ □ नहीं □

2.6.2 चूने का मसाला हाँ □ नहीं □

2.6.3 सीमेंट का मसाला हाँ □ नहीं □

2.7 दीवारों का निर्माण *

2.7.1 दो आड़ी दीवारों के बीच, दीवार की लम्बाई, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.2 दीवारों में द्वार, दरवाजा एवं खिड़की के खुले भाग, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.3 दीवार की ऊँचाई और मोटाई का अनुपात, मानक के अनुरूप है ? हाँ □ नहीं □

2.7.4 पत्थर की दीवारों की मोटाई में 'आर–पार पत्थर' तथा कोनों पर लंबे पत्थर दिए गए हैं? हाँ □ नहीं □

3.0 भूकम्प सुरक्षा प्रावधानों की जाँच *

3.1 अंदरूनी एवं बाहरी, सभी दीवारों में क्षैतिज भूकम्पीय पट्टी

3.1.1 कुर्सी स्तर पर हाँ □ नहीं □

3.1.2 खिड़की के निचले स्तर पर हाँ □ नहीं □

3.1.3 लिंटल (सरदल) स्तर पर हाँ □ नहीं □

3.1.4 सपाट फर्श/छत के निचले स्तर पर हाँ □ नहीं □

3.1.5 ढालवाँ छतों के ओलती स्तर पर हाँ □ नहीं □

3.1.6 तिकोने दीवार पर ढ़ालदार पट्टी हाँ □ नहीं □

3.1.7 रिज दीवार के उपर हाँ □ नहीं □

3.2 दीवारों में ऊर्ध्वाधर प्रबलन की छड़े

3.2.1 कमरों के कोनो पर हाँ □ नहीं □

3.2.2 दीवारो के T–जोड़ों पर हाँ □ नहीं □

3.2.3 दरवाजों और खिड़कियों के पाखों पर हाँ □ नहीं □

* इस हेतु भारतीय मानक IS:4326 एवं IS:13828 देखें।

4.0 विशेष जोखिम की जाँच

4.1 उच्च जलस्तर (भूतल से 3 मी. के अंदर) एवं बलुआही मिट्टी हो, तो, सम्भावित द्रवीकरण भूस्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.2 भवन में गंभीर ऊर्ध्वाधर अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 2 ग्रेड से, अधिकतम G5 तक बढ़ा दें)

4.3 भवन में गंभीर प्लान अनियमितता हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता 1 ग्रेड से, अधिकतम G4 तक बढ़ा दें)

4.4 भूस्खलन प्रवण स्थल हाँ □ नहीं □
(अगर हाँ तो क्षतिग्रस्तता ग्रेड G5 हो सकता है)

5.0 भवनों के गैर–संरचनात्मक अंग

गैर–संरचनात्मक अंग मौजूद हैं और भूकम्प के विरूद्ध स्थिर हैं ?

5.1 कमरे ईंट या लकड़ी की पतले दीवार से विभाजित हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.2 बाहरी सतह पर सजावटी facade का आच्छादन है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.3 फाल्स सिलिंग लगे है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.4 ईंटों की मुंड़ेर/प्लांटर्स बने हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.5 छतों पर चिमनियां दी गई हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.6 छत पर आर.सी.सी./चिनाई के पानीटैंक है ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

5.7 संकेत/प्रदर्शन बोर्ड आदि लगे हैं ? हाँ □ नहीं □
भूकम्प के विरूद्ध स्थिरता है ? हाँ □ नहीं □

6.0 कुछ या कई चिनाई भवनों में संभावित क्षतिग्रस्तता

चिनाई **भवनों के प्रकार** (तालिका 1 देखें)	**A**	**B**	**B+**	**C**	**C+**	**D**
भूकम्प जोन III में **क्षतिग्रस्तता ग्रेड**, मध्यम तीव्रता (तालिका–2 देखें)	**G4**	**G3**	**G2**	**G2**	**G1**	**G1**
नोट : + चिन्ह थोड़ा बढ़ा हुआ शक्ति यानी थोड़ा कम क्षतिग्रस्तता दर्शाता है। साथ ही, एक स्थल पर, एक ही प्रकार के भवनों के लिये, उपर दर्शाये गये सम्भावित क्षतिग्रस्तता को 1 ग्रेड से कम किया जा सकता है। सर्वेक्षक भवन के प्रकार का पहचान कर पेन से गोल बनाकर घेर देंगे और तदनुरूप क्षतिग्रस्तता ग्रेड को भी घेर देंगे।						

7.0 मूल्यांकन के दौरान की अनुशंसा

यदि क्षतिग्रस्तता ग्रेड है :

- G1/G2 : भवन को भूकम्पीय दृष्टि से सुरक्षित माना जा सकता है।
- G3 : भवन के ढ़हने की संभावना नहीं होगी, लेकिन यह मध्यम से भारी क्षति हो सकती है। ऐसे मामले में, भवन के रेट्रोफिटिंग (सुदृढ़ीकरण) की सलाह दी जा सकती है।
- G4 : भवन असुरक्षित है, इसे पुनः मूल्यांकन और उसके बाद रेट्रोफिटिंग की आवश्यकता होगी।

यदि कोई जोखिम हो :

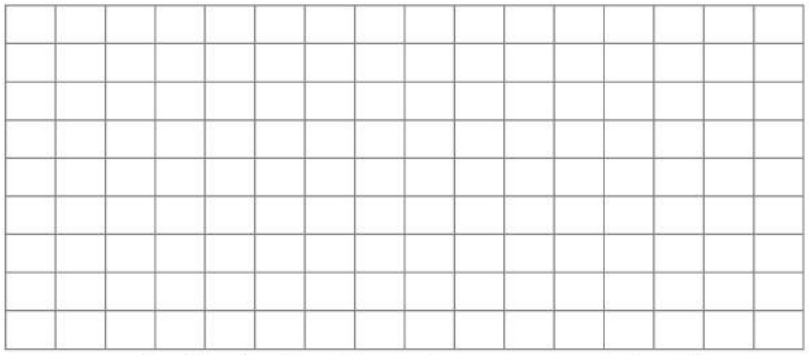
- विशेष खतरा (कंडिका 4.0) पाये जाने पर उसे रोका या हटाया जाना चाहिए।
- यदि गैर–संरचनात्मक अस्थिर अंग (कंडिका 5.0) मौजूद हो तो इसे हटा देना चाहिए या स्थिर कर देना चाहिए।
- यदि दीवारों के निर्माण (कंडिका 2.7) कोड के अनुरूप नहीं हों, तो, गम्भीर क्षति होंगे अतएव, रेट्रोफिटिंग की आवश्यकता होगी।

नोटः

1) 5.0 का आकलन भवन के क्षतिग्रस्तता ग्रेड को प्रभावित नहीं करता, बल्कि अस्थिर गैर–संरचनात्मक अंग आवासियों को हानि पहुँचा सकता है।

2) संक्षिप्त रूपः RVS: Rapid Visual Screening, आर.सी.सी.ः प्रबलित सिमेंट कंक्रीट, आर..बी.ः प्रबलित ईंट

8.0 आरीकाट के साथ, निर्मित भवन का रेखाचित्र या आरेखन तथा भवन का फोटो संलग्न करें।



लम्बाई, चौड़ाई एवं आरीकाट के साथ भवन का रेखाचित्र

भवन का फोटो

सर्वेक्षक का हस्ताक्षरः _____

नामः _____

कार्यपालक अभियन्ता का हस्ताक्षरः _____

सर्वेक्षण की तिथिः _____

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(10)
Masonry Buildings: Seismic Retrofitting

90 min

EXISTING MASONRY BUILDINGS

- Masonry buildings are common type of construction used for housing
- Low seismic resistance has resulted in extensive damage during earthquakes
- Recommended seismic resistant measures may save life and property.

- **Non Engineered Buildings**
  Traditional buildings with locally available material : Buildings in field stone, fired brick, concrete blocks, adobe or rammed earth, wooden, or a combination of these
- **Engineered Buildings**
  normally designed by Architects and Engineers working together or Civil Engineers: Reinforced Masonry Buildings, Reinforced concrete and steel buildings

ASSESSMENT OF BUILDING

- Rapid Visual Screening Study of Drawings, Simple calculation
- Detailed Analysis as per Current Seismic Codes Testing (NDT- hammer test, Ultrasonic Pulse Velocity test & Core Cutting)

RETROFITTING

- Buildings condition
  - Seismically deficient
  - Earthquake damaged
- Techniques
  - Conventional
  - Non-conventional

RETROFITTING *vs* RECONSTRUCTION

- Cost of reconstruction vs cost of retrofitting: Retrofitting is adopted, if the cost of repair & retrofitting < 30 % of reconstruction,.
- Preservation of historical architecture, and
- Maintaining functional, social, and cultural environment

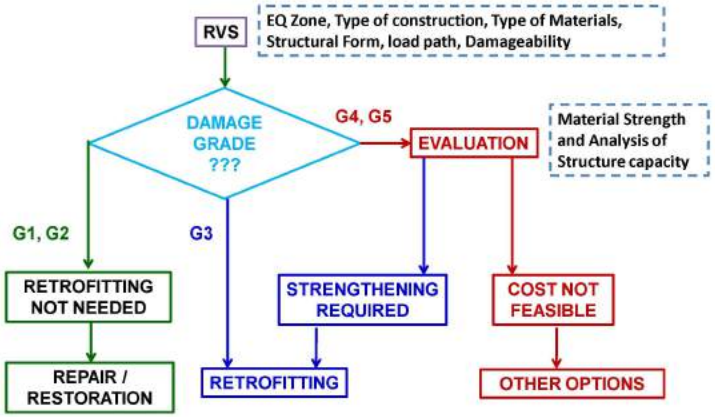
516

Repair (मरम्मति)
is done to resume the functions quickly
- Repair of non-structural members
- Patching up minor cracks & plaster
- Repairing doors, floors, plumbing

Restoration / Structural Repairs (जीर्णोद्धार/पुनरूद्धार)
to restore original shape and strength
- Repair cracks / voids in RCC members
- Strengthening a portion of wall
- To strengthen damaged beam/column

Seismic Retrofitting (भूकम्प के दृष्टिकोण से सुदृढ़ीकरण)
to make buildings stronger than before, Efficiency up to level of recent code
- Correction of structural form
- To unify the components of building
- To increase lateral strength
- Provisions to avoid brittle failure
- To reduce weight of storey

DAMAGE / DAMAGEABILITY ASESSMENT & SUGGESTIONS



Basic Data for Retrofitting of Masonry Buildings

- Existing structural scheme
- Understanding structural behavior
- Building material used
- Strength of wall
- Integrity of members

By Retrofitting Improve

- strength of existing masonry
- in-plane strength of the wall
- out-of-plane strength of wall
- structural integrity of structure

Strengthening / Retrofitting Details (IS: 13935 – 1993), Revised 2009

520

RETROFITTING MATERIALS

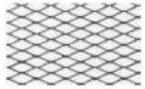
Cement mortar

Cement Concrete

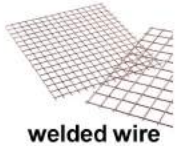
Admixture for Non-shrink-age / Bond

rods, angles, beams, channels

bolts



expanded metal



welded wire fabric

Chicken Mesh

Various forms of Steel

RETROFITTING MATERIALS …contd

- Cement Grout :
  - water, cement and optional materials like sand, water reducing admixtures, expansion agent and pozzolana, Fine sand is used to avoid segregation
  - water to cement ratio is around 0.5
- Polymer grout and Epoxy grout
- The desirable properties of grout :
  - Fluidity
  - Minimum segregation
  - Low shrinkage
  - Adequate strength after
  - Good bond with the subs
  - No detrimental compoun
  - Durable

Non-shrink Grouts: Repair small / medium cracks

RETROFITTING MATERIALS …contd

Quick-setting cement mortar

Non-hydrous magnesium phosphate cement with a liquid and a dry powder components, mixed in a manner similar to cement concrete.

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

Polymer concrete
Polymer binder + Aggregates (silica, q uartz, granite, limesto ne)

Shotcrete: Repair concrete surfaces

RETROFITTING MATERIALS …contd

EPOXY RESINS

- Excellent binding agents with high tensile strength
- Epoxy components are mixed just prior to application
- Compositions of can be changed as per requirements
- Low viscosity can be injected in fine cracks
- For gluing steel plates to the distressed members.
- Higher viscosity epoxy resin can be used for surface coating or filling larger cracks or holes

Epoxy Resins

Epoxy Glue Gun Dispenser

Gluing steel plates to RCC

RETROFITTING MATERIALS …contd

EPOXY MORTAR

- epoxy mortar = epoxy resins + sand
- for larger void spaces in RCC
- mortar is forced up to the end of the crack
- Higher compressive and tensile strength

Fine crack

Large cracks

medium cracks

Repairs by epoxy mortar

RETROFITTING MATERIALS ...contd

Anchors provide both shear and tension resistance

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

Mechanical Anchors: To Add / Connect new members

RETROFITTING MATERIALS ...contd

STRUCTURAL OVERLAY / ADHERED FABRIC

- Fiber Reinforced Plastic (FRP)
  - High strength to weight ratio
  - High stiffness to weight ratio
  - High corrosion and fatigue resistance
- fabric sheet materials
  - Carbon Fiber Reinforced Plastic (CFRP)
  - Glass Fiber Reinforced Polymer (GFRP)

FRP: Strengthening Beam and Columns

FRP bars being used in a bridge deck

RESTORATION OF MASONRY BUILDINGS

Cracks in masonry load bearing members reduce their resistance. All cracks must be located and repaired by one of the following technique:

- Pressure injection into medium cracks
- Filling concrete into wide cracks
- Repairing wide cracks by grouting and steel mesh

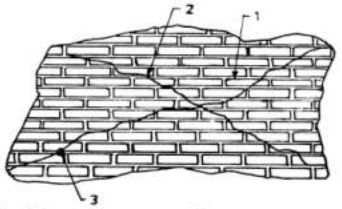
RESTORATION OF MASONRY WALLS

Repair of Minor and Medium Cracks (0.50-5 mm)

Pressure injection of non-shrink grout

EPOXY GROUT

- Applicable to : beams, columns, walls and RCC floor units
- prior to injection of epoxy, proper cleaning of steel bar and is necessary



1 Plaster removed
2 Cracks sealed after cleaning
3 Grout points

cement polymer grout for brick walls

Pressure injection for cracks (0.50 - 5 mm)

continued ....

- Plastic / Aluminium Grout ports placed on both sides of cracks and secured in place with 1:3 cement mortar
- C/C of ports = thickness of the element to be repaired
- Low viscosity grout injected into one port at a time
- Smaller the crack higher is the pressure or the ports more closely spaced
- Injection begins at the lowest part of vertical crack, or at one end of horizontal crack.
- The resin is injected till it flows from the opposite sides or from the next higher port.
- Port is closed and equipment moved to the next port.

Pressure injection for cracks (0.50 - 5 mm)

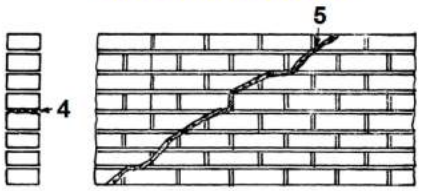
continued ....

Grout Ports

Grouting Machine

RESTORATION OF MASONRY WALLS

Repair of cracks wider than 5 mm and Crushed Concrete

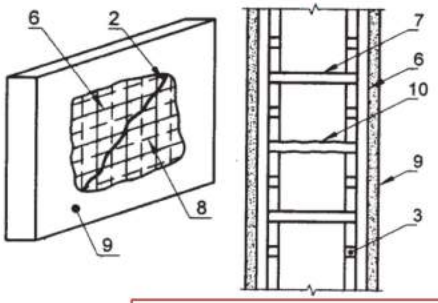


4 V groove joints
5 Cement mortar & flat stone chips

- Remove loose material & fill quick setting expansive cement mortar & flat stone chips
- Add shear / flexural bars if necessary & covered by mortar
- Replace the member or portion of member, if very severe damage

REPAIRING WIDE CRACKS (> 5mm) BY GROUTING AND STEEL MESH

Repairing walls and floors



2 Cracks sealed after cleaning
3 Grout ports
6 Wire mesh on both surface
7 Clamps
8 Wire mesh on back face
9 Cement plaster
10 Crack in wall

- Provide steel mesh on the outside surface and nail to the wall / roof slab
- Cover with plaster or micro-concrete

REPAIRING WIDE CRACKS BY GROUTING AND STEEL MESH

Repairing walls and floors

- Replace the old portion of steel with new steel using butt welding or lap welding.
- Add stirrup ties in the damaged portion
- If additional steel needs anchoring into existing concrete:-
  - A hole larger than the bar is drilled.
  - The hole is filled with epoxy, expanding cement or other high strength grouting material.
  - The bar is pushed into place and held there until the grout has set.

DAMAGEABILITY GRADES AND RETROFITTING ACTIONS	
Damage Grade	suggested actions regarding retrofitting
G1	Retrofitting not needed
G2	Retrofitting not needed, Perform restoration. Stabilize unstable non-structural elements
G3 or G4	a) Restore & Retrofit Structural and non-structural elements b) Evaluate global and local element deficiencies. Design the retrofitting suitably
G5	Actions similar to G4 OR, Replace the existing damaged building with a new earthquake resistant building

BUILDING CATEGORIES

Building Use	Building Category in Seismic Zone			
	II	III	IV	V
Ordinary (I = 1.0)	B	C	D	E
Important (I = 1.5)	C	D	E	E

Provision in IS 4326 & Actions for Retrofitting of walls

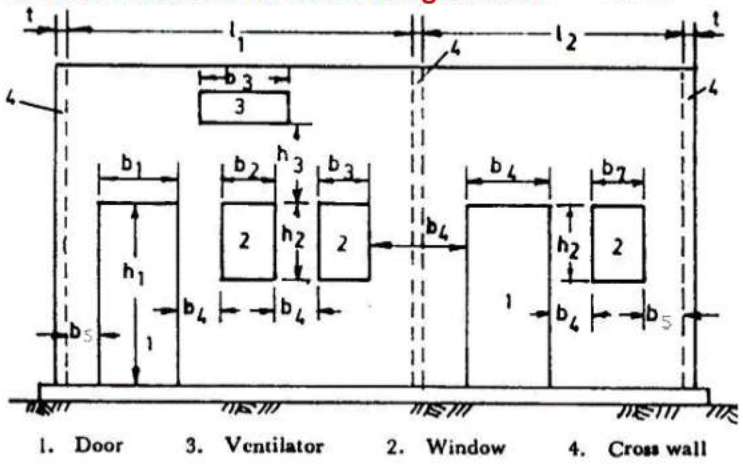
(IS 13935 Clause 8.1)

sl	Item of Masonry	Requirement as per IS 4326 for Building category				Action for Retrofitting, if Code Requirement not Found Satisfied
		B	C	D	E	
i)	Mortar	CLS 1 : 2 : 9 or CS 1 :6		CLS 1 : 1 : 6 or CS 1 : 4		Change of mortar not feasible. Hollowness to be filled by grouting; Walls strengthened by ferro-cement plating / fibre-wrapping

IS 4326 & Actions for Retrofitting of walls cont...

sl	Item of Masonry	Requirement as per IS 4326 for Building category				Action for Retrofitting, if Code is not Satisfied
		B	C	D	E	
ii)	Door, Window opeinings:					Increase piers by build-up or reinforce with belt
	1) b_5 minimum	0.0	230 mm	450 mm	450 mm	
	$(b_1+b_2+.b3)/l1$, Max:					Attain the limit by closing / narrowing an opening or reinforce the opening by seismic belting
	a) one storey	0.6	0.55	0.5	0.5	
	b) two storey	0.50	0.46	0.42	0.42	
	c) three storey	0.42	0.37	0.33	0.33	
	d) four storey	0.42	0.37	0.33	4 storey not allowed in Zone V	

IS 4326 & Actions for Retrofitting of walls cont...



1. Door 3. Ventilator 2. Window 4. Cross wall

IS 4326 & Actions for Retrofitting of walls cont...

sl.	Item of Masonry	B	C	D	E	Action for Retrofitting, if Code is not Satisfied
	2) b4 minimum	340 mm	450 mm	560 mm	560 mm	*Increase by build-up or reinforce with belt*
iii)	Length of wall between cross walls	-	Maximum length = 35 times thickness or 8 m whichever less			If length more, provide pilaster or buttress
iv)	Height of wall from floor to ceiling	-	Maximum = 15 times thickness or 4 m whichever less			If height more, add pilaster to increase effective thickness
v)	Random – Rubble walls	'Through' or Header stones, 1 each in 0.72 m^2 surface area of wall Long stones at corners of walls, in every alternate course				Install RC Headers in holes made by removing stone

IS 4326 & Actions for Retrofitting of walls cont...

sl.	Item of Masonry	B	C	D	E	Action for Retrofitting, if Code is not Satisfied
vi)	Horizontal seismic Bands: a) Plinth level	Needed if soft (Type III) soil at base				Provide seismic belt, if plinth height > 90cm
	b) Door window lintel level	Needed in all cases with varying reinforcement & thickness specified in each case				Provide seismic belt of equivalent strength on both sides of walls
	c) Ceiling or eave level	Needed in sloping roofs or floors or roofs of prefab, materials				-do-
	d) Gable or ridge wall	Needed in case of pitched roofs				-do-
	e) Window sill level or dowels	Not required	Not required	Required in 3 & 4 storeyed buildings	Required in all buildings	-do-

IS 4326 & Actions for Retrofitting of walls cont...

sl.	Item of Masonry	B	C	D	E	Action for Retrofitting, if Code is not Satisfied
vii)	Vertical bar at each corner and T-junction of wal	Needed in only 4 storey building	Needed in 3 & 4 storey buildings	Needed in all buildings	Needed in all buildings, (4 storeys not permitted)	Install equivalent bars or vertical belts at corners and T-junctions
Viii)	Vertical bar at jambs of windows and doors	Not needed	-do-	-do-	-do-	Install equivalent seismic belts around the opening

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IS 4326 & Actions for Retrofitting of roofs and floors

sl	Item of Roof/Floor	B	C	D	E	Action for Retrofitting, if Code Requirement not Found Satisfied
i)	Roof/floor with prefabricated/pre-cast elements	Tie beam all round		All round tie beam and RC screed		Provide RC screed[1)] and seismic belt or band around
ii)	Roof/floor with wooden joists, various covering elements (brick, reeds, etc.) and earth fill	-	All round seismic band and integration of units as a rigid horizontal diaphragm			Provide seismic belt around, interconnect beam ends through blocking

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Actions for Retrofitting of roofs and floors cont...

sl	Item of Roof/Floor	B	C	D	E	Action for Retrofitting, if Code Requirement not Found Satisfied
iii)	Sloping roofs with sheet or tile	-	i) Horizontal x-bracing at level of ties of the trusses ii) X-bracing in the planes of the rafters and purlins			Install the x-bracings, anchor trusses into walls and rafters into seismic belt Eave.
iv)	Jack arch roof/floor	-	Connect the steel joist by horizontal ties at intervals to prevent spreading and cracking of the arches. Provide seismic band all around.			Install steel flats as ties by welding them to the steel joists and provide seismic belt
	[1)]RC screed – RC screed consists of minimum 40 mm concrete reinforce with 6 mm dia bars @ 150 mm c/c both ways (single layer), covering the whole roof/floor.					

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Improvements Against Global Deficiencies

(Clause 8.1)

sl	Item	B	C	D	E	Retrofitting Action if Code Provision not Satisfied
i)	Sloping raftered roofs		Preferably, use full trusses			Covert rafters into A-frames or full trusses to reduce thrust on walls
ii)	Unsymmetrical plans		Symmetrical plans are suggested			Inserting new walls to reduce dissymmetry
iii)	Perpendicular walls not connected at corners and T-junctions		Perpendicular walls should be integrally constructed			Stitch the perpendicular walls using tie rods in drilled holes and grouted, or, with seismic belts

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STRENGTHENING OF EXISTING WALLS

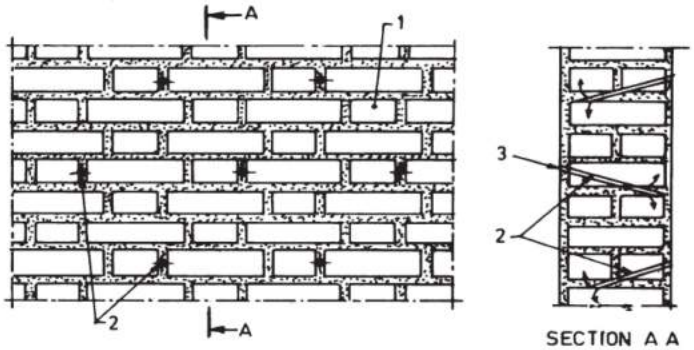
- Walls of masonry buildings are most vulnerable during earthquake. Failure of walls are the main reason for collapse of masonry buildings.
- To improve lateral strength of buildings, increase the strength and stiffness of individual cracked or un-cracked walls.
- Methods are :
  - Grouting,
  - Adding wire mesh and mortar
  - CFRP sheet overlays
  - Confining with RC / steel elements
  - Add bars into walls by center core method
  - Shotcrete

STRENGTHENING OF EXISTING WALLS
By GROUTING

- Holes @ 2-4 per sqm are drilled in the wall.
- Water is injected in order to wash the hole and to improve the cohesion between the grouting mixture and the wall.
- Cement water mixture (1 : 1) is grouted at low pressure (0.1 to 0.25 MPa) in the holes starting from the lower holes and going up.
- Polymeric mortars may be used in stead of cement water mixture for grouting.
- Pressure need for grouting can be obtained by gravity flow from super-elevated containers.

Grouting can not be relied to improve connection between orthogonal walls.

GROUTING THE EXISTING WALLS continued



1 Brick or Brick wall, 2 Injection Hole 3 Grout Mixture

STRENGTHENING OF EXISTING WALLS
with WIRE MESH and MORTAR

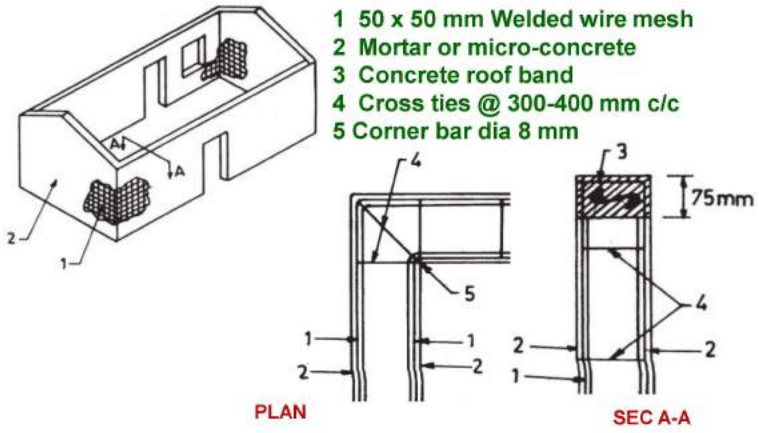
Multiple cracks appearing on both sides on the wall or weak wall regions

- Provide 50 mm × 50 mm galvanized steel wire fabric on both sides of wall.
- Cover the fabric with 20 - 40 mm thick layer of cement mortar or micro concrete
- Connect the both fabric on either side of the wall by galvanized steel rods at 300 to 400 mm c/c

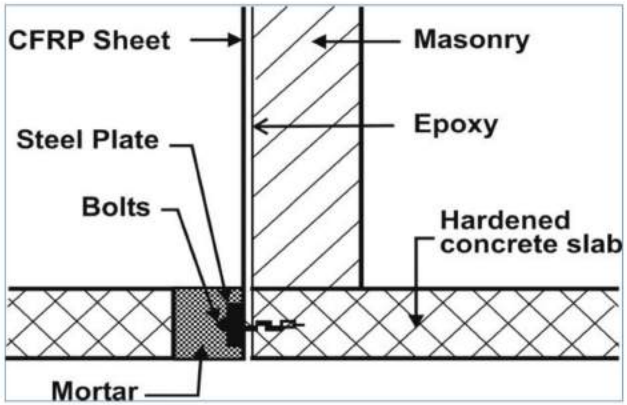
STRENGTHENING with WIRE MESH and MORTAR

continued ...

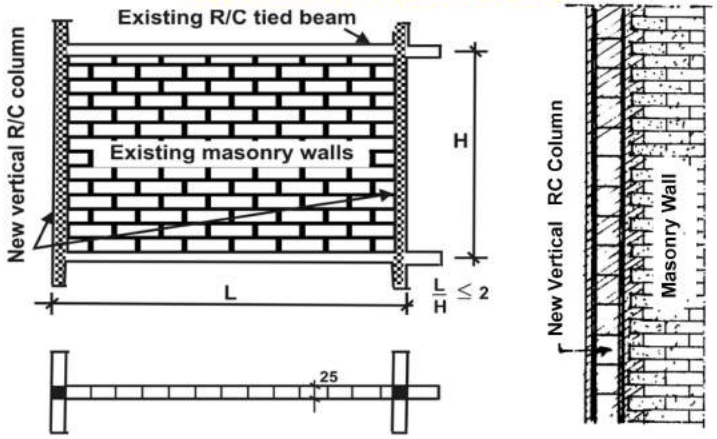
1 50 x 50 mm Welded wire mesh
2 Mortar or micro-concrete
3 Concrete roof band
4 Cross ties @ 300-400 mm c/c
5 Corner bar dia 8 mm



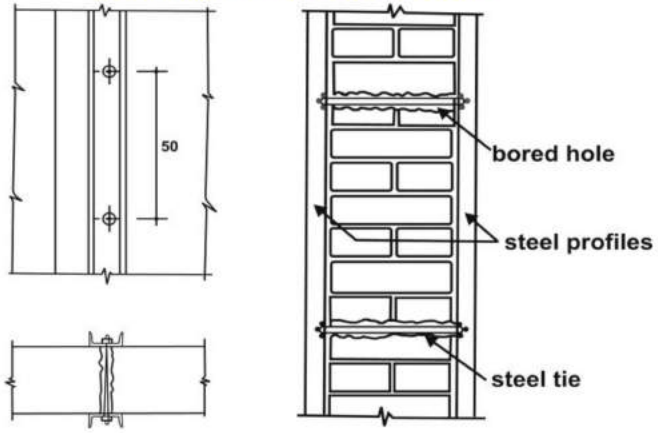
STRENGTHENING WALLS BY CFRP SHEET OVERLAYS

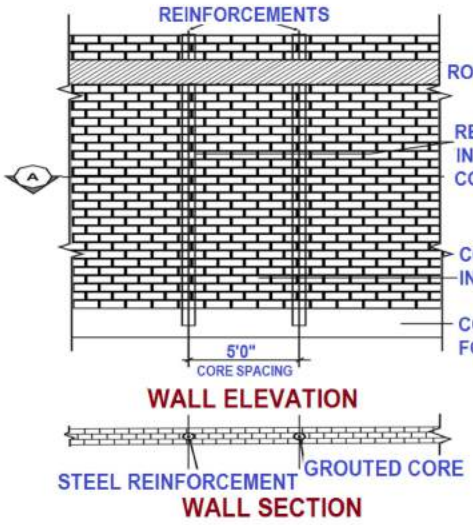


STRENGTHENING WALLS BY CONFINING WITH RC ELEMENTS



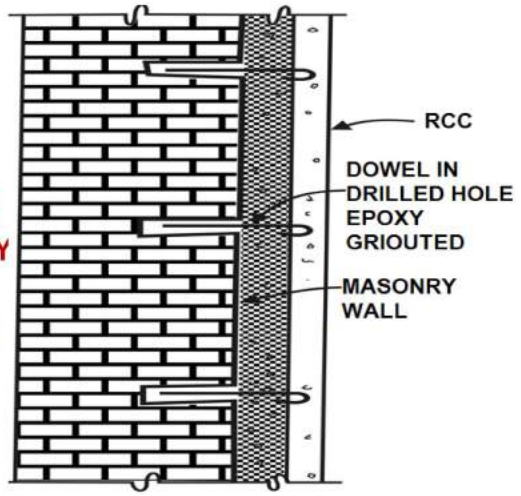
STRENGTHENING WALLS BY CONFINING WITH STEEL SECTION





ADD BARS INTO WALLS BY CENTER CORE

RCC OVERLAYS TO MASONRY WALLS (shotcrete)



STRENGTHENING OF EXISTING STONE WALLS

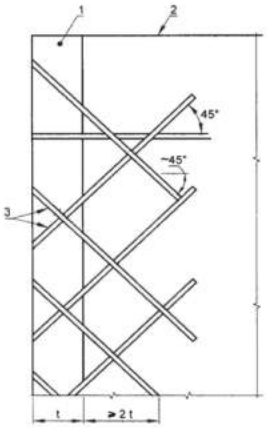
Connection between existing thick walls

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

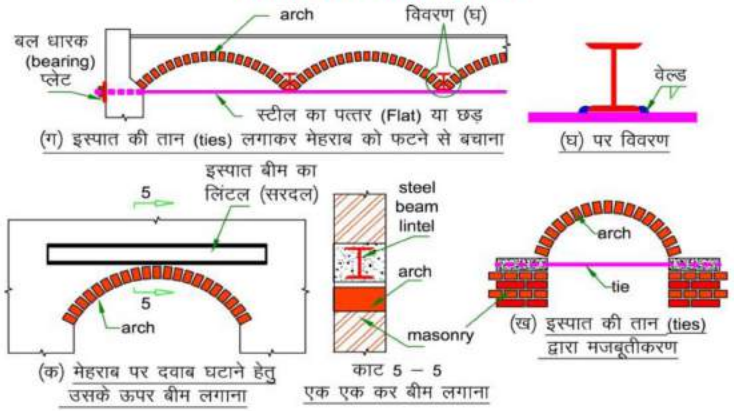
Sewing Transverse Walls with Inclined Bars

- 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



MASONRY ARCHES

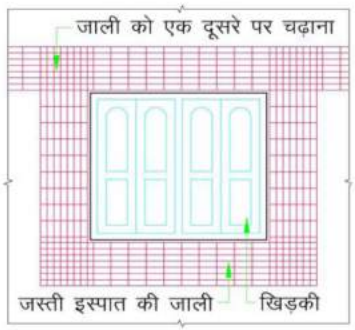


चिनाई मेहराब (Masonry Arches) का मजबूतीकरण

REINFORCING AROUND OPENING

Restoring strength of wall piers in masonry building

- In category D and E buildings, Use
  - Mesh of gauge 10 with 8 wires @ 25 mm c/c in longitudinal direction, and
  - belt width 200 mm
- In category C buildings, Use
  - Mesh of gauge 13 with 10 wires @ 25 mm c/c in longitudinal direction, and
  - belt width 250 mm



ACHIEVING INTEGRAL BOX ACTION

ACHIEVING INTEGRAL BOX ACTION

The overall lateral strength and stability of load bearing wall buildings is improved, if the integral box like action of room enclosures is ensured.

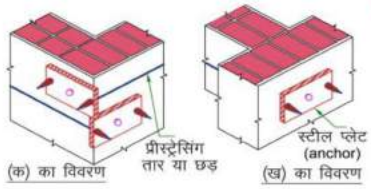
This can be achieved by

(a) Use of pre-stressing
(b) Providing horizontal belts.

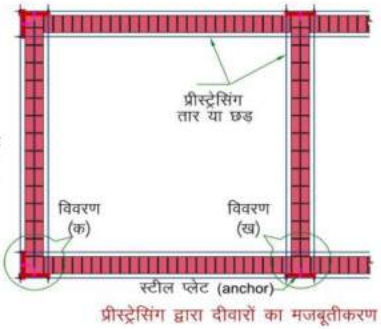
Bending Strength of shear walls is achieved by providing vertical steel at T and L junction of walls.

ACHIEVING INTEGRAL BOX ACTION

USE OF PRE-STRESSING




Turnbuckles के सहारे तान (Tension)



प्रीस्ट्रेसिंग द्वारा दीवारों का मजबूतीकरण

ACHIEVING INTEGRAL BOX ACTION
EXTERNAL BINDING

Splint and Bandage Strengthening Technique

Provide steel mesh and mortar / micro-concrete on

- Outside surface of external walls
- Vertical splints located between the openings
- Horizontal 'bandages' formed over spandrel walls
- Splints / Bandages made maintaining continuous steel at the corners
- WIRE MESH WITH WIDTH > 400 MM

ACHIEVING INTEGRAL BOX ACTION
USE OF SEISMIC BELTS

यह विधि उन घरों के लिये है

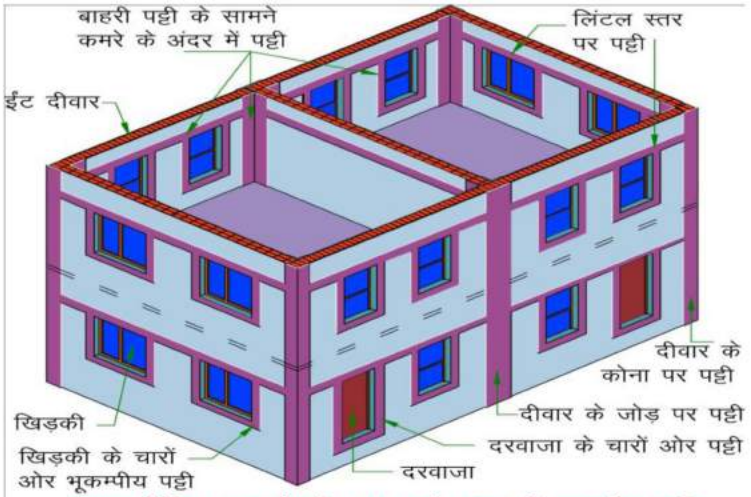
- मकान आयताकार है।
- ईंट जोड़ाई भारवाहक दीवार पर के ऊपर सपाट या ढलान छत रखकर घर बना है।
- कमरों की लम्बाई एवं चौड़ाई तथा दीवार की उँचाई एवं मोटाई और ईंट एवं मसाला की शक्ति IS 4326 के प्रावधानों के अनुसार पर्याप्त हैं।
- IS 4326 के प्रावधानों के अनुसार क्षैतिज भूकम्परोधी बैंड नहीं बना हो तथा दीवार में स्टील के छड़ खड़े नहीं किये गये हों।

भूकम्पीय पट्टी कहाँ लगाना है?

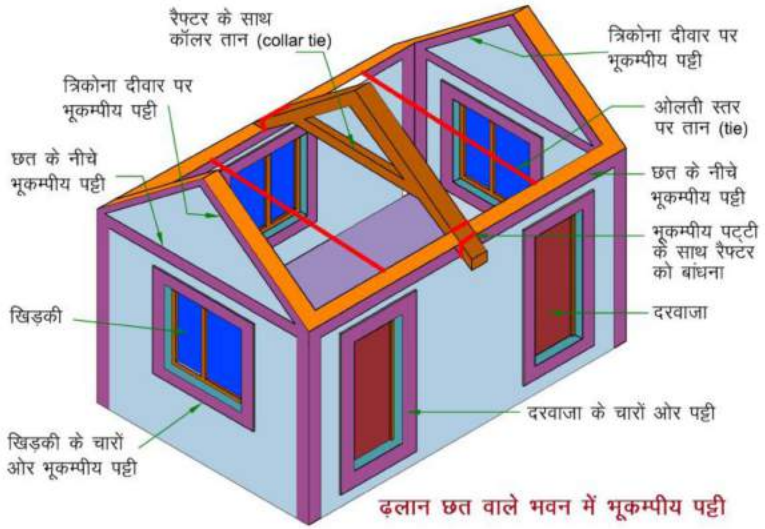
सभी दीवारों पर, सामने–सामने दोनों सतहों पर

- क्षैतिज भूकम्पीय पट्टी
  - ✓कुरसी स्तर पर
  - ✓लिंटल के उपर
- ऊर्ध्वाधर (खड़ा) भूकम्पीय पट्टी
  - ✓दीवारों के सभी बाहरी जोड़ों पर
- ढ़लान छत वाले भवनों में अतिरिक्त पट्टी
  - ✓ओलती स्तर पर
  - ✓त्रिभुजाकार गेबल पर

कमरों में, दीवार सभी कोनों पर छड़ खड़ा करना है।



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



ढ़लान छत वाले भवन में भूकम्पीय पट्टी

MESH REINFORCEMENT IN HORIZONTAL SEISMIC BELTS

Length of Wall	Category B			Category C			Category D			Category E		
M	Gauge	N	H	Gauge	N	H	Gauge	N	H	Gauge	N	H
<5.0	G 14	9	250	G 13	9	250	G 12	9	250	G 10	10	280
6.0	H 13	9	250	G 12	9	250	G 10	10	280	G 10	14	380
7.0	G 12	9	250	G 10	10	280	G 10	14	380	G 10	18	460
8.0	G 10	9	250	G 10	14	380	G 10	18	460	G 10	23	580

NOTES:

1. Guages : g 10 = 3.25 mm, g 11 = 2.95 mm, g 12 = 2.64 mm, g 13 = 2.34 m, g 14 = 2.03 mm.
2. N = Number of longitudinal wires in the belt at spacing of 25 mm.
3. H = Height of belt on wall in micro-concrete, in mm.
4. The transverse wires in the mesh could be spaced upto 150 mm.
5. The mesh should be galvanized to save from corrosion.

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भूकम्पीय पट्टी बनाऐंगे कैसे ?

भूकम्पीय पट्टियों में,

स्टील तार के जाली डालतें हैं।

तार की जाली डालने से पहले की तैयारी करें

- ✓ प्लास्टर हटाऐं
- ✓ टाई छड़ डालें
- ✓ पतला प्लास्टर करें

स्टील तार की जाली लटकाऐं

अंत में प्लास्टर करके, भूकम्पीय पट्टी बनाऐं

तार की जाली डालने से पहले की तैयारी करें

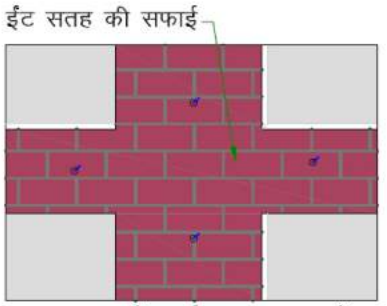
प्लास्टर हटाऐं

✓ दीवार की दोनों सतहों पर, दीवार के उपर पट्टी का निशान बना लें।

✓ पट्टी की चौड़ाई, जाली की चौड़ाई से 25 मि.मी.ज्यादा रहनी चाहिए।

✓ निशान बनाये गये अंश से, प्लास्टर हटा लें।

✓ ईंट के जोड़ों के बीच, 20 मिलीमीटर की गहराई तक मसाला हटाकर, खाँच बनाऐं।



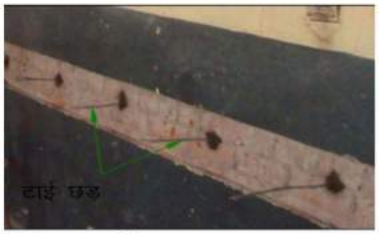
प्लास्टर हटाऐं, टाई छड़ ग्राउट करें

तार की जाली डालने से पहले की तैयारी करें

टाई छड़ डालें

- ✓ 16 मिलीमीटर व्यास के ड्रिल बिट वाले मशीन द्वारा, 450 मिमी. की दूरी पर, दीवार में छेद करे।
- ✓ छेद के गर्द को ब्लोअर से उड़ाकर साफ कर लें।
- ✓ छेद में, 8 मि.मी. व्यास के टाई छड़ डालकर, सिमेंट–पोलीमर मसाला से ग्राउट करें।

छेद करने के लिये,
ड्रिल मशीन का उपयोग

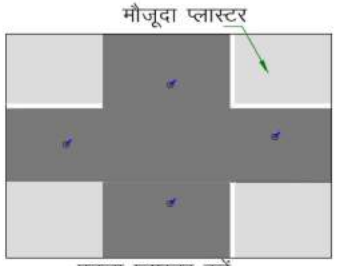


टाई छड़ ग्राउट करना

तार की जाली डालने से पहले की तैयारी करें

पतला प्लास्टर करें

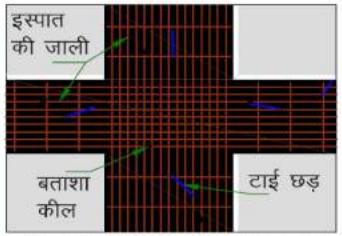
- ✓ सादा सिमेंट या सिमेंट–पोलीमर का घोल से बांड कोट करें।
- ✓ ईंट के खाँच को भरते हुए, सिमेंट:बालू के 1:3 के अनुपात में, पतला (10–15 मिलीमीटर) खुरदुरा प्लास्टर करें।



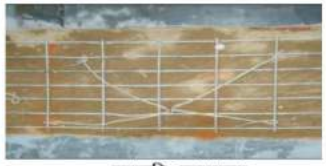
पतला प्लास्टर करें

स्टील तार की जाली लटकाऐं

- ✓ सही साइज की जाली काटकर, 15 मि.मी. कील के सहारे लटकाऐं।
- ✓ दीवार के कोनों पर, आरी दीवार के उपर, जाली को 300 मिलीमीटर तक चढ़ा दें।
- ✓ जाली को जोड़ना पड़े, तो, एक दूसरे पर 300 मिलीमीटर तक चढ़ा कर रखें।
- ✓ दोनों सतहों पर स्थित जाली को टाई छड़ से बाँध दें।



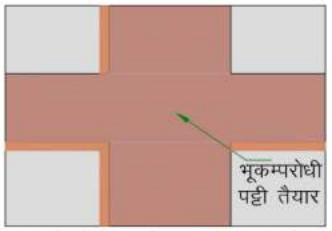
कील के सहारे इस्पात जाली लगाऐं



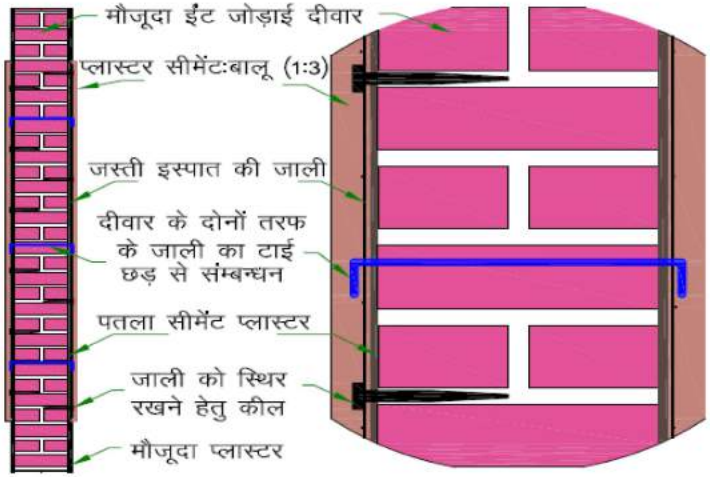
जाली लगाना

अंत में भूकम्पीय पट्टी बनाते हैं

- ✓ पट्टी में, सिमेंट–बालू 1:3, 20 मिलीमीटर मोटा प्लास्टर करें।
- ✓ सिमेंट मसाला के बदले सूक्ष्म कंक्रीट (micro concrete) का उपयोग कर सकते हैं।
- ✓ प्लास्टर को अगले 10 दिनो तक स्वच्छ जल से भिंगोकर रखें।
- ✓ दीवार की सफाई कर, पेंट कर लें।

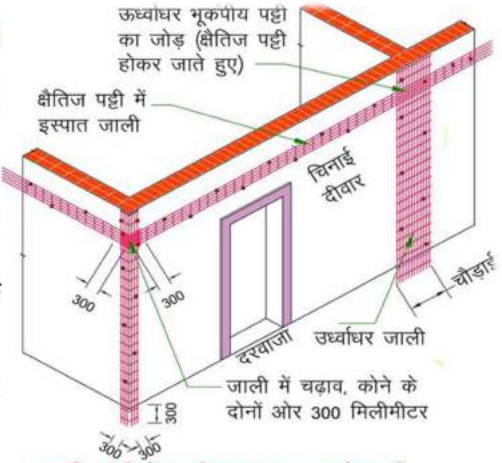


25 मिलीमीटर मोटा प्लास्टर चढ़ाऐं



VERTICAL SEISMIC BELTS AT CORNER & JUNCTIONS

जमीन में 300 मि.मी. गड्ढा खोदकर, खड़ा जाली को गड्ढा में ले जाकर मोडें, गड्ढे को कंक्रीट से भरें। उपरी मंजिल के स्लैब में छेद करके खड़ा जाली को उस छेद से पार कराऐं।



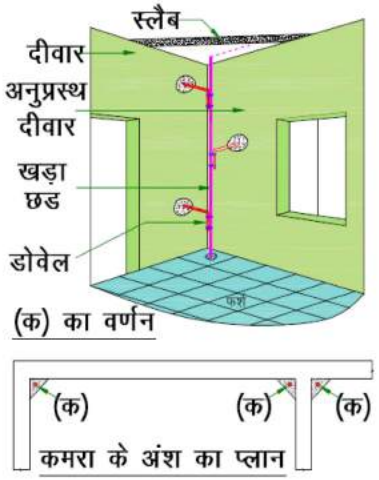
भकम्पीय पट्टी में जस्तीकत स्पात तार की जाली

VERTICAL BAR OR MESH REINFORCEMENT IN VERTICAL BELT AT CORNERS OF ROOMS

No. of Storeys	Storeys	Category C			Category D			Category E		
		Single Bar	Mesh (g 10)		Single Bar	Mesh (g 10)		Single Bar	Mesh (g 10)	
		Mm	N	B	mm	N	B	mm	N	B
One	One	-	-	-	10	10	300	12	14	400
Two	Top	-	-	-	10	10	300	12	14	400
	Bottom	-	-	-	12	14	400	16	-	-
Three	Top	10	10	300	10	10	300	12	14	400
	Middle	10	10	300	12	14	400	16	25	650
	Bottom	12	14	400	12	14	400	16	25	650

NOTES:

1. Galvanized wire mesh, Guage10=3.25 mm dia, spacing 25 mm.
2. N = Number of longitudinal wires in the mesh.
3. B = Width of the micro concrete belt
4. Transverse wires: spacing 150 mm.



कमरा के अंदर कोनों पर, छड़ खड़ा करना

Vertical Bar at Inside Corner

कमरा के अंदर सभी कोनों पर, छड़ खड़ा करना है

प्लास्टर हटाऐं

- ✓ दीवार के कोनों पर, दोनों दीवारों पर, फर्श से छत तक, 150 मिलीमीटर चौड़ा निशान बनाऐं।
- ✓ निशान बनाये गये अंश से, प्लास्टर हटा लें।
- ✓ ईंट के जोड़ों के बीच 20 मिलीमीटर की गहराई तक मसाला हटाकर खाँच बनाऐं।

छड़ खड़ा करें

- ✓ फर्श में 750 मि.मी. गड्ढा खोद लें।
- ✓ आवश्यक छड़ को खड़ा कर गड्ढा में ले जाकर मोड़ दें। गड्ढे को कंक्रीट से भरें।
- ✓ उपर के स्लैब में छेद कर लें और खड़ा छड़ को उस छेद में से पार कराकर छत के स्लैब में संबंधन करें।

खड़े छड़ को दीवार से संम्बंधन कर प्लास्टर करें

दीवार से कनेक्सन हेतु डोवेल छड़

- ✓ दीवार में 1 मीटर के अंतराल पर 75 मिलीमीटर का छेद कर लें।
- ✓ छेद में, L आकार का 8 मिलीमीटर डोवेल छड़ डालना है।
- ✓ डोवेल का क्षैतिज भाग 150 मिलीमीटर, खड़ा भाग 400 मिलीमीटर
- ✓ डोवेल के क्षैतिज भाग को छेद में डाल कर, खड़े भाग को, खड़े छड़ के साथ तार से बाँधें।
- ✓ डोवेल को नहीं सिकुड़ने वाले सिमेंट–पोलीमर से ग्राउट करें।

दीवार के कोना में प्लास्टर

- ✓ सिमेंट–बालू 1:3 में प्लास्टर करके खड़े छड़ों को छिपा दें।
- ✓ दीवार की सफाई कर, पेंट कर लें।

STRENGTHENING BRICK PILLARS BY RCC JACKETING

CONNECTION OF JACKETTING WITH FOUNDATION

छड़ों से परिबंधित ईंट पीलर

आर.सी.सी. आवरण बनाकर ईंट पीलर का सुदृढ़ीकरण

यदि बरामदा के किनारे ईंट के पीलर बनाये गये हों तो, पीलर के चारो कोनों पर छड़ खड़ा करके कंक्रीट के आवरण से ढ़क दें। खड़ा किये गये छड़ों को नींव से संम्बंधन करना चाहिए।

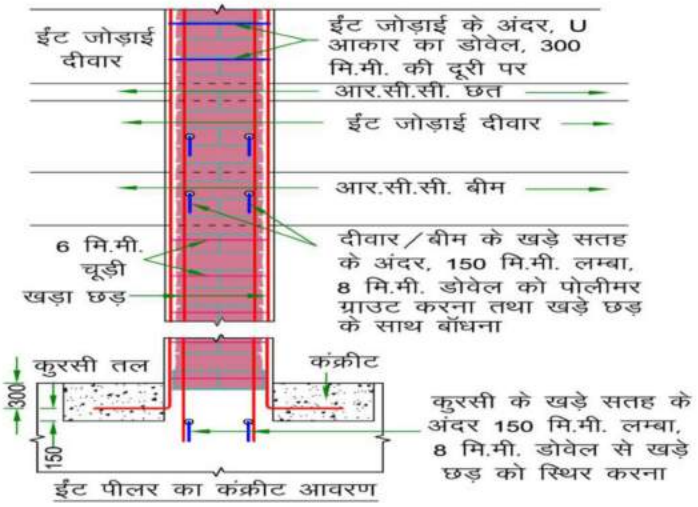
प्लास्टर हटाकर टाई छड़ ग्राउट करें

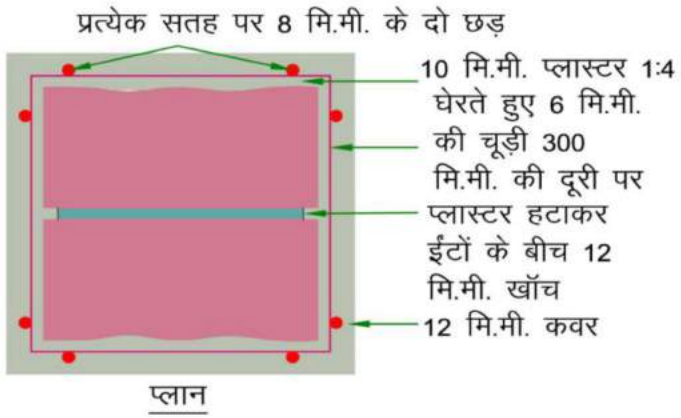
- ✓ ईंट पीलर के उपर का प्लास्टर हटाऐं।
- ✓ ईंट के जोड़ों के बीच 20 मिलीमीटर की गहराई तक मसाला हटाकर खाँच बना लें।
- ✓ 450 मिलीमीटर की दूरी पर, 16 मिलीमीटर व्यास के ड्रिल बिट वाले मशीन द्वारा 75 मिलीमीटर छेद करें।
- ✓ छेद में, 8 मिलीमीटर व्यास के, 200 मि.मी. लम्बा टाई छड़ डालें।
- ✓ टाई छड़ को सिमेंट–पोलीमर मसाला से ग्राउट करें।

आर.सी.सी. आवरण बनाकर ईंट पीलर का सुदृढ़ीकरण

छड़ खड़ा कर प्लास्टर करें

- ✓ दीवार की सतह पर, सादा सिमेंट या सिमेंट–पोलीमर का घोल से बांड कोट करें।
- ✓ बांड कोट पर, सिमेंट:बालू के 1:3 के अनुपात में, पतला (अधिकतम 10 मिलीमीटर) खुरदुरा प्लास्टर करें
- ✓ 8 मि.मी. के आठ खड़ा छड़ : नींव से छत तक, प्रत्येक सतह पर दो छड़ खड़ा करें।
- ✓ खड़े छड़ों को, घेरते हुए, 300 मि.मी. की दूरी पर, 6 मि.मी. की चूड़ी से बाँध दें।
- ✓ टाई छड़ को खड़े छड़ के साथ बाँध दें।
- ✓ 20 मिलीमीटर मोटाई का सूक्ष्म कंक्रीट का प्लास्टर करके छड़ों को छिपा दें।

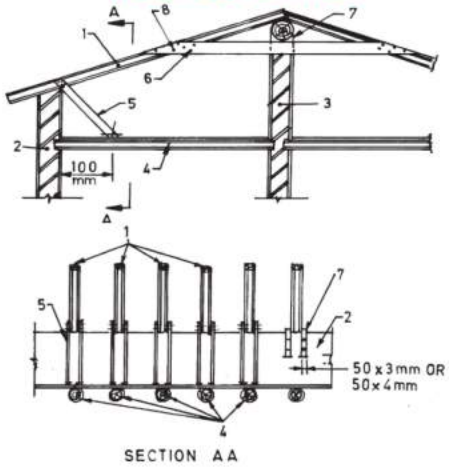




MODIFICATION OF ROOFS OR FLOORS

- Replace Brittle roofing tiles by GCI / sheeting.
- Substitute false ceilings by non-brittle material, like hessian cloth, bamboo matting or light foam substances.
- Brace the roof truss frames diagonally by welding or clamping in both vertical & horizontal planes.
- Improve the anchors of roof trusses to supporting walls.
- Use collar ties for inclined rafters supported over walls.

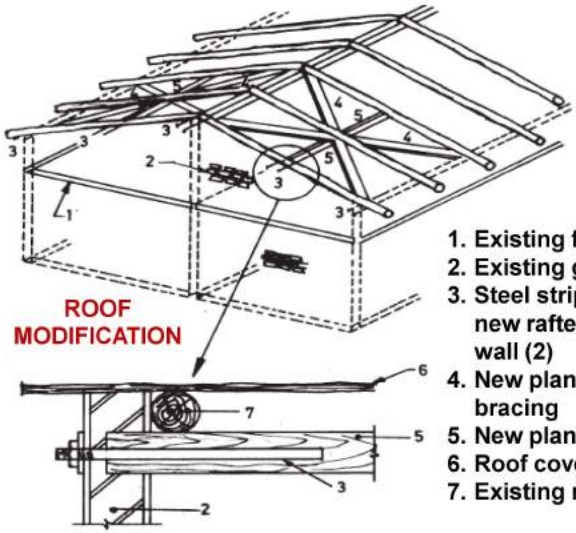
ROOF MODIFICATION



COLLAR TIE TO REDUCE THRUST OF WALLS

1. Existing rafters
2. Existing outer wall
3. Existing inner wall
4. Existing floor beam
5. New planks 200 × 40 mm nailed at ends
6. New planks 200 × 40 mm nailed at ends to take rafter thrust
7. U-Steel anchor clamp bolted to existing wall at 3 to 4 m apart
8. Nails

ROOF MODIFICATION



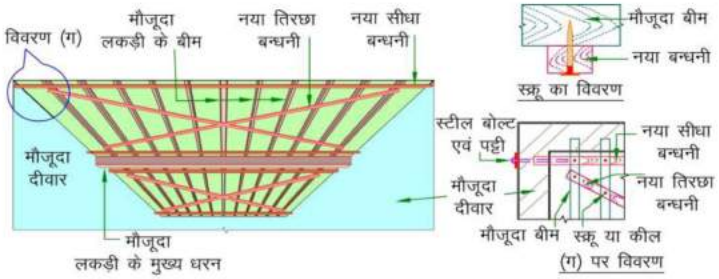
NEW BRACING FOR INCLINED ROOF RAFTERS

1. Existing floor
2. Existing gable wall
3. Steel strips bolted to new rafters ties (5) and wall (2)
4. New planks, diagonal bracing
5. New planks ties
6. Roof covering
7. Existing roof rafters

SEISMIC STRENGTHENING TECHNIQUES

Modification of Roofs or Floors

Integration of roof / floor carrying brick tiles. over Wooden beams

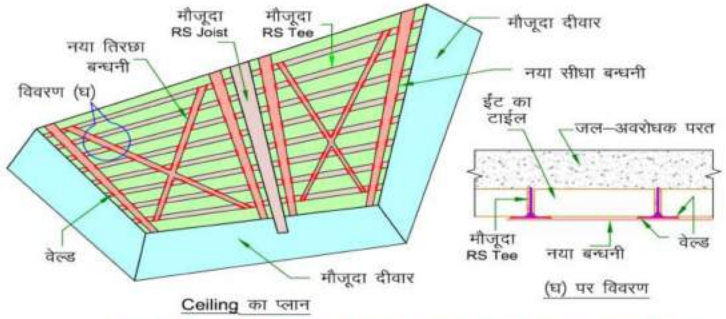


लकड़ी के बीम पर आधारित सपाट क्षैतिज छत का मजबूतीकरण, छत में लकड़ी का नया बन्धनी

SEISMIC STRENGTHENING TECHNIQUES

Modification of Roofs or Floors

Integration of roof carrying brick tiles, over Steel beams

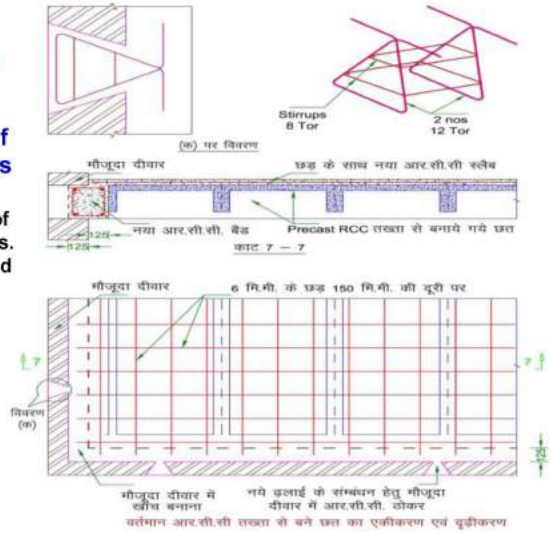


RS Joist एवं RS Tee पर आधारित सपाट क्षैतिज छत का मजबूतीकरण, छत में नया स्टील प्लेट का बन्धनी

SEISMIC STRENGTHENING TECHNIQUES

Modification of Roofs or Floors

Integration of roof carrying brick tiles. Over prefabricated RC units



SEISMIC STRENGTHENING TECHNIQUES

Inserting New Walls

- Masonry walls are inserted to separate the parts of buildings to achieve individual symmetric units.
- Walls may be inserted either internally as shear walls or externally as buttresses.
- Cross wall are Inserted to provide transverse supports to longitudinal walls.

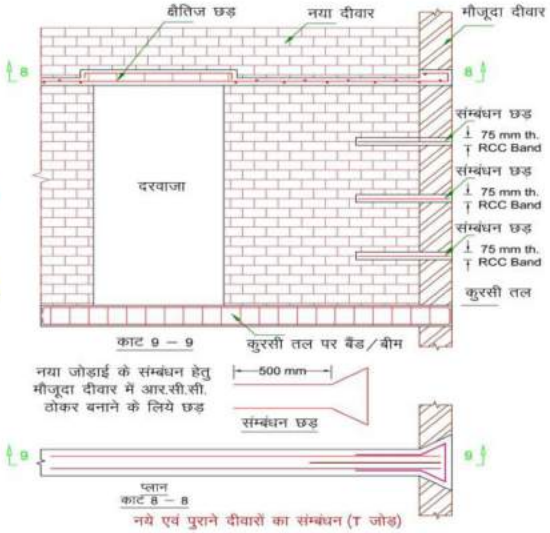
Connection of new walls with old walls:

- Link to the old walls by means of a number of keys made in the old walls. Steel is inserted in them and concrete is filled.
- Or, connect with a number of steel bars inserted in small length into drilled holes filled with fresh cement-grout.

SEISMIC STRENGTHENING TECHNIQUES

Connection of new walls with old walls:

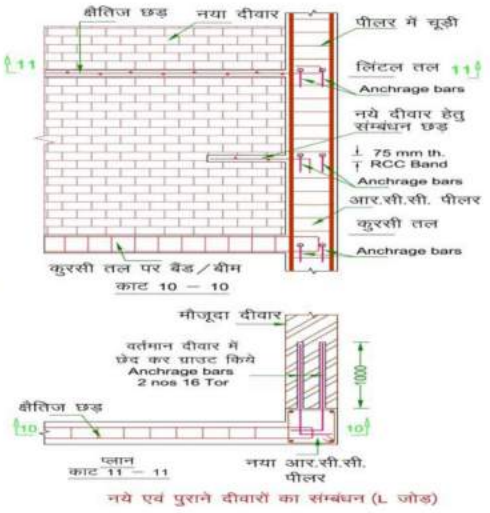
T-junction



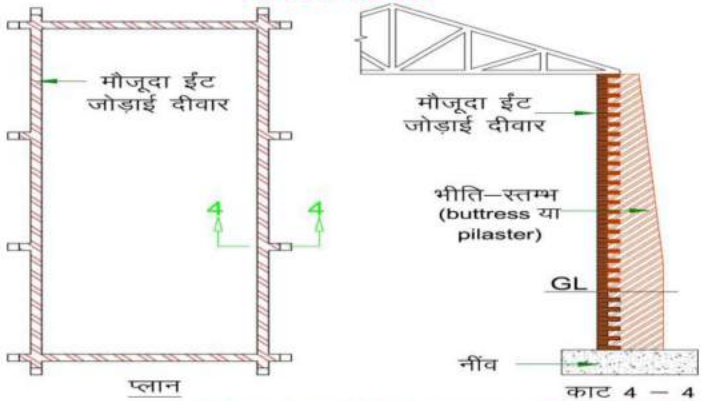
SEISMIC STRENGTHENING TECHNIQUES

Connection of new walls with old walls:

L-junction

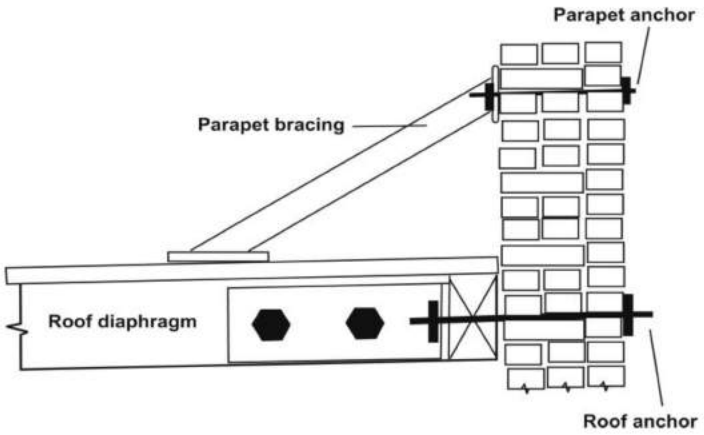


STRENGTHENING OF LONG WALLS BY BUTTRESS



भीति–स्तम्भ से दीवार का मजबूतीकरण

STRENGTHENING OF PARAPETS



THANK YOU

(10)

Masonry Buildings: Seismic Retrofitting

POINTS FOR CONSIDERATION AND DISCUSSION

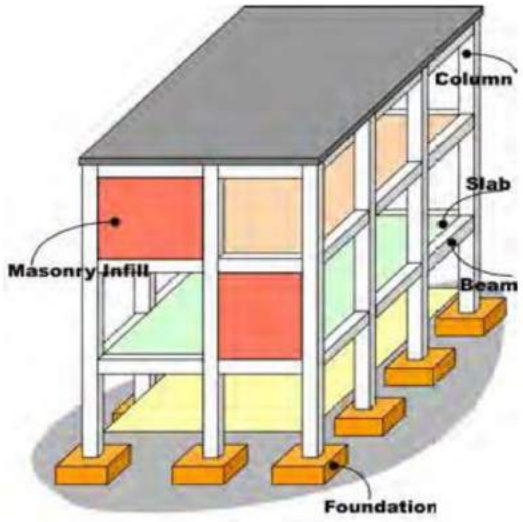
1. Differentiate between Non Engineered Buildings and Engineered Buildings.
2. When should we adopt retrofitting of a damaged building in liew of its reconstruction?
3. Differentiate between Repair, Restoration and Seismic Retrofitting.
4. Enlist the materials available for retrofitting.
5. What is the difference between micro concrete and polymer concrete?
6. How will a chemical anchor is fixed into a RCC member?
7. What are the benefits using Fiber Reinforced Plastics in seismic retrofitting?
8. Explain the processes of repairing cracks< 5 mm and cracks> 5 mm in masonry walls.
9. Explain the process of repairing RCC roof slab..
10. How can you convert an unsymmetrical plan into a symmetrical plan?
11. How can you strengthen the existing walls of a masonry building?
12. How will you strengthen a masonry arch and wall around a wide window opening?
13. How will you achieve box action of a masonry building?
14. Explain the procedure of providing seismic belts over the masonry walls.
15. How will you integrate seismic belts and vertical bars with the existing walls?
16. Explain the process to strengthen a brick pillars with RCC jacketing.
17. How to integrate a flat roof with walls, carrying brick tiles over wooden beams?
18. How to add a new wall to an existing masonry building?
19. How to add a butress to an existing long wall?
20. How to connect a masonry parapet with roof?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(11)
RC Buildings: Failures & Recommendations

90 min



A typical RC frame building with masonry infills and its Components

(source: C.V.R. Murty).

AHMADABAD IN BHUJ EQ 2001

1. Non-adherence to BIS Codes

- Ignorance of the Architects and Structural Engineers about
  - The Contents of the relevant earthquake resistant *Building Codes.*
  - The earthquake shaking of the building in all three directions; longitudinal, transverse and vertical (*not accounted for in design*)
  - The foundation soil, which plays critical role in amplifying the ground motion (*not properly explored, nor considered in design*).

Recommendation:-

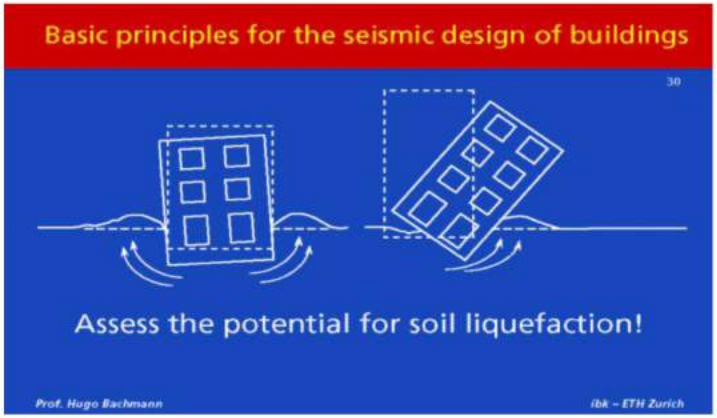
Architect's and Structural engineer's design office should have the current copies of these standards available in their offices and all their staff should fully familiarize with contents of these codes:-

1. IS: 456 - 2000 "Code of Practice for Plain and Reinforced Concrete"
2. IS: 875 Part 1 "Unit weights of materials".
3. IS: 875-1987 Design loads (other than earthquake) for buildings and structures, Part 2 Imposed Loads
4. IS: 875-1987 Design loads (other than earthquake) for buildings and structures, Part 3 Wind Loads

Recommendation:- Cont. 2

5. IS: 1904-1987 "Code of Practice for Structural Safety of : Foundation"
6. IS: 1905-1987, Code of Practice for Structural Safety of Buildings: Masonry
7. IS:1893(Part-I)-2002 "Criteria for Earthquake Resistant Design of Structures (Fifth Revision)".
8. IS:13920-1993, "Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice"
9. IS: 4326-1993, "Earthquake Resistant Design and Construction of Buildings - Code of Practice (Second Revision)"
10. IS-NBC-2005: National Building Code of India.

2. Softness of Base Soil:



2. Softness of Base Soil: cont...

The soft soil on which most buildings in Ahmedabad were founded would have affected the response of the buildings in the following ways:

(i) Amplification of the ground motion at the base of the building;

(ii) Absence of foundation raft or piles;

(iii) Relative displacement between the individual column foundations vertically and laterally, in the absence of the plinth beams

(iv) Resonance or, semi-resonance of the whole building with the long period ground waves.

2. Softness of Base Soil:

Damages due to soil liquefaction and differential settlement

cont…

TILTING

FAILURE OF STRUCTURE

CRACKING

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

The building sank evenly about 1 m due to soil liquefaction. The displaced soil caused a bulge in the road.

The inclined building sank unevenly and leans against a neighboring building

The solid building tilted as a rigid body and the raft foundation rises above the ground.

Recommendation:-

Soil exploration at the buildings site must be carried out at sufficient points and to sufficient depth so as to give the following data:

I. Soil classification in various layers and the properties like grain size distribution, field density, angle of internal fritting and cohesion a plastic and liquid limits and coefficient of consolidation of cohesive soils.

II. Position of water table just before and just after monsoon.

III. SPT values and CPT values.

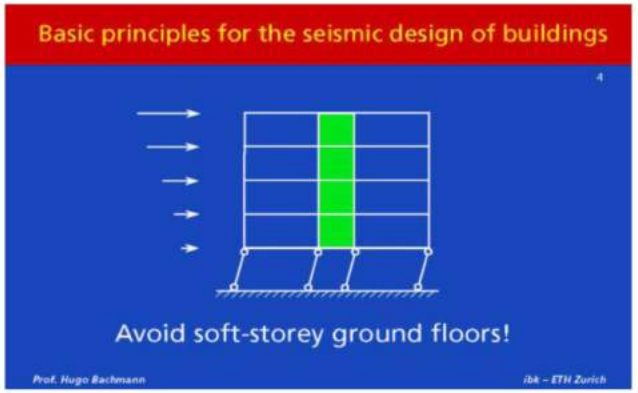
IV. The output results should include liquefaction potential, safe bearing capacity and the type of foundation to be adopted such as raft, raft on piles, piles, interconnected individual footings.

3. Soft-Ground Storey:

Open ground storey (stilt floor) used in most severely damaged or, collapsed R.C. buildings, introduced 'severe irregularity of sudden change of stiffness' between the ground storey and upper storey since they had infilled brick walls which increase the lateral stiffness of the frame by a factor of three to four times.

Such a building is called a building with '*soft' ground storey*, in which the dynamic ductility demand during the probable earthquake gets concentrated in the soft storey and the upper storey tend to remain elastic.

AVOID SOFT STOREY GROUND FLOORS



Often the columns are damaged by the cyclic displacements between the moving soil and the upper part of the building

Sway mechanisms with soft storey ground floors (Izmit, Turkey 1999)

Soft first storey collapsed upper part of the building fall onto the ground (Kachchh, 2001)

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

***Recommendation*:-**

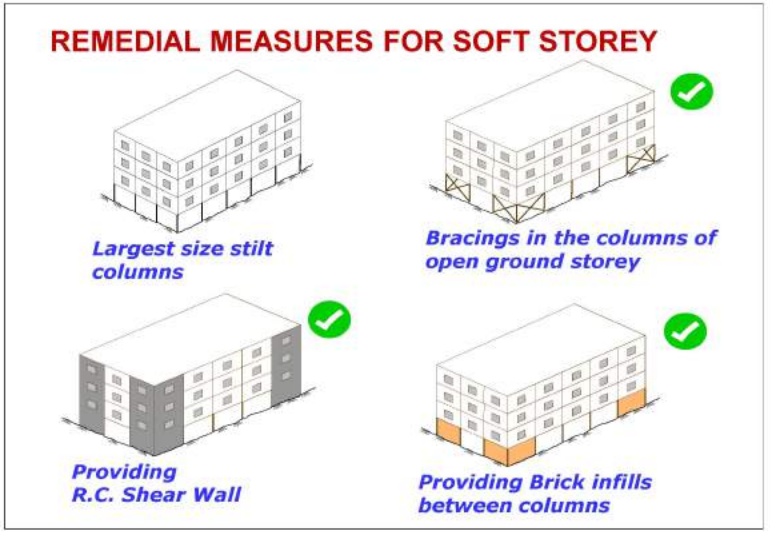
In view of the functional requirements of parking space under the buildings, more and more tall buildings are being constructed with stilts. To safeguard the soft first storey from damage and collapse, clause

IS: 1893-2002 (Part 1) Cl, 7.10 provides two alternative design approaches

I. 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.

***Recommendation*:-** *cont. 2*

II. **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.**



Intermediate Soft Storey

Some times a soft storey is created some where at mid-height of the multi-storey building, for using the space as restaurant or gathering purposes. For such a case also, the storey columns should be designed for the higher forces OR a few shear walls introduced to make up for the reduced stiffness of the storey.

COLLAPSE OF SOFT MIDDLE STOREY IN A BUILDING AT BHUJ

4. Bad Structural System:

The structural system adopted using floating columns, for reasons of higher FSI is very undesirable in earthquake zones of moderate to high intensity as in Zone III, IV & V since it will induce large vertical earthquake forces even under horizontal earthquake ground motions due to overturning effects.

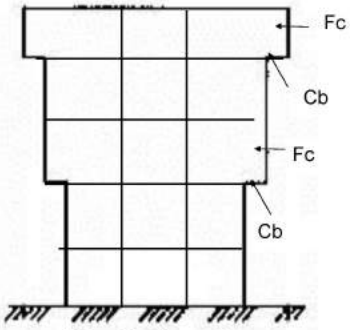
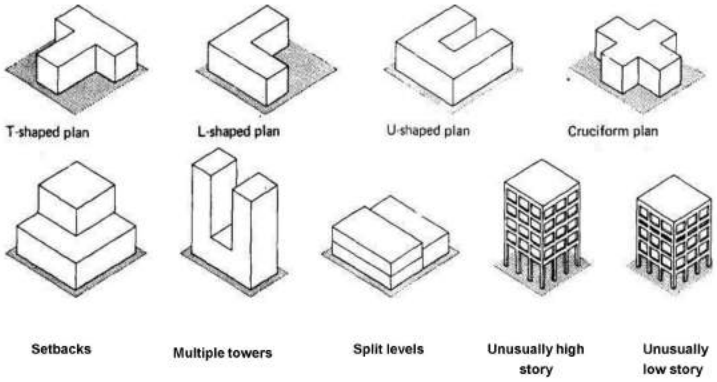


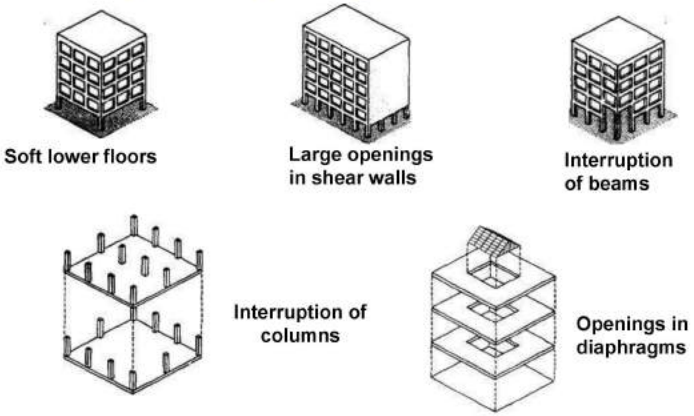
Fig.:-Floating columns
Fc= Floating Columns
Cb= Cantilever Beams

IRREGULAR STRUCTURE OR FRAMING SYSTEMS

A. Buildings with Irregular Configuration



B. Buildings with Abrupt Changes in Lateral resistance



Recommendation:-

The structural engineer should provide for the *load path* in the building from roof to the foundation.

A building with floating columns requires transfer of the floating column loads to horizontal cantilever beams through shear forces. The *load path*, therefore, is not vertical but changes from vertical to horizontal members before reaching the foundation.

5. Heavy Water Tanks on the Roof:

Heavy water tanks add large lateral inertia forces on the building frames due to the so called 'whipping' effect under seismic vibrations, but remain unaccounted for in the design.

5 storey R.C., collapse of open plinth, water tank at top dislocated (Bhuj)

Damage to overhead tanks (Bhuj)

Recommendation:-

All projected systems above the roof top behave like secondary elements subjected to *roof level horizontal earthquake motions* which act as base motions to such projecting systems.

To account for such heavy earthquake forces, IS:1893-2002 (Part 1) clause 7.12 provides that their support system should be designed for *five times* the design horizontal seismic co-efficient Ah specified in clause 6.4.2.

Similarly any horizontal projections as the balconies or the cantilevers supporting floating columns, the cantilevers need to be designed for *five times* the *design vertical co-efficient* as specified in clause 6.4.5 of IS: 1893-2002 (Part 1)

6. Lack of Earthquake Resistant Design:

The structural designers ignored the seismic forces in design as specified in IS: 1893, which was in existence from 1962, revised in 1970, 1976 and 1984.

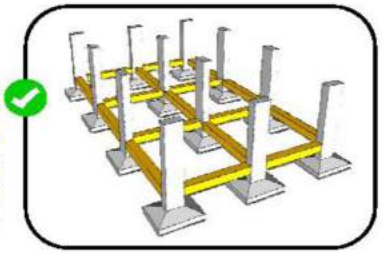
The applicable seismic zoning in Gujarat had remained the same as adopted in 1970 version. It is the same even in 2002 version of IS: 1893 (Part I).

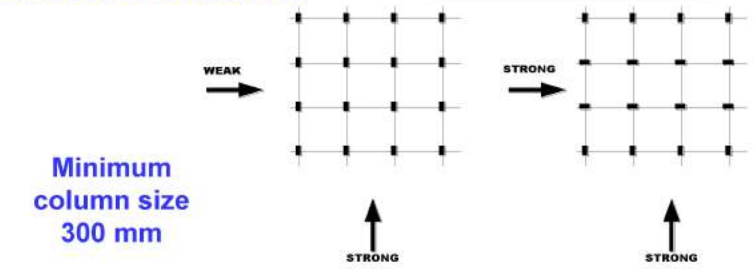
Recommendation:

All buildings must be designed for earthquake forces as per IS: 1893, 4326 and 13920.

DESIGN FOR LATERAL FORCES

The design lateral forces specified in the standard {IS:1893 (Part 1)} shall be considered in each of the two orthogonal horizontal directions of the structure.





Minimum column size 300 mm

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

7. Improper Dimensioning of Beams & Columns:

- Dimension of beams and columns was inadequate in terms of provisions in IS: 13920-1993.
- Reinforcements at Beam-Column joints were not installed properly in terms of provisions in IS: 456 and IS: 13920.

Recommendation:

- Column width must be greater than beam width.
- Small dimension columns like 200 or 230 mm need not be used.
- Space for proper concreting should be ensured while sizing columns in design.
- Longitudinal beam bars should pass through Vertical column bars.
- Longitudinal beam bars needs to be anchored into end column.
- Local kinking of the reinforcing bars must be avoided.

8. Improper Detailing of Reinforcement:

The stirrups detailing in the columns was not in conformity to satisfy lateral shear requirements in the concrete at the joint as required under IS 4326- 1976 and IS: 13920-1993.

The shape and spacing of stirrups seen in collapsed and severely damaged columns with buckled reinforcement was indicative of non-conformity even with the basic R.C. Code IS: 456-1978.

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)

Recommendation:

- Detailing of reinforcement in beams, columns, beam-column joints as well as shear walls have to be carefully understood and adopted in design as per IS:13920.
- To ensure flexural hinge formation before shear failure, beams must be over-design in shear.
- The highly compressed concrete in columns must be confined by use of properly shaped shear stirrups with 135 degree hooks.
- strong-column, weak-beam system design should be adopted as far as practical.

Recommendation:

- Full ductility details as specified in IS: 13920 permit the use of the High Reduction Factor R=5 which would make the design economical.
- But, if such ductility details are not adopted, the Reduction Factor is permitted as only 3.0, which means that the design force will become 1.67 times the case when full ductile detailing is adopted which may indeed turnout to be more expensive and at the same time brittle and relatively unsafe.

10. Short Column Detailing

When a column is surrounded by walls on both sides; such as up to the window sills and then in the spandrel portion above the windows; but, it remains exposed in the height of the windows.

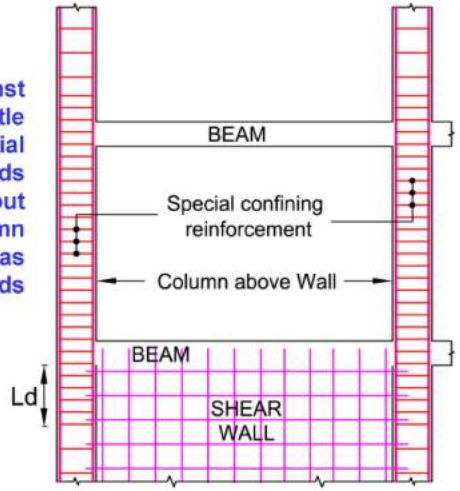
Such a column behaves as a short column under lateral earthquake loading, where the shear stresses become much higher than normal length columns, and fail in shear.

Short Column behavior

Short Column: Inadequate ties

Recommendation:

To safe guard against short column brittle shear failure, special confining stirrups needs be provided throughout the height of the column at short spacing as required near the ends of the columns.



11. Torsional Failures

Torsional failures are seen to occur where the symmetry is not planned in the location of the lateral structural elements.

Example : providing the lift cores at one end / corner of the building; or, un-symmetrically planned buildings in L shape at the street corners.

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

Recommendation:

- 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.

12 Pounding Damage of Adjacent Building

विभिन्न कुल उँचाई वाले या मजिंलों की भिन्न–भिन्न उँचाई वाले या **Unsymmetrical** प्लान वाले दो निकटवर्ती भवन भूकम्प के दौरान अलग–अलग प्राकृतिक आवृति में डोलते हैं और अपने निकटवर्ती भवन को ठोकर मार कर, क्षतिग्रस्त कर देते हैं, यहाँ तक कि कई ढ़ह गये।

अतएव, भवन के अलग–अलग खंडों के बीच पर्याप्त जगह (गैप) छोड़ा जाना आवश्यक है। यह गैप, दोनों निकटवर्ती भवनों के गतिशील भूकम्पीय क्षैतिज विचलन पर निर्भर करता हैं। आर. सी. सी फ्रेम संरचना के खण्डों के बीच कम से कम 40 मिलीमीटर गैप रखा जाना चाहिए।

Pounding Damage

Separation Gap Between Adjacent Units

IS 1893 P1 - Cl. 7.11.3

For Non-similar blocks,

Gap = R1.d1 + R2 d2

Where R1,d1 and R2,d2 are Risk reduction factors and Storey drifts respectively for the two adjacent buildings.

For equal similar blocks,

Gap = (R1d1+R2 d2)/2

13. Lack of Stability of Infill Walls:

The infill walls not properly attached either to the column or the top beams for stability against out-of-plane bending under horizontal earthquake forces.

Wall cracking and falling was widespread.

Recommendation:

- Infill walls have their brittle failure due to the diagonal compression in the panel or, diagonal tension cracking; and more important is their lateral stability under out of plane earthquake force acting on their own mass.
- While conducting the retrofitting studies of buildings, the 114 mm thick brick infill walls have turned out to be one of the main issues to handle. Such walls will have to be contained with in pairs of vertical angles spaced at 1.2 – 1.5 m apart.
- Therefore, while designing a new multistoried building, the stabilization of the infill wall panels should be properly considered.

Concluding Remarks

Seismic safety of a multistoried RCC building will depend upon:-

- Architectural and Structural configuration
- Quality of the Structural design
- Reinforcement detailing to achieve stability of elements and their ductile performance under severe seismic loading.
- Proper quality of construction and stability of the infill walls are additional safety requirements of the structure as a whole.

Any weakness left in the structure, whether in design or in construction will be fully revealed during the maximum considered earthquake for the seismic zone stipulated in the code IS: 1893.

14. Poor Construction Quality:

Bad quality of concrete in the columns just below the floor beams and within the beam column joints.

Good quality of construction will include:-

- Good quality water, sand and aggregates
- Designed quantity of cement in the mix
- Proper mixing of all the ingredients
- Control on water cement ratio
- Appropriate sampling and testing of materials
- Well maintained Results of tests for inspection
- Proper placement of steel
- Control on the cover to steel
- Adequate compaction of concrete by vibrators
- Supervision of all RCC operations
- Adequate curing
- Inspection while striking of the form work.

THANK YOU

FOR YOUR ATTENTION

(11)

RC Buildings: Failures and Recommendations

POINTS FOR CONSIDERATION AND DISCUSSION

1. What is the difference between a load bearing building and a framed building?
2. Why the architects and structural Engineers do not follow to the BIS Codes?
3. Which is the basic BIS code for Earthquake Resistant Design of Structures?
4. Which BIS code deals with Earthquake Resistant Design of Masonry Buildings?
5. Which BIS code deals with Ductile Detailing of RC Buildings?
6. Which BIS code deals with Plain and Reinforced Concrete?
7. Which BIS code deals with Wind Loads?
8. What are the problems associated with soft base Soil, during earthquake shaking?
9. What remedial measures will you suggest for Soft Ground storey?
10. What do you mean by floating column?
11. What precautions should we take to construct a Water Tanks on Roof?
12. How should we orient columns in a RCC frame building?
13. What do you mean by sufficient beams & columns sizes?
14. What type of failure may occure, if links in a RCC column is widely spaced?
15. How seismic force is reduced, if we select ductile detailing as per IS 13920?
16. What is short column in the context of seismic shaking of a RC building?
17. What problem may arise during earthquake shaking, if shear walls are eccentrically placed?
18. How much seismic gap should be provided, between adjacent buildings?
19. How can you improve lateral stability of Infill walls in RC buildings?
20. At what location in a RCC Building, concrete quality is generally poor?

बिहार सरकार
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Ductile Details of RC Members (IS:13920) & Other essential Details

90 min

RC - multi-storey buildings

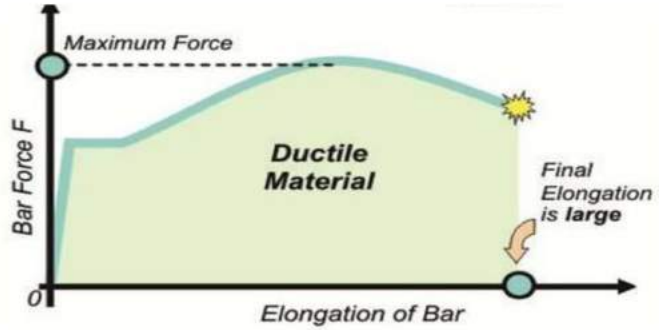
IS 456 – 2000 : General RCC
IS 1893 – 2002 : EQ Resistant Design
IS 13920 – 1993 : DUCTILE DETAILS

Ductility of a structure, or its members,

is the capacity to undergo large inelastic deformations

without significant loss of strength or stiffness

(often withstanding many cycles without fracture / collapse).



DUCTILITY

Actual forces that appear on structures during earthquakes are much greater than the design forces specified in IS:1893 P1.

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.*

IS: 13920 shall be adopted for all RCC Structures located in Zone III, IV & V.

Ductility is Key to earthquake resistance avoiding collapse.

Ductility Failure of Columns in Multistoreyed Buildings



LACK OF TIES

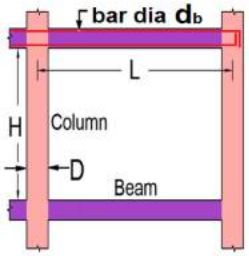
HOW DUCTILITY ACHIEVED IN BUILDINGS

- **Planning:** Symmetry, Separation Joints, Avoid Soft Stories/ Short columns/ Eccentric framing/ Weak column/ Non-uniformity in Mass / stiffness
- **Analysis & Design:** Load reversals / Avoid shear failure of members/ Beam-Column junctions / Richer concrete mix
- **Detailing:** Communication of good seismic design from Designer to construction Engineer through Clear and Well Detailed Structural Drawings

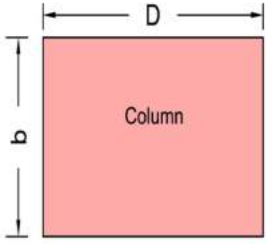
IS 13920 : 1993
PROVISIONS FOR DUCTILITY

- Sufficient sizes of members
- Lapping of bars, Curtailments
- Closely spaced Special confining ties in columns
- Requirement of hooks in stirrups and ties
- Confined Beam-column junctions
- Reinforcement details at joints
- Shear strength larger than flexural strengths
- Shear capacity of beam & column at joints
- Plastic hinges may form in beams, not in columns
- Under-reinforced beam design
- Proper anchorage of beam/column Reinforcement
- Treatment of Non-structural elements
- Specific attention on Reinforcement congestion, Construction sequence, Floor Depressions, Cutouts

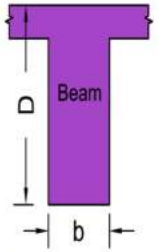
COLUMN AND BEAM SIZES IN RCC FRAME
sizes in preliminary design



ELEVATION
BEAM - COLUMN FRAMING

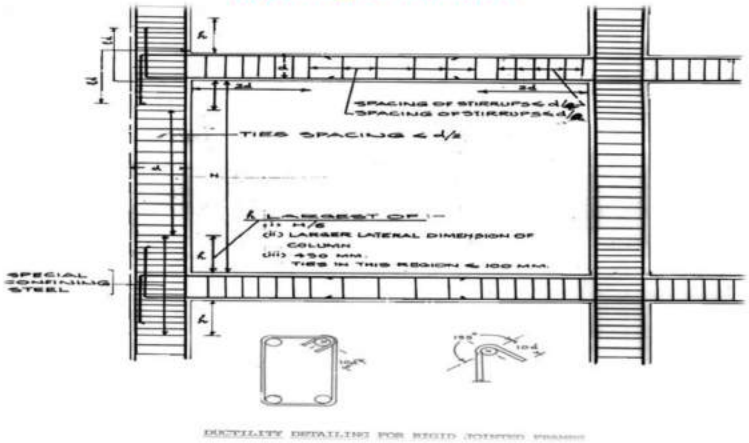


$b > 300$ mm
$b > 0.45\ D$
$D > 15\ d_b$



$b > 200$ mm
$b > 0.3D$
$D > L / 4$

DUCTILE FRAMES

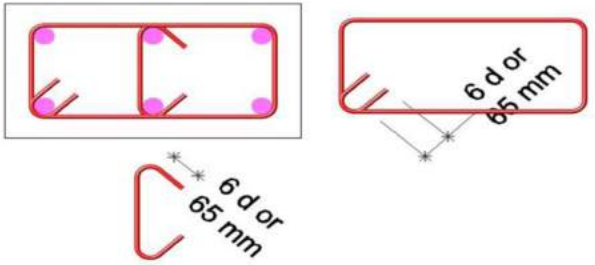


DUCTILITY DETAILING FOR RIGID JOINTED FRAMES

DIMENSION OF HOOK FOR LATERAL TIES

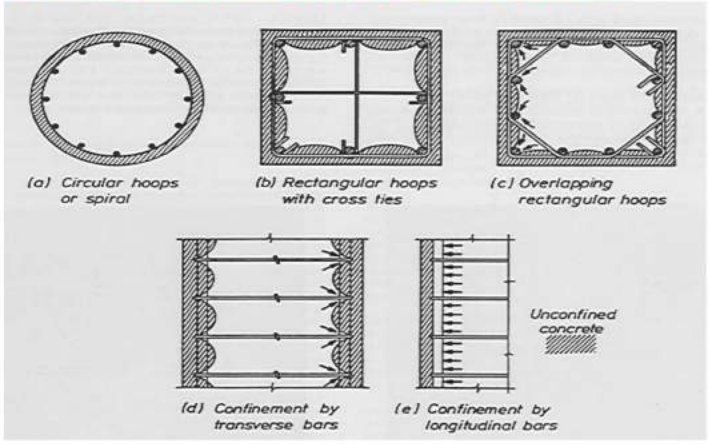
IS 13920 -1993 Cl. 6.3.1

Straight Length of HOOK = 6d



PLAN : COLUMN
TRANSVERSE REINFORCEMENT

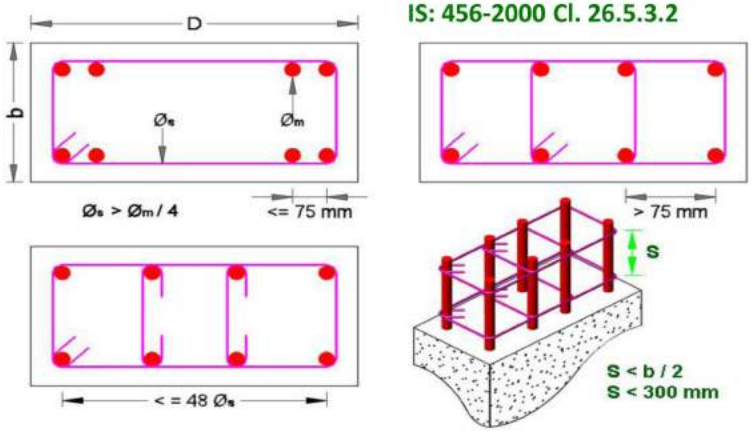
Lateral Ties Provides Confinement to Concrete & Prevents Premature Buckling of Reinforcement



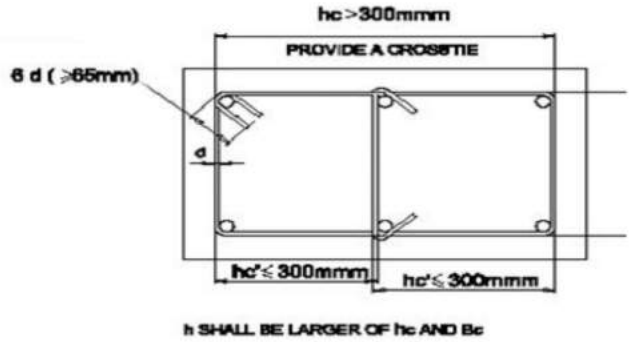
COLUMNS

Max. Long. Bars 4%
Lateral Ties as below

IS: 456-2000 Cl. 26.5.3.2

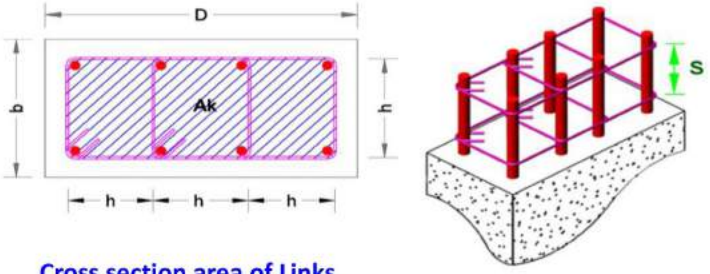


CLOSED TIES IN COLUMNS
IS 13920 -1993 Cl. 7.3.2



Exposed length<300

COMPUTATION OF SPECIAL CONFINING LINKS
IS 13920 -1993 Cl. 7.4.7



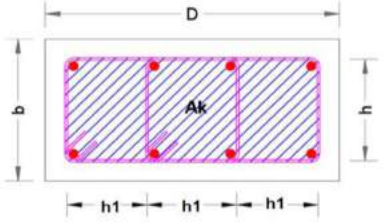
Cross section area of Links,

Ash = 0.18 S . h. fck . (Ag / Ak – 1.0) / fy

Ag = b x D, Ak = core area (hatched)

h = max 300 mm, provide Cross tie to reduce h

COMPUTATION OF SPECIAL CONFINING LINKS



b = 300 mm, D = 750 mm, Ag = 225,000 sqmm

8 nos 25 mm main bar and 8 mm links of Fy 500 mpa

Ak = 236 x 686 = 161,896 sqmm, conc M25, S=75 mm

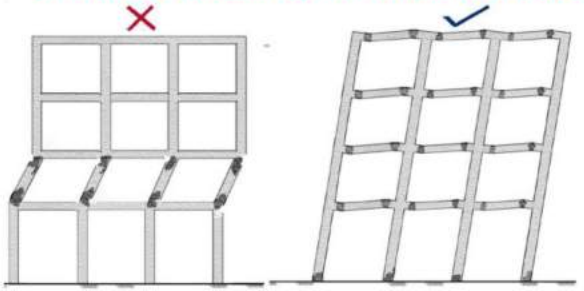
h = max of 236 or 686/3 = 236 mm

Cross section area of Links,

Ash = 0.18 x 75 x 236 x 25 (225 / 162 – 1.0) / 500

= 61.95 sqmm > 50 sqmm, Hence Revise

STRONG COLUMN & WEAK BEAM DESIGN



Hinge in column is not desirable.

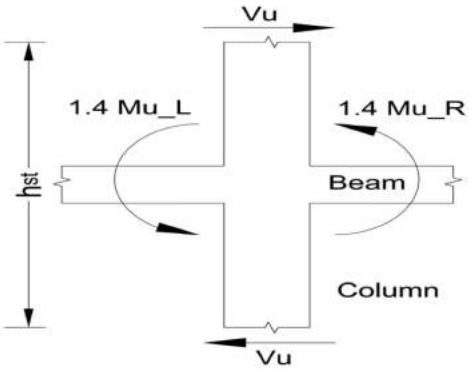
Hinge in beam is permitted. For every beam column joint it is ensured that

$\Sigma M_c \geq 1.4\ \Sigma M_b$

पीलर का brittle shear failure, बीम के plastic moment capacity से पहले नहीं हो जाए, इस हेतु :– **(IS 13920-1993 Clause 7.3.4)**

प्रत्येक मंजिल पर, प्रत्येक जोड़ पर, दोनों क्षैतिज दिशाओं में, न्यूनतम shear capacity, Vu का प्रावधान करना चाहिए।

प्रत्येक जोड़ पर, दोनों तरफ के बीम के, IS 456-2000 के आधार पर गणना की गयी moment of resistance के 1.4 गुणा के योग में, मंजिल की उँचाई से भाग देकर पीलर के इस Vu की गणना करते हैं।



$$Vu = \frac{1.4\,(Mu\_L + Mu\_R)}{h_{st}}$$

COLUMN SHEAR BASED ON PLASTIC MOMENT CAPACITY OF BEAM

DEVELOPMENT LENGTH OF STEEL BARS IN TENSION

IS: 456-2000 Cl. 26.2.1

$$Ld = \emptyset.\ \sigma s\ /\ (4.\tau_{bd})$$

Where,
Ø = dia of bar,
σs = tensile stress in bar
= 0.87 x fy

τ_{bd} = design bond stress in limit state method for torsteel bars in tension

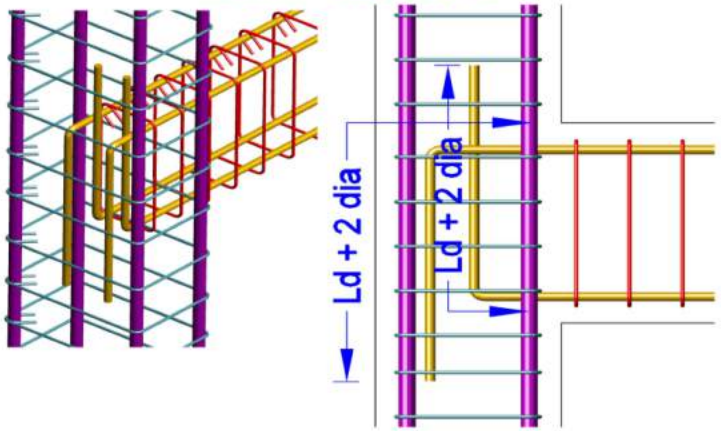
Grade of concrete	M 20	M 25	M 30	M 35	M 40 and above
Design bond stress	1.92	2.24	2.4	2.72	3.04

For M20 and Fe 415, Ld = 47 Ø

Anchorage value of bars in tension = 4.d for each 45° bend

Anchorage of beam bars at an external joint

IS 13920 -1993 Cl. 7.4.7



DETAILS OF RCC COLUMN

IS 13920 -1993 Cl. 7.2, 7.3, 7.4

COLUMN

b = lesser dimension

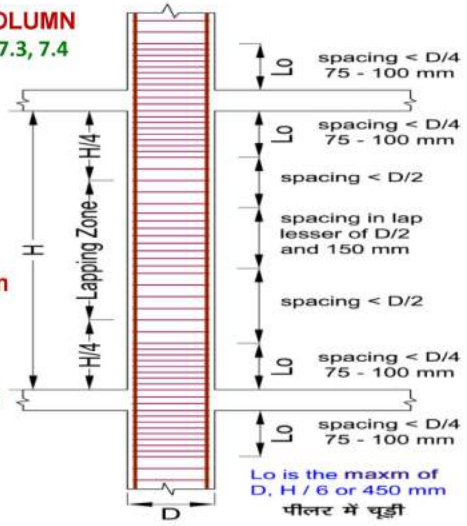
D = Larger dimension

LINKS MINIMUM

- @ b/2 c/c or 300
- *Special Confining*
  @ 75-100 mm in Lo length

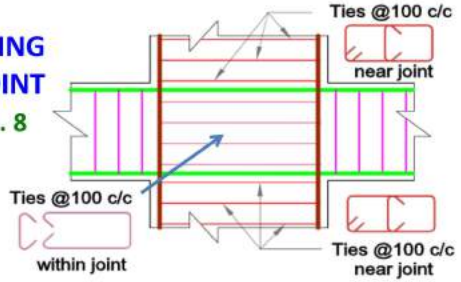
LAPPING LONG. BARS

- Central half of height
- Maxm. 50% bars to be Lapped
- Ties @ 150 c/c



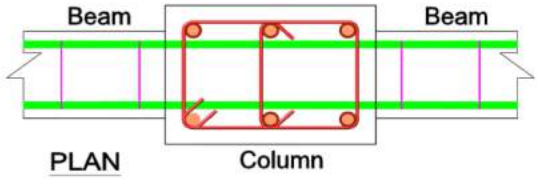
SPECIAL CONFINING TIES WITHIN JOINT

IS 13920-1993 Cl. 8

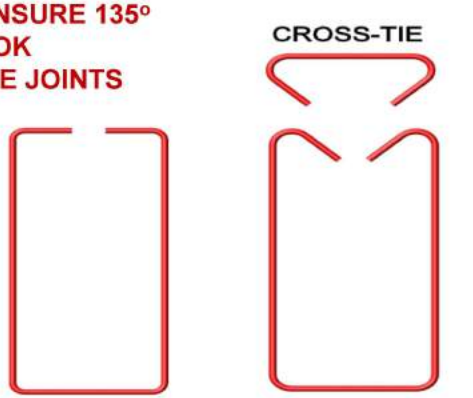


SECTION THRO COLUMN

BEAM – COLUMN JUNCTION

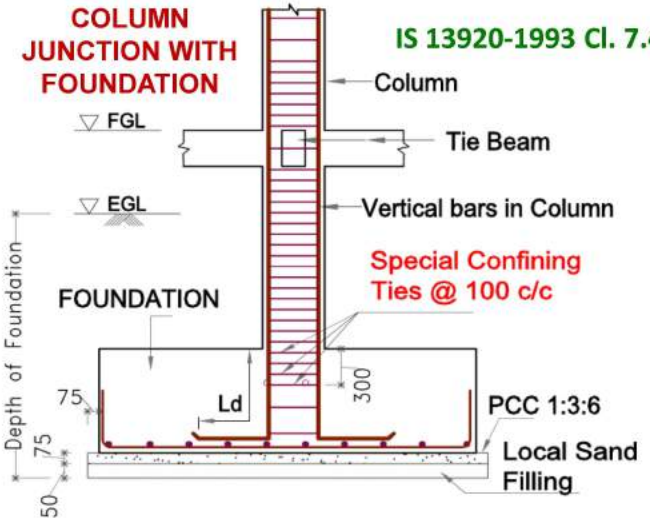


STEPS TO ENSURE 135° HOOK WITHIN THE JOINTS



COLUMN JUNCTION WITH FOUNDATION

IS 13920-1993 Cl. 7.4.2

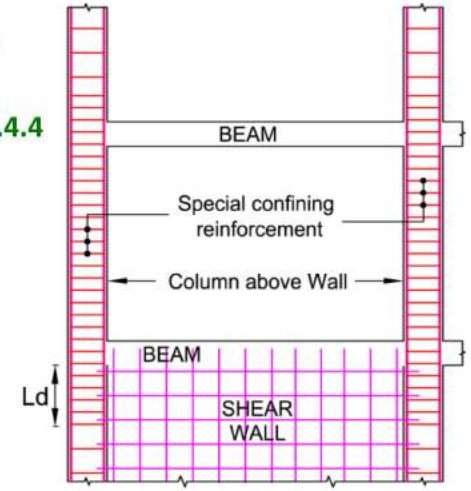


DISCONTINUOUS RCC WALL

IS 13920-1993 Cl. 7.4.4

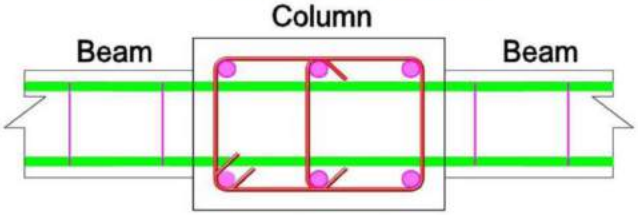
SPECIAL CONFINING TIES IN COLUMNS

Ld = development Length of Longitudinal bars



Beam bars through column

IS 13920-1993 Cl. 6.2.5



PLAN : BEAM COLUMN JOINT

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

LONGITUDINAL REINFORCEMENTS IN BEAMS

IS 13920-1993 Cl. 6.2.1 to 6.2.4

Under reinforced design

Minimum Steel = 0.24 (√ fck / fy) bD

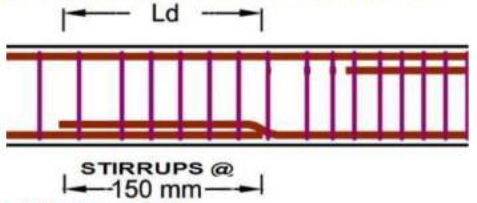
Maximum Steel = 0.025 bD

Lapping the longitudinal bars

IS 13920-1993 Cl. 6.2.6

- Over the entire length of lap of the longitudinal bars, the spacing of stirrups < 150 mm
- The lap length > Ld, development length of bar in tension

Maximum 50% of bars to be lapped at a section

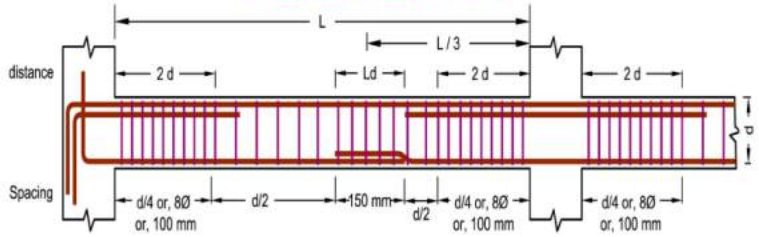


Lap splices shall not be provided

- Within a joint
- Within a distance of 2d from the joint face
- Within L/4 from column face

MAXM. SPACING OF VERTICAL STIRRUPS IN BEAMS

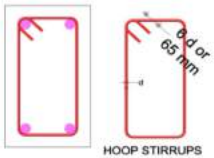
IS 13920-1993 Cl. 6.3.5



Distance of 1st stirrup from column face < 50mm

Ø = dia. smallest longitudinal bar

d = Effective depth of beam



SECTION : BEAM

Bending में बीम के plastic होने से पहले ही इसका brittle shear failure न हो जाय, यह सुनिश्चित करने के लिये:–

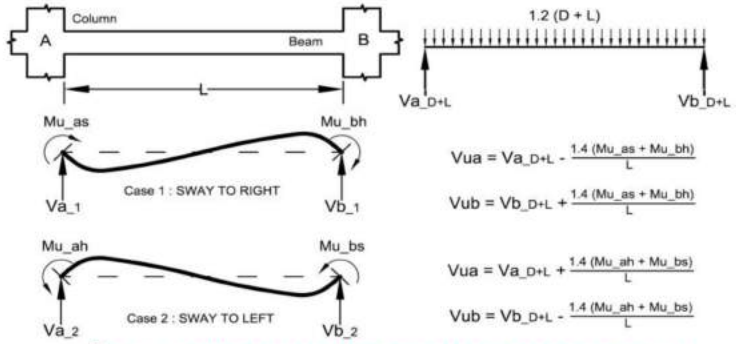
(IS 13920-1993 Clause 6.3.3)

(a) Gravity load के कारण बीम के छोर पर shear का 1.2 गुणा करें और

(b) IS 456 के आधार पर गणना की गयी, बीम के छोरों का moments of resistance के कारण बीम के छोर पर shear का 1.4 गुणा करें,

इन दोनों shear का योग करके इस shear capacity के लिये, बीम का निरूपण करना चाहिए।

कम्प्यूटर सौफ्टवेयर का उपयोग से आवश्यक stirrup की गणना की जा सकती है।



चित्र–45 BEAM SHEAR BASED ON PLASTIC MOMENT CAPACITY OF BEAM

CANTILEVER PROJECTION

IS 1893 p1-2002 Cl. 7.12.2

Seismic Force for Cantilever Projection : -

- For Vertical Projection : **5 times Ah**
- For Horizontal Projection : **3.33 times Ah**

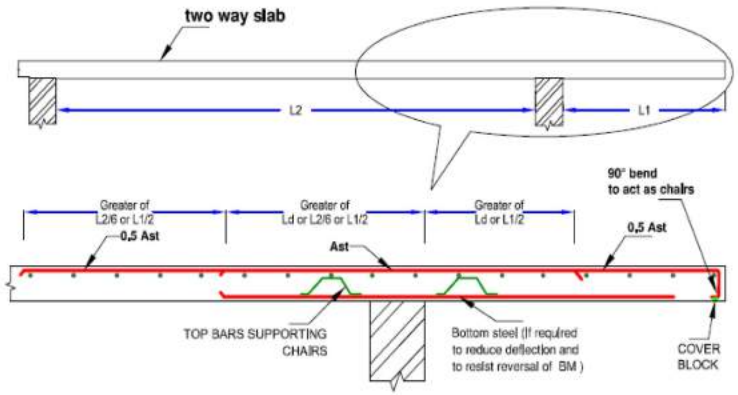
for a typical 10 m high building in zone IV,
bare RCC frame on soft soil
T=0.42 sec

$A_h = (Z/2)*(I/R)*(Sa/g) = 0.24*0.2*2.5 = 0.12$

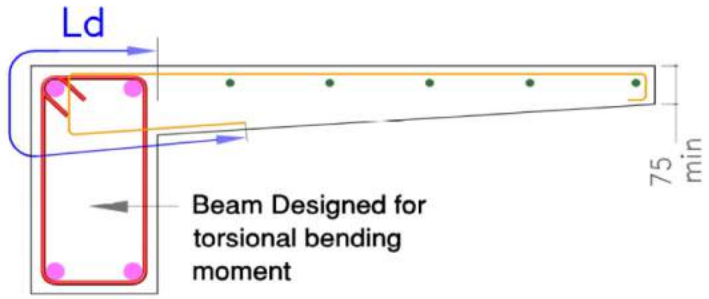
Total Design Force, DL+LL+EL

- **For Vertical Projection : 1.6 times DL+LL**
- **For Horizontal Projection : 1.4 times DL+LL**

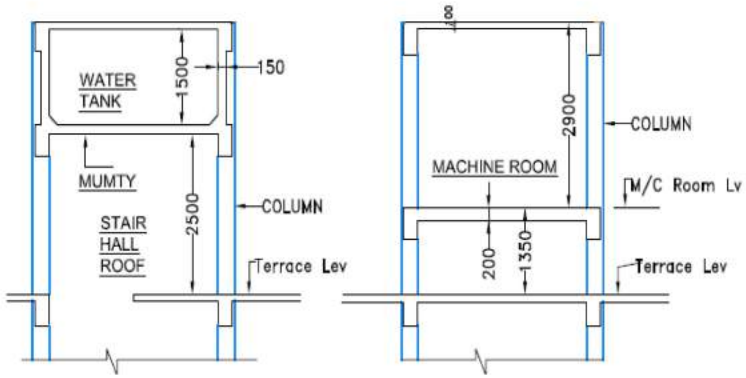
CANTILEVER SLAB
CONTINUOUS OVER BRICKWORK



RCC SLAB CANTILEVER FROM A BEAM

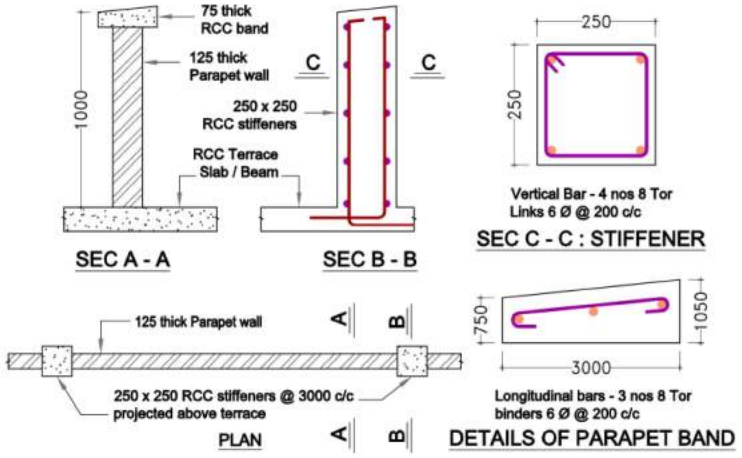


VERTICAL PROJECTIONS ABOVE ROOF

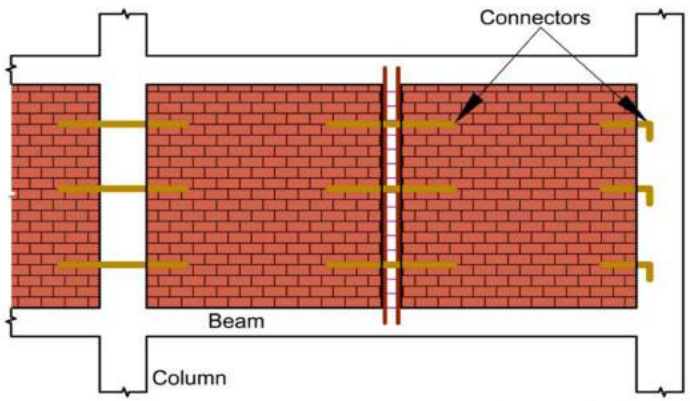


Columns From Foundation to Top

PARAPET IN BRICK WORK



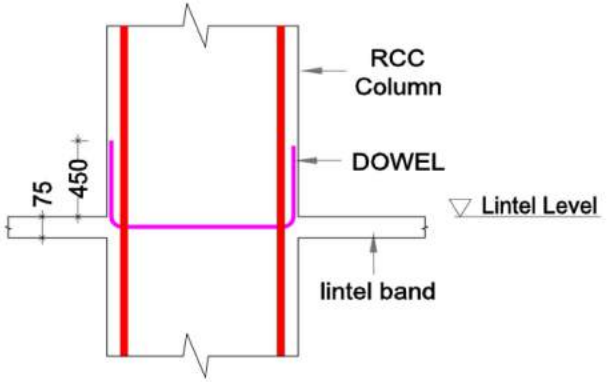
CONNECTION OF BRICK INFILL



SHEAR CONNECTORS FOR FILL-IN BRICKWORK

CONNECTION OF LINTEL

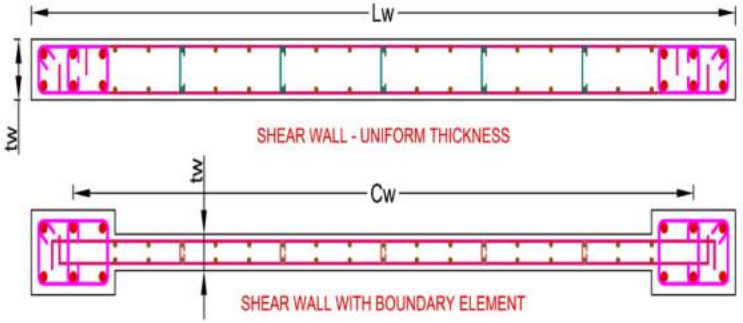
DOWEL FOR LINTEL BAND



Badly damaged concrete shear wall building

SHEAR WALL

IS 13920-1993 Cl. 9



Tw >= 150 mm

Minimum Steel 0.25% of gross area in both direction

WRONG CONSTRUCTION PRACTICES

beam bars are bent at column-beam junction

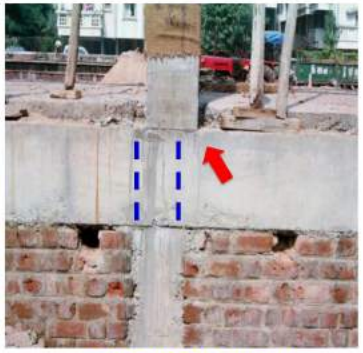
WRONG CONSTRUCTION PRACTICES

Beam bars not anchored into column

wrong position of construction joint

WRONG CONSTRUCTION PRACTICES

discontinuous beam, huge filling load



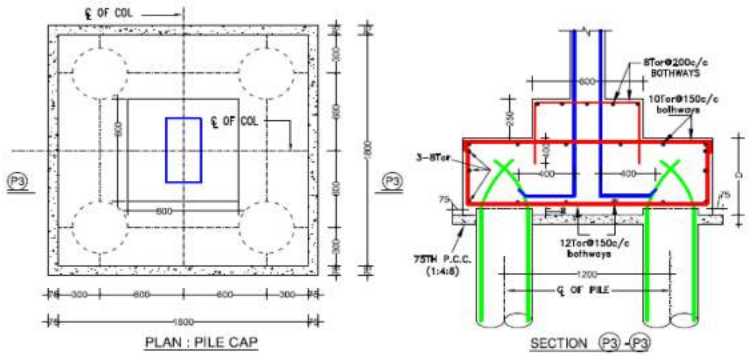
Eccentric Column

WRONG CONSTRUCTION PRACTICES

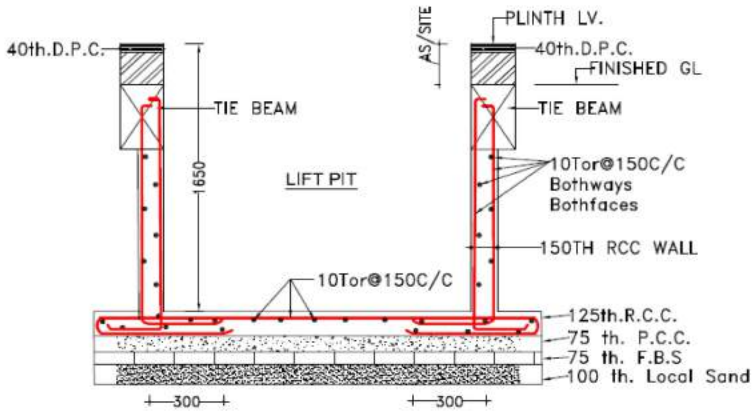
Cutting through a structure member

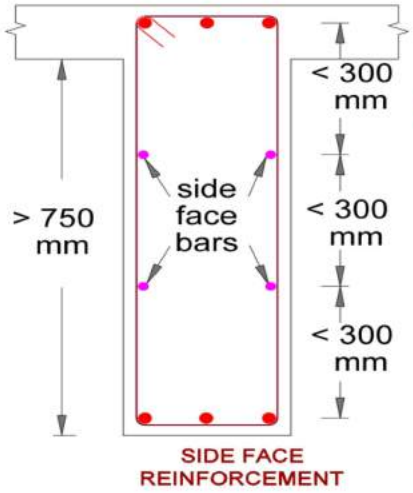
OTHER ESSENTIAL DETAILINGS

PILE CAP



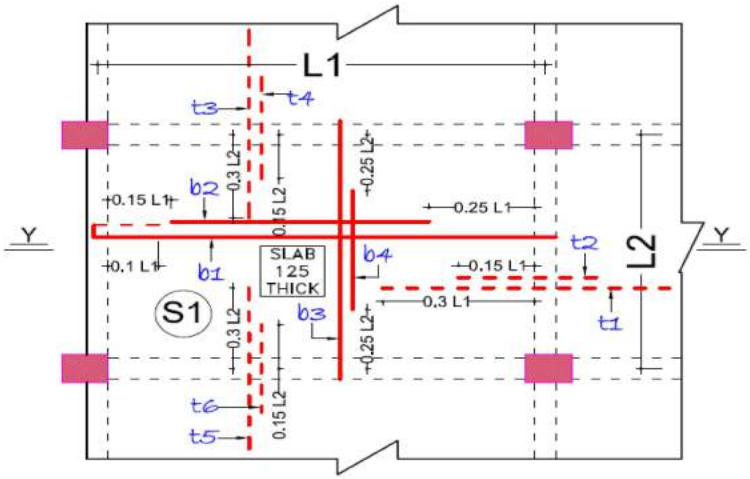
LIFT PIT





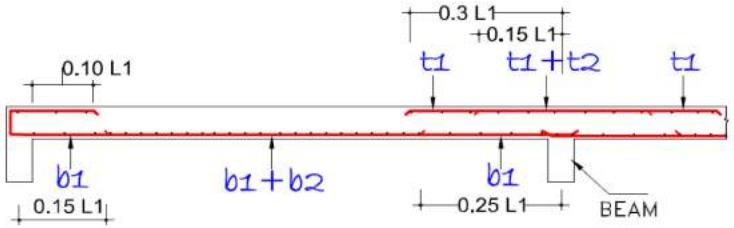
SIDE FACE REINFORCEMENT IN BEAMS

0.05 % of web area on each face



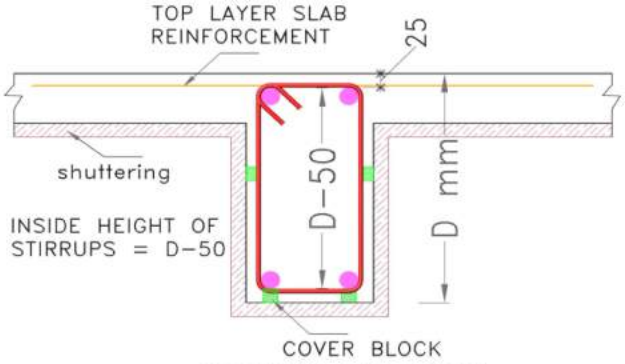
PLAN : SLAB REINFORCEMENT

REINFORCEMENTS IN RCC SLAB



SEC Y - Y THRO TWO WAY SLAB

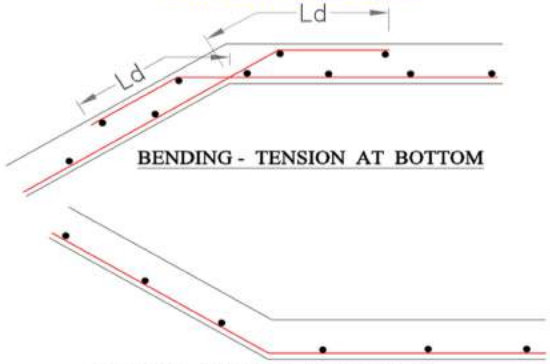
STIRRUP SIZE AND TOP COVER TO TOP LAYER BARS IN SLAB



SECTION : TEE BEAM

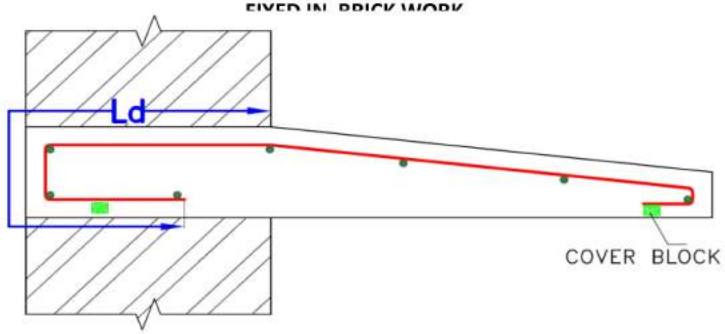
INCLINED RCC SECTION

Reinforcement Details

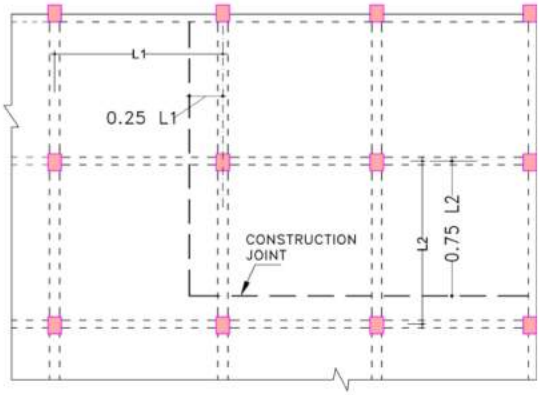


INCLINED BEAM ALONG STAIR

A SIMPLE CANTILEVER CHAJJA

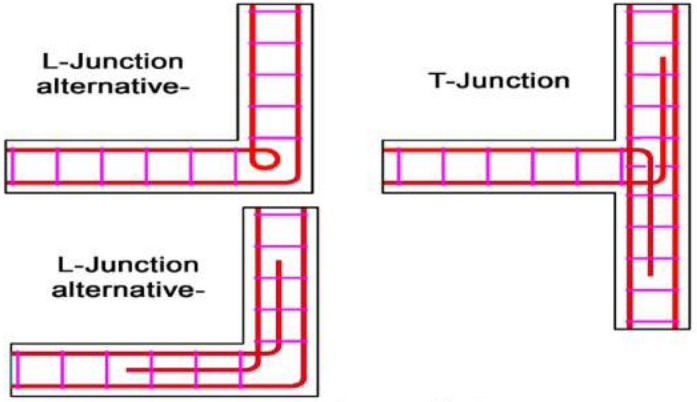


CONSTRUCTION JOINTS



Construction joints can not be provided at the support or mid span.

RC BAND IN MASONRY WALLS



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

THANKS FOR LISTENING

(12)

Ductile Details of RC Members (IS: 13920) &other essential Details

POINTS FOR CONSIDERATION AND DISCUSSION

1. What do you mean by ductility of a structure, or its members?
2. Why the provisions for ductility is important for a RC building?
3. Enlist the provisions of ductility for a RC building.
4. What should be the minimum sizes of column and beam in RCC frame?
5. How much straight length of lateral ties is necessary for confinement of concrete?
6. Calculate area of special confining link for a RC column.
7. How to ensure that plastic flexural failure of beam precedes brittle shear failure of columns?
8. Calculate development length of steel bars in tension.
9. How much anchorage of beam bars is needed, at an external joint in a RCC frame?
10. Explain the reinforcement details of RCC column shown in the sketch.
11. How will you provide special confining ties within a beam-column joint?
12. Explain the provision of special confining ties at column- wall joint and at column- foundation joint?
13. Can beam bars pass within vertical bars of column, if width of column and beams are equal?
14. Explain the provision of reinforcements, their lapping and vertical stirrups in beams?
15. How to ensure that plastic flexural failure of beam precedes brittle shear failure in beams?
16. What are the provisions of IS code for the design of cantilever projections?
17. How to construct a masonry parapet, if terrace slab is under construction?
18. Explain the details of slab reinforcements.
19. Have you ever seen the layout of reinforcements at joints, in lintel band placed over brickwork?
20. Specify the location of construction joint, if roof casting will be continued next day?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(13)

Construction Materials, Precautions in Construction, Quality Assurance & Quality Audit

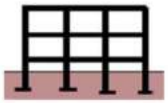
90 min

LET US THINK OVER

- Weak Structures: Why?
- How weak brickwork is constructed?
- What are the defects in Concrete?
- How of RCC work should done?
- How quality of works are assured?
- What is Quality Audit?

WEAK STRUCTURE : why ?

Design ?
Checking ?
Details ?



weak soil ?

Material ?

Trained ?

Supervision ?

Inspection ?

BRICWORK

- DEFECTS IN BRICKWORK
- MATERIALS FOR MASONRY
- RECOMMENDED MORTAR PROPORTION
- WATER SOAKING OF BRICKS
- LAYING CURING
- RAT-TRAP BOND

DEFECTS IN BRICWORK

- POOR QUALITY OF MATERIALS
- POOR QUALITY OF CONSTRUCTION

MATERIAL FOR MASONRY

- Cement – sand mortar with lime is most suitable. This stretches without crumbling at low earthquake shaking and bonds well with bricks.
- The earthquake response of masonry walls depend on the relative strength of bricks and mortar.
- Bricks must be stronger than mortar.

Building categories AS PER IS 4326

Building categories based on importance factors and Seismic Zone :				
Importance Factor	Seismic Zone			
	II	III	IV	V
1.0	B	C	D	E
1.5	C	D	E	F

MORTAR RECOMMENDED AS PER IS 4326	
Category of Building	Proportion of cement-lime-sand
A	M_2 (cement:sand,1:6) or, M_3 (lime:cinder,1:3) or richer
B,C	M_2 (cement:lime:sand,1:2:9) or, cement:sand,1:6) or, richer
D,E	H_2 (cement:sand,1:4) or, M_1 (cement:lime:sand 1:1:6) or, richer

SOAKING OF BRICKS

(IS 2212-1991 Clause 10)

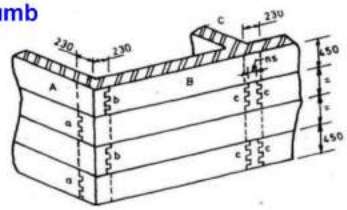
- Water to penetrate whole depth of bricks
  Normally 4 to 6 hour is sufficient
- It assists in removing the dirt and dust
- It reduces chances of efflorescence
- It prevents suction of water from wet mortar
- Soaked bricks to be kept on a clean place
- At the time of use, saturated but skin-dry

BRICKWORK: LAYING, CURING

(IS 2212-1991 Clause 11, 6.4)
(IS 4326 Clause 8.2.4)

- Brick to be laid on a full bed of mortar
- When laying, slightly press the bricks
- Brick joints to be packed with mortar
- Uniform layers, Bed joint thickness < 12 mm
- Construct up to 1 m above general level
- Horizontally aligned, true to plumb

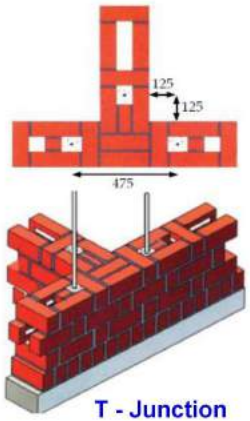
Toothed Joint to be made in both the walls alternatively in lifts of about 450 mm



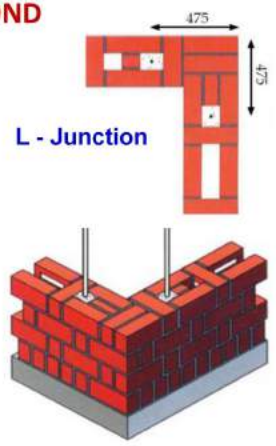
Cement Mortar
1:4, 1:6

Minimum 7 days curing

RAT-TRAP BOND



T - Junction



L - Junction

DEFECTS IN CONCRETE

- SEGREGATION & BLEEDING
- PLASTIC SHRINKAGE CRACKING
- HONEYCOMBING
- CORROSION
- INCOMPLETE COMPACTION
- POOR VIBRATION

SEGREGATION

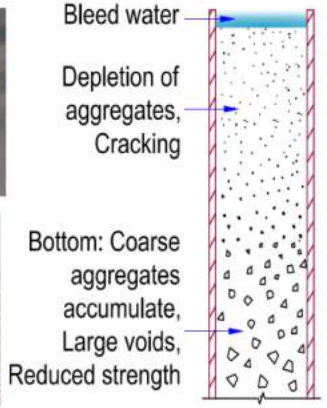
Coarse aggregates separate out from the paste

BLEEDING

Water rises to the surface.

till the paste has stiffened (1 hr)

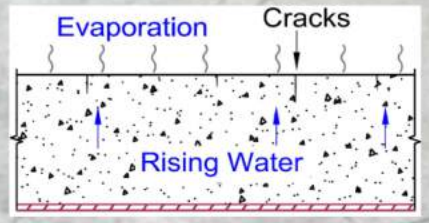
Reasons:
- **Lack of fines,**
- **Excess of water**
- **Non Cohesive Mix**



PLASTIC SHRINKAGE CRACKING

Evaporation rate > Bleeding rate

Drying While plastic



Plastic concrete:
- **Drying**
- **Surface cracks**
- **Loss of bond**

CONTROL :
- **Increase humidity**
- **Moisten forms,**
- **Spray water**

Reduce evaporation
- **Wind barriers**
- **Polyethylene cover**
- **Curing compound**
- **use ice**

HONEYCOMBING AT JOINTS

- **Lack of paste & fines**
- **Rebar congestion**
- **Leaking form joints**
- **Poor compaction**

CORROSION

- **Low cement content**
- **Less Compaction**
- **Less cover to steel**

INCOMPLETE COMPACTION	
air voids	loss of strength
5%	30%
10%	60%

POOR VIBRATION

EXECUTION OF RCC WORK

- MATERIALS & PROCESSES
- ASSEMBLY OF REINFORCEMENT
- ENVIRONMENTAL EXPOSURE CONDITIONS
- COVER TO REBARS
- CONCRETE GRADE & W/C RATIO & CEMENT QTY
- CONCRETE PROPORTIONING
- CONCRETE MIXING
- WORKABILITY AND SLUMP MEASUREMENT
- CONCRETE CASTING, COMPACTION
- CONSTRUCTION JOINT
- CURING OF CONCRETE
- REMOVAL OF FORMWORK

MATERIALS & PROCESSES

- 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

MATERIALS

FORMWORK

Gives concrete its shape

Can be removed
Strong & accurate
Joints: No leakage

Materials: steel, ply board, timber

Formwork face: (IS 456 2000 Cl. 11.2)
- Clean & apply form release agent
- Release agents not to coat rebars

Bolts to secure and align the form-work: **Don't pass** completely through walls / slabs, unless, or, take precautions for **water-tightness**

ASSEMBLY OF REINFORCEMENT

Prepare bar bending schedule

Place the bars as shown in the drawings

Steel bars not to be re-bent Place Bars

Beam bars should pass within column bars

Keep bars straight at joints

Welded Joints or mechanical Connections: Test the joints for full strength of bars

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

Nominal cover may be reduced by 5 mm, *if,*
- *Mild exposure and up to 12-mm main reinforcement*
- *Grade M35 & above in Severe /Very severe exposure*

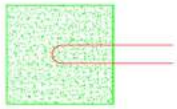
Nominal cover < Actual cover < Nominal cover + 10 mm

CONCRETE COVER TO REBARS

- Min. cover for footings = 50 mm
- Min. cover to long bar in cols = 40 mm

BOTTOM COVER

COVER BLOCK CASTING



SIDE COVER

CHAIR
for top layer bars in slab @ 1 m

CONCRETE GRADE & W/C RATIO & CEMENT QTY 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

CONCRETE GRADE, W/C RATIO & CEMENT

IS 456 2000 Table 3 / 5

Exposure conditions: Mild, Moderate, Severe, Very severe, Extreme → Adopt Moderate (Exposed to rain or under water)

Min concrete grade M25 Use higher → max size of aggregate 20 mm → Max w/c ratio ≤ 0.5 Use lower

450 ≤ Quantity of cement in RCC, kg / cum ≥ 300

High cement content in thin sections

Low cement content in thick sections

CONCRETE PROPORTIONING (IS 456 2000 Cl.10)

1. Stock Materials at least a day before use
2. Check the grading of aggregates frequently
3. Densest concrete with available aggregates
4. Design the mix design as per IS 10262-1982
5. Make allowance for moisture and bulking
6. Weigh-batching of all ingredients
7. If volume batching, Check mass / volume frequently

CONCRETE MIXING

- Always machine mixing
- Mixers with water measuring devices
- Maintain water-cement ratio
- Pour 25% of the water into the drum
- Discharge dry sand and chips into the drum
- Deposit full quantity of cement into the drum
- Pour balance quantity of water
- Mixing till uniform colour and consistency
- 25 to 30 revolutions of the drum
- Minimum mixing time, 2 min
- Check the slump frequently

WORKABILITY AND SLUMP MEASUREMENT

WORKABILITY

- Easy to mix, place, compact and finish
- Easy to flow (slump)

IS 456 Cl. 7.1

50-100 mm slump for heavily reinforced sections in slabs, beams, walls, columns

SLUMP MEASUREMENT IS: 1199

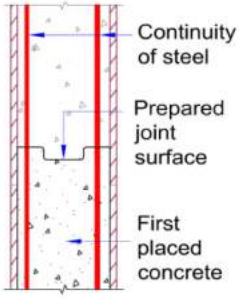
- Take sample: middle fraction
- Fill in three layers
- 16 mm bar, 25 Tamping
- Scrape off the surface
- Lift cone vertically
- Measure the subsidence
- Record the result

CONCRETE CASTING, COMPACTION

- Maximum free fall 1.5 m
- Proper space at the joints for concreting
- Vibrate and compact before initial setting
- Compact around reinforcement & fixtures
- Compact by 16 mm bar at corners and edges
- Use immersion vibrator
- If external vibrator, design formwork for location
- Uniform & full compaction

CONSTRUCTION JOINT

IS 456 2000 Clause 13.4



Prepare Joint Surface

- After initial setting of first concrete
  - Expose the aggregates, sound, irregular & clean SSD surface
  - Use air / water jet & wire brush
- If hardened concrete, Hacking

- Stop curing of joint: 1 hr. before second concreting
- Clean joint & grout a thin layer of cement-water
- No segregation along the joint & thorough compaction

CURING OF CONCRETE

(IS 456 2000 Clause 13.5)

Prevents the loss of moisture
Maintains temperature gradients
Dry concrete = dead concrete

- Begin curing: Exposed surface hardened, 1 - 2 hrs.
- Keep surfaces wet: Ponding or cover with jute blanket
- More curing in : Low w/c ratio, high rate of strength gain
- Temperature > 45°, fast setting, less durable

Longer Curing

REMOVAL OF FORMWORK

(IS 456 2000 Clause 11.3.1)

If temperature does not fall below 15°C and adequate curing is done

Period for Striking Formwork		
Type of Formwork	For OPC	For PPC
Vertical formwork to columns, walls, beams	16 – 24 hrs	24 hrs
Props to beams and arches:		
1) Spanning up to 6 m	14 days	21 days
2) Spanning over 6 m	21days	24 days

QUALITY ASSURANCE

- SUPERVISION
- INSPECTION
- SIEVE ANALYSIS
- TESTS FOR BURNT CLAY BRICKS
- ELONGATION TEST FOR STEEL BARS
- TESTS FOR CEMENT
- CONCRETE CUBE TEST
- QUALITY AUDIT

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

SIEVE ANALYSIS OF SAND, STONE CHIPS & MIX

(IS: 2386 Part I clause 2)

% passing, as per IS: 383 1970 Table 2, Table 4 & Table 5				
Sieve	Sand zone-II	Stone chips 20mm	Stone chips 10mm	All in aggregate
40	-	100	-	100
20	-	85-100	-	95-100
12.5	-	-	100	-
10	-	0-20	85-100	25-35
4.75	90-100	0-5	0-20	0-10
2.36	75-100	-	0-5	-
1.18	55-90	-	-	-
600 micron	35-59	-	-	-
300 micron	8-30	-	-	-
150 micron	0-10	-	-	-
75 micron	-	-	-	-

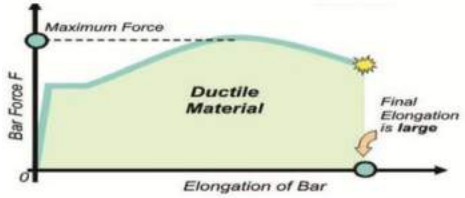
TESTS FOR BURNT CLAY BRICKS

(IS: 1077:1992)

CHECKS

- Compressive Strength > 3.5 mpa
- water absorption < 15 %
- Effloresce : slight

TEST FOR ELONGATION OF STEEL BARS



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 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 TEST

Sampling- IS: 1199-1959 clause 3
cubes made, cured & tested- IS: 516-1959

- 15 cm Moulds: clean, bolt, Oil
- Representative sample
- Compact the concrete in 3 layers with tamping bar
- Cover the cubes with wet hessian & polythene
- Label the cubes and record
- Test at 28 days

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

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

Objectives of Quality Audit

- To assess overall benefit to the end users
- To achieve efficiency of delivered objectives through design, execution, safety and maintenance
- To achieve cost savings in the design process
- To reduce or eliminate the problem areas and resolve the issues raised during the process

Types Of Quality Audits

- Pre-selection Audits: before contract
  To assess designer / supplier / contractor
- Third-Party Audits: By a hired organization
- Internal Audits:
  Inspection and test procedures Performance of Designers/ Contractors
- Audits by the Project Managers:
  All contractual requirements regarding the quality management system

The Audit Report

Includes all the important information and evidences:

- Planning the construction place
- Safety during construction
- Appropriate materials
- Quality Control measures
- Following points must be identified:
  - Observations : objective and factual evidence
  - Nonconformities
  - Improvements Corrective and Preventive Actions
- Important decisions to be taken, after an audit
- Continual improvement based on
  - ✓not only non-conformances and corrective actions,
  - ✓but also highlight areas of good practice

Quality Audit Management

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

(13)

Construction Materials, Precautions in Construction, Quality Assurance & Quality Audit

POINTS FOR CONSIDERATION AND DISCUSSION

1. What are the reasons for weak structures?
2. Why complete soaking of water into the ores of bricks is necessary?
3. What are the important steps in laying the bricks in a wall?
4. For how many days it is necessary to cure the brickwork with water.
5. How can we reduce seggregation and bleeding of fresh concrete mix?
6. How can we reduce plastic shrinkage cracks of fresh laid concrete?
7. How can we reduce honeycombing of concrete?
8. How can we reduce corrosion of steel reinforcements?
9. What are the steps involved in concrete work?
10. Enlist the five environmental exposure conditions stipulated in IS 456.
11. How cover to rebars, concrete grades, w/c ratios and cement quantities are related with exposure?
12. How will you ensure proper proportioning, mixing and workability for concrete?
13. Enumerate the points to be observed during casting and compaction of concrete?
14. How will you start concreting at a construction joint?
15. What is the difference between supervision and inspection?
16. How to conform proper mix of aggregates after sieve analysis?
17. What is the minimum compressive strength of burnt clay bricks?
18. How much minimum elongation is required for Fe500 bars?
19. What is approximate 7 days strength of cube made with PPC?
20. How many concrete cube speciments shall be necessary for 50 cum concrete?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

(14)

NON-STRUCTURAL RISK MITIGATION

FIRE SAFETY, SAFETY OF SERVICES

GREEN BUILDING

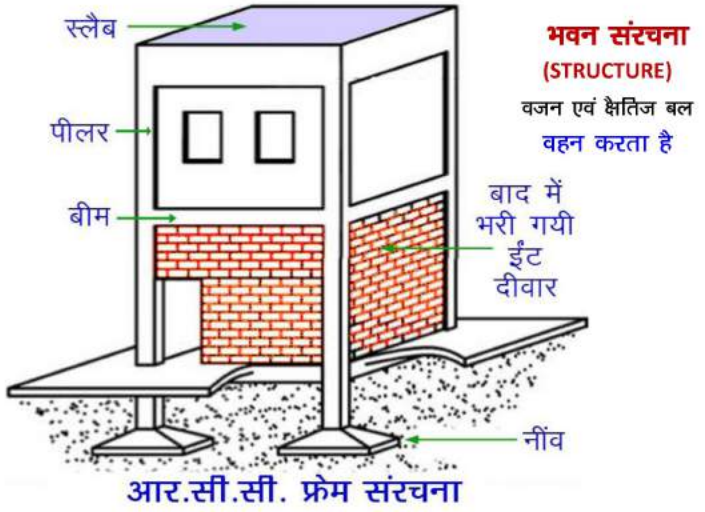
90 min

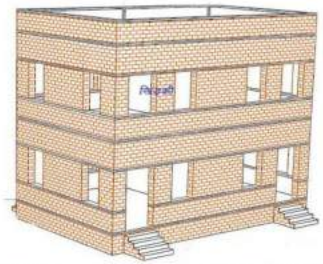
NON-STRUCTURAL RISK MITIGATION

STRUCTURAL ELEMENTS

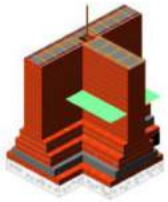
The structural elements differ in each type of building, but generally they include:

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



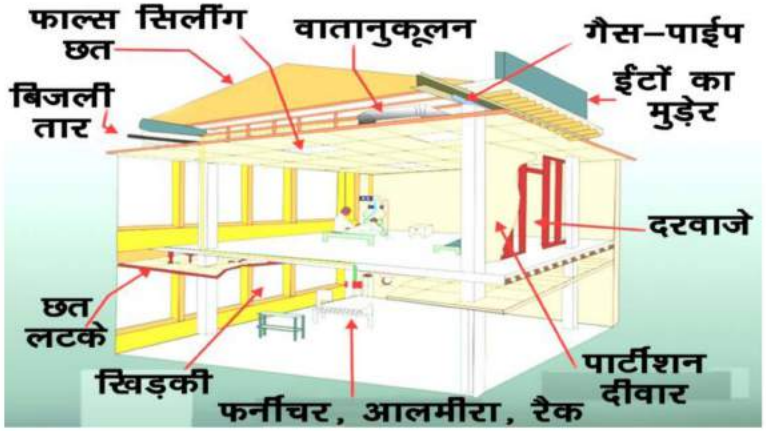


भारवाहक दीवार वाली भवन संरचना



गैर–संरचना अवयव (NON-STRUCTURE ELEMENTS)

संरचना पर लटके या स्थापित



NON-STRUCTURAL ELEMENTS

Chhajja

Parapet

Wall cladding

Partitions

Stairways

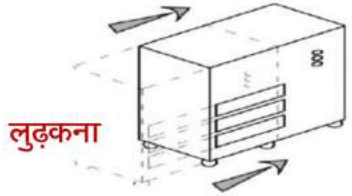
Balcony

Chimneys

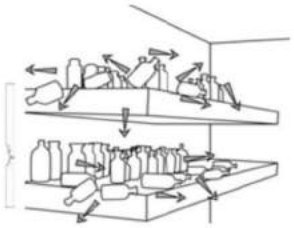
Water Tank

पलटना

RISK OF INJURIES due to BUILDING CONTENTS

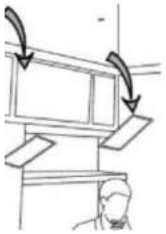


लुढ़कना



गिरना

भूकम्प के दौरान भवन सामग्रियों से खतरे



फोटो फ्रेम गिरने से
चोट लग सकता है।

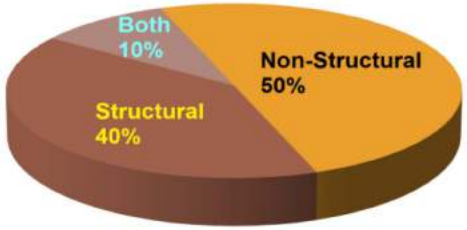
आलमीरा गिरने से
दरवाजा बंद हो सकता है।

आलमीरा गिरने से चोट लग सकता है।

FALLING HAZARD RISK 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*

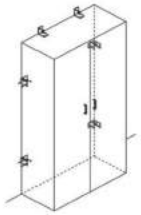


Injuries during earthquake

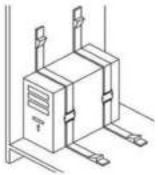
NSE RISK MITIGATION

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

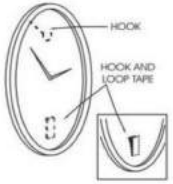
- उन्हें संरचना के साथ मजबूती से बाँधना होगा,
- अथवा, उन्हें हटा देना चाहिए।



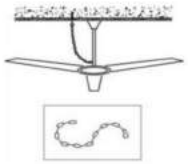
angles



strap



hook



chain

संरचना के साथ बाँधने की सामग्री

FIRE SAFETY OF BUILDINS

Earthquakes are frequently followed by **fire**

Buildings shall be made **fire resistant**

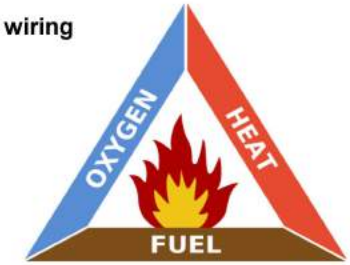
Provisions of Indian Standards for fire safety:

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

15 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
- Earthquakes



FIRE TRIANGLE

MAIN COMPONENTS OF FIRE PROTECTION

- Preventing the initiation of fire
- Restricting the growth and spread of fire
- Containment of fire within a part of building
- Means of escape for the occupants
- Control of fire by devices and by active fire fighting

PASSIVE MEASURES OF FIRE SAFETY

- Install fire sources away from combustible materials
- Reduce quantity & area of combustible material
- Separation of buildings to avoid spread
- Provision and design of escape routes
- Measures for smoke control & save facilities

ACTIVE MEASURES OF FIRE SAFETY

- Fire detection and warring system
- Sprinkler installation
- Fire fighting

REQUIREMENTS OF EXITS

Exits 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

TRAVEL DISTANCE FOR SAFE EXITS

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

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

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 door, when opened, width not less than 0.9 m.
4) Exit doorways shall open outwards, but not obstruct travel.
5) Exits doors shall be operable from the inside without the use of a key.
6) Exit doors shall open into a landing and not directly into a flight of stairs.

FIRE DOOR

Rating 20-minutes to 3 hours

Maintain fire doors and shutters in good operating condition

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

obstructed
fire escape stair

STAIRWAYS

RELATION BETWEEN TREAD & RISER

- Tread + 2 (rise) = between 550 to 700 mm.
- Average human (horizontal) stride is ~600 mm and vertical direction is 300 mm

ACCIDENTS

- More accidents take place while descending than ascending.
- When width of tread reduces, chances of miss-steps increases.

WALKING SPEEDS

- People travel faster while moving down. trend reverses in dense crowd.

STAIRWAYS
INTERIOR STAIRS

1. No combustible material
2. Self contained, with at least one wall adjacent to an external wall.
3. Generally, shall not be arranged around a lift shaft.
4. min. width = 100 cm
5. min. tread = 25 cm for residential buildings; and 30 cm for other buildings.
6. 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.

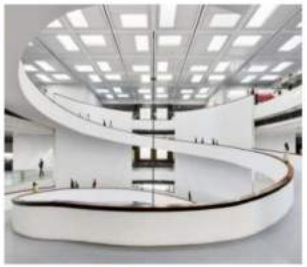
SPIRAL STAIRCASE

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

RAMPS

1. maximum slope of 1:10 (can substitute for 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 slopes >1:10, non skid materials to be used. Should not be within minimum setbacks.

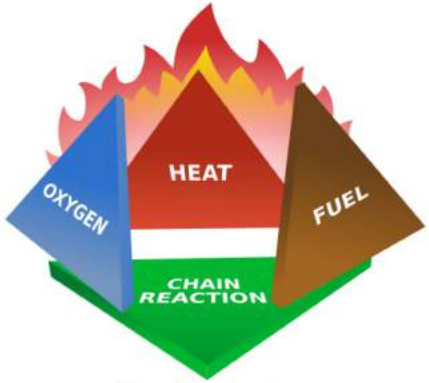
1. for heights >2.40 meters, slope shall not be greater than 1:20.
2. Hospital ramps should not have slopes > 1:20.
3. Permitted in the basement within minimum setback, provided it does not obstruct movement of the fire engine.



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

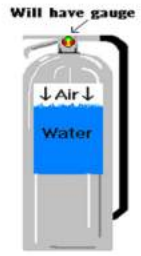
CLASSIFICATION OF FIRE based on types of FIRE EXTINGUISHERS

	Class of Fire	Description	Suitable suppression
	Class A (A - Ash)	Combustible materials (paper, wood, cloth, some rubber, plastic, most kinds of trash)	Most suppression techniques
	Class B (B - Barrel)	combustible liquids, flammable gases, greases, some rubber and plastic materials	Inhibiting chemical chain reaction by water mist, dry chemical or Halon
	Class C (C - Circuit)	energized electrical equipment	Nonconductive extinguishing media. (water not to be used)
	Class D (D - Dynamite)	combustible metals (such as magnesium, titanium, zirconium, sodium, lithium and potassium)	Specialist suppression required
	Class K (K-Kitchen)	Grease	By removal of oxygen or use of water mist

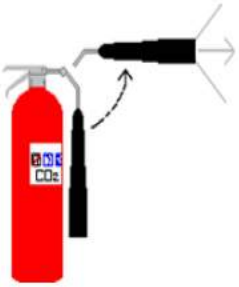
PORTABLE FIRE EXTINGUISHERS

- 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



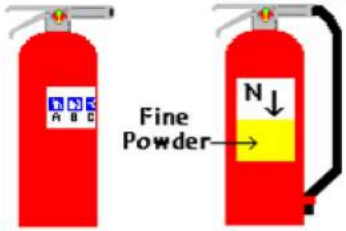
Pressurized Water
Class A fires
Pressure gauge



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



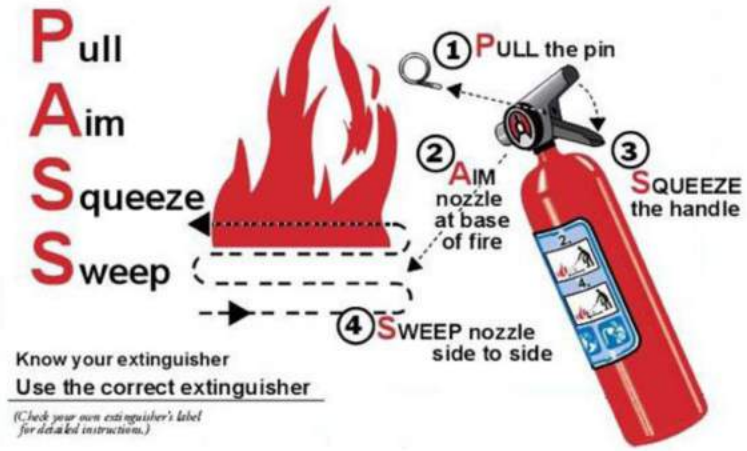
Multi-Purpose Dry Chemical
Use on Class A, Class B, and Class C fires
Fine powder under pressure
Pressure gauge present

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:



FIRE FIGHTING SYSTEMS

fire alarm system

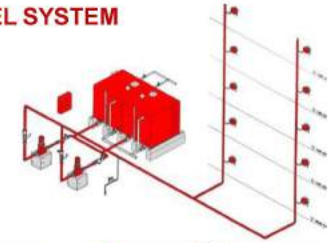
smoke detector

heat detector

fire hydrant

automatic sprinkler systems

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

SAFETY OF BUILDING SERVICES

Mechanical Services
Fire fighting
Escalators and lift
HVAC Systems
(heating, ventilation, and air-conditioning)

Electrical Services
Lighting
Cables & wires
Control devices
diesel generators
battery-based units

Plumbing Systems
Water tanks
Bathroom fixtures
Water Supply line
Fire hydrant
Rainwater pipes
Storm Drainage
Sewage pipelines
Drainage of wastes

Safety
Security and alarm systems
Fire detection and protection

Data base Systems
Security Systems
Fire Alarm Systems
Public Address Systems
Cable TV Systems
Data cables
Communication network

Efficiency
Facade
Gas pipelines

DAMAGED BUILDING SERVICES

electric substation damaged

circuit breaker damaged

Damaged Transformer

Light mount failure

DAMAGED BUILDING SERVICES continued...

collapse of transmission towers

Electric pole overturned

Communication rack damage

air-conditioning ducts collapsed

DAMAGED BUILDING SERVICES continued...

Fire hydrant

failure of sprinkler system

failure of hot water system

Collapsed water tank

DAMAGED BUILDING SERVICES continued...

Gas leakages

Lift Door

Waterline pipe joints

DAMAGED BUILDING SERVICES continued…

Brocken sludge pipe

Water pipe & sewer line crossing

Brocken sewer pipe

pipe joint moved

GREEN BUILDINGS

ABUSE OF NATURAL ENVIRONMENT

WORSENING NATURAL DISASTERS

IMPACT ON HUMAN HEALTH


Commuting Traffic


Stress


Smog


High temperature


Extreme Weather


Health Deterioration

WHAT IS A GREEN BUILDING

- A building that is environmentally responsible and resource-efficient throughout its life-cycle.
- uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space for occupants as compared to conventional buildings.
- Designed to reduce the adverse impact of the built environment on human health & natural environment

FUNDAMENTAL PRINCIPLES

FEATURES OF GREEN BUILDINGS

SUSTAINABLE SITE DEVELOPMENT


GULMOHAR


JACARANDA


ALSTONIA


AMALTAS


NEEM


KACHNAR

- Minimal disturbance to landscapes and site conditions
- Using native plants that survive without extra watering)

To reduce pressure on undeveloped land.
Minimum disruption of natural ecosystem.

FEATURES OF GREEN BUILDINGS
MATERIALS SELECTION

MATERIALS IN CONSTRUCTION
- Re-use
- Recyclable
- From renewable sources
- Natural
- Durable
- Locally available


straw


grasscrete


Fly ash bricks

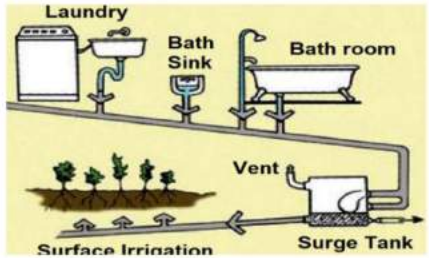

bamboo

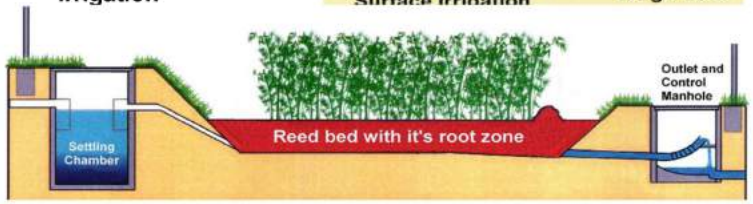

Recycled Plastic


Timbercrete walls

FEATURES OF GREEN BUILDINGS
WATER EFFICIENCY

- Reduced water consumption
- Protect water quality
- Water purification and reuse
- Use of non-sewage water for on site irrigation





FEATURES OF GREEN BUILDINGS
ENERGY EFFICIENCY Active Systems


Photovoltaic Panels


Solar Water Heating


Wind Turbines

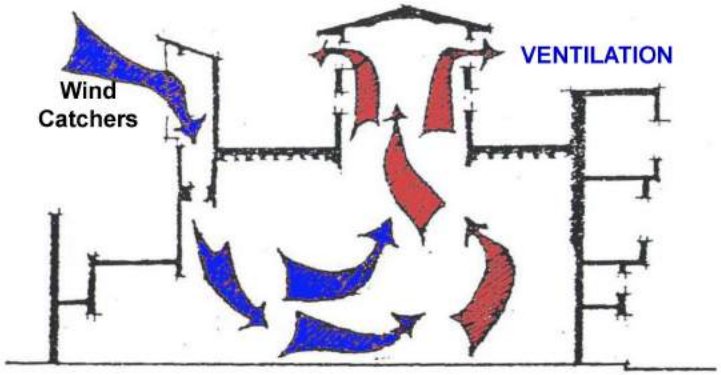

Hydro-electric Power

Onsite generation of renewable energy through
1. solar power 2. wind power 3. hydro power
4. biomass 5. geothermal power

FEATURES OF GREEN BUILDINGS
ENERGY EFFICIENCY: Passive Systems

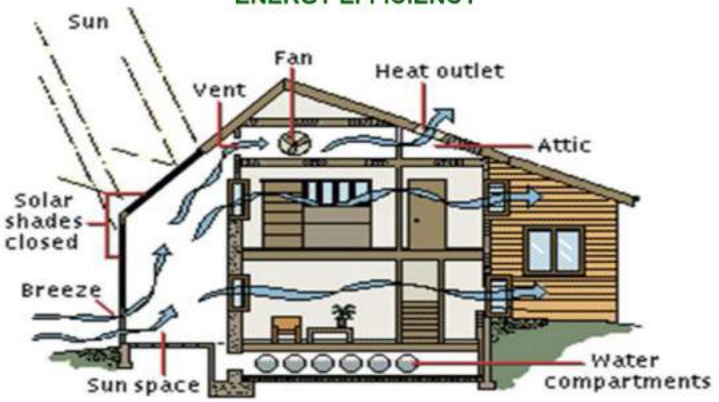
FEATURES OF GREEN BUILDINGS

ENERGY EFFICIENCY: Passive Systems



FEATURES OF GREEN BUILDINGS

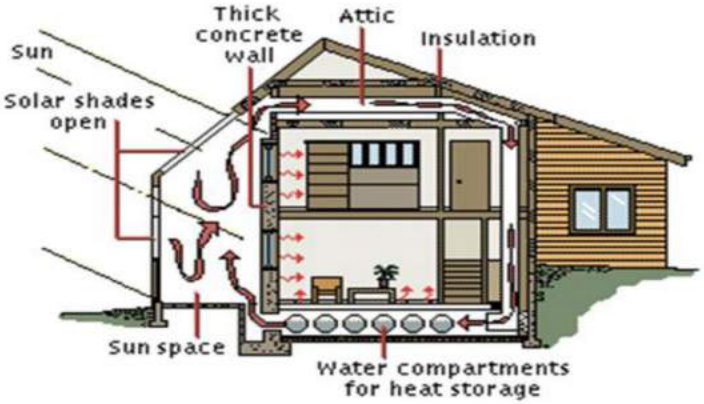
ENERGY EFFICIENCY



Passive solar cooling
(Summer)

FEATURES OF GREEN BUILDINGS

ENERGY EFFICIENCY

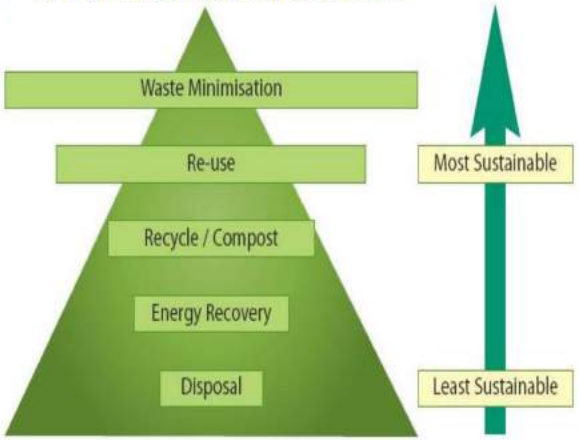


Passive solar heating
(Winter)

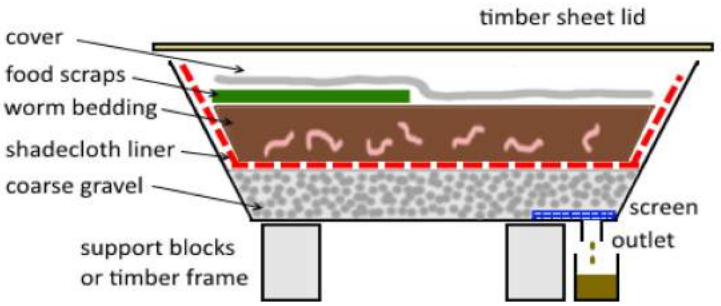
FEATURES OF GREEN BUILDINGS

ENERGY EFFICIENCY: TREE SHADE

FEATURES OF GREEN BUILDINGS
WASTE AND TOXIC REDUCTION



FEATURES OF GREEN BUILDINGS
WASTE AND TOXIC REDUCTION



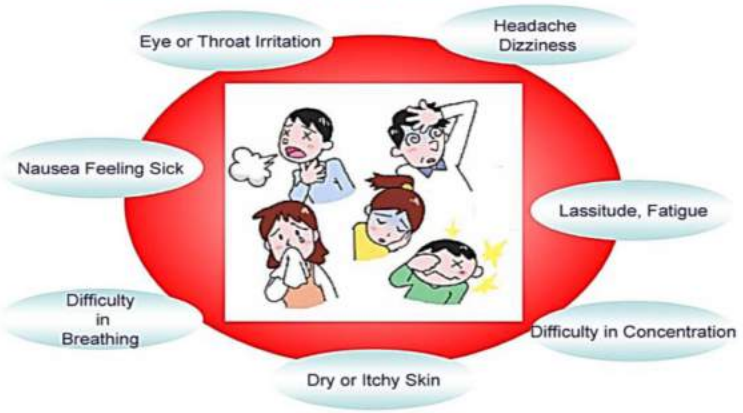
Vermicomposting

FEATURES OF GREEN BUILDINGS
WASTE AND TOXIC REDUCTION

Waste recycling

waste to fuel

FEATURES OF GREEN BUILDINGS
INDOOR ENVIRONMENTAL QUALITY
Indoor air is more polluted than outdoor air



FEATURES OF GREEN BUILDINGS

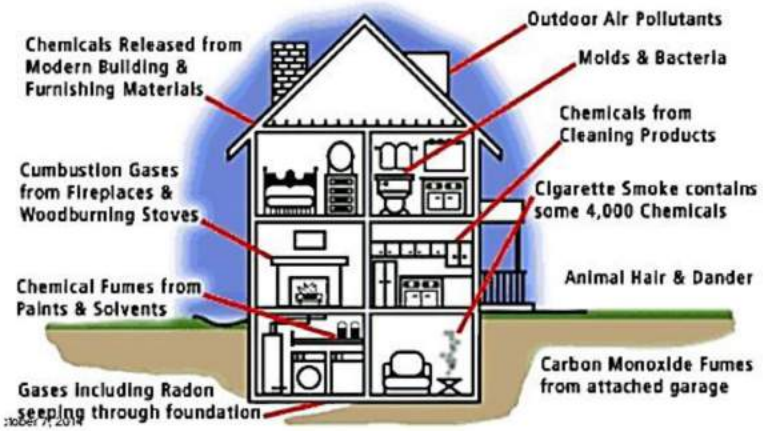
INDOOR ENVIRONMENTAL QUALITY

UNHEALTHY MATERIALS

- Carbon tetrachloride: highly potent liver toxin.
- Benzene: Leukemia.
- Chlopyrifos: Nervous break down.
- Phenol, Methylnaphthalene: Cancer.
- Epoxides: Damage genetics & immune system.
- Vinyl Chloride: Brain Damage.

FEATURES OF GREEN BUILDINGS

SOURCES OF INDOOR POLLUTANTS

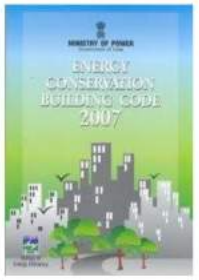


FEATURES OF GREEN BUILDINGS

INDOOR ENVIRONMENTAL QUALITY

GREEN BUILDING POLICY & CODES

NATIONAL BUILDING CODE (NBC) The Bureau of Indian Standards (BIS)



ENERGY CONSERVATION BUILDING CODE (ECBC) The Bureau of Energy Efficiency (BEE)

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) Ministry of Environment and Forests (MoFE)

INDIAN GREEN BUILDING COUNCIL

NEW BUILDING	EXISTING BUILDING	GREEN HOMES
RESIDENTIAL SOCIETIES	INTERIORS	HEALTHCARE
SCHOOLS	INDUSTRIES FACTORIES	DATA CENTER
GREEN CAMPUS	VILLAGES	TOWNSHIPS
CITIES	SEZs	LANDSCAPES
MASS RAPID TRANSIT SYSTEM	EXISTING TRANSIT SYSTEM	GOVERNMENT INCENTIVES

GRIHA RATING SYSTEM

Green Rating for Integrated Habitat Assessment

Based on Panchabhutas – five elements of the nature

applicable to all five climatic zones of India

Perfect blend of ancient architecture & modern technology

IGBC rating have become National Choice and Global in Performance.

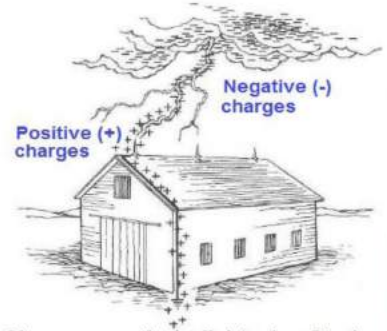
LEED-INDIA & GRIHA RATING SYSTEM

different levels of certification:-

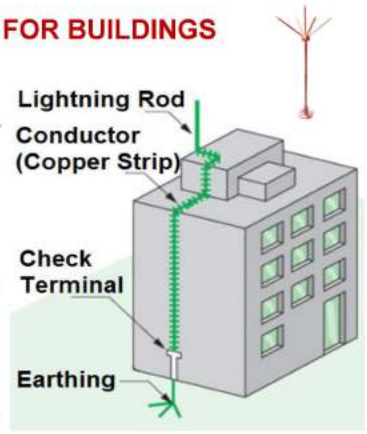
- 'Certified' to recognise best practices.
- 'Silver' to recognise outstanding performance.
- 'Gold' to recognise national excellence.
- 'Platinum' to recognise global leadership.

40-49 50-59 60-79 80+

LIGHTNING ARRESTER FOR BUILDINGS



Charges creating a lightening Stroke



THANK YOU

(14)

Mitigation of Non-Structural Hazards, Fire Safety, Safety of services, Green Building,

POINTS FOR CONSIDERATION AND DISCUSSION

1. Differetiate between Structural elements, non-structural elements and buildinding contents.
2. What are the risks of injuries due to non-structural elements and building contents?
3. What percentage of injuries are reported due to non-structural hazards during earthquakes?
4. How the risks due to non-structural elements can be mitigared?
5. What are the commomn causes of fire?
6. What are the basic requirements of safe exits?
7. What are the minimum provisions of exterior fire scape stairs?
8. What do you mean by fire fighting?
9. Classify the fire based on the types of fire extinguishers.
10. What are the materials used in different fire extinguishers?
11. How to operate a fire extinguisher?
12. Enumerate the fire fighting systems.
13. What are the types of building services?
14. What is a green building?
15. Which type of construction material will you select for green buildings?
16. Explain active and passive system for energy efficiency?
17. How to dispose waste in a green building concept?
18. What are ingradients of healthy indoor environment?
19. What is GRIHA rating system?
20. How to safeguard a building from lightening?

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

(5) भूकम्परोधी भवन पर जिलों में अभियंताओं का प्रशिक्षण

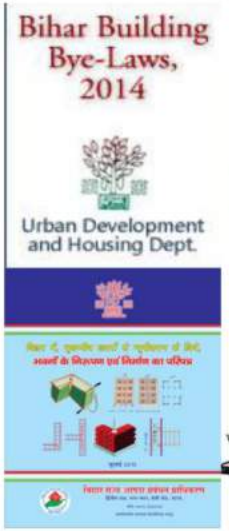
(15)

BIHAR BUILDING BYE LAWS 2014

STRUCTURAL DESIGN BASIS REPORT

DRR Road Map 2015-2030

60 min



BIHAR BUILDING BYE LAWS 2014

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 shall prepare the structural design and furnish a certificate to supervise the structural part of the construction and shall be responsible for any structural failure, except the owner terminates his services.

4. **Provision for preparedness against hazards** *{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 {Article (16)(4)}**

   Municipal authority shall verify that the building complies with the provisions of life safety as mentioned in National Building Code 2005 . 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. **Section (22)(1); Section (22)(2)**

   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.
   other rivers 100 m

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)}*

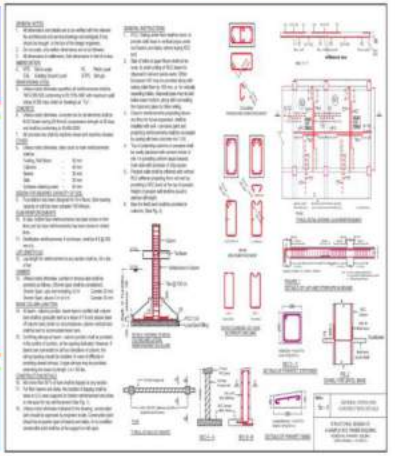
In case of multi storied buildings the exterior open space around a building shall be of hard surface capable of taking load of fire engine weighting up to 45 tonnes. *{Section (36)(3)}*

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.

STRUCTURE DESIGN BASIS REPORT (SDBR)

BIHAR BUILDING BYE-LAWS

"For buildings more 15 m 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."

SDBR is prepared by:-
The structural designer, while initiating structure analysis, *Prior to Structural Design*

SDBR is prepared for :-

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

TO FILL UP RELEVANT INFORMATIONS in Prescribed SDBR Form

FORM

Column 1: Description of Structure Design item

Column 2: Information of Design parameters / values

Column 3: Notes having reference to BIS Codes

- ✓ Supplemented with Plan & Sections of buildings

CONTENTS OF SDBR FORM

- LOAD BEARING MASONRY BUILDING
- RCC FRAME BUILDING
- STEEL BUILDING

Part 1: General Data

Sl No	Description	Information	Notes
1	Address of the building • Name of the building • Plot number • Subplot number • TPS scheme a. Name b. Number • Locality/Township • District		
2	Name of owner		
3	Name of Builder on record		
4	Name of Architect/Engineer on record		
5	Name of Structural engineer on record		
6	Use of the building		
7	Number of storeys above ground level (including storeys to be added later, if any)		
8	Number of basements below ground Level		
9	Type of structure • Load bearing walls • R.C.C frame • R.C.C frame and Shear walls • Steel frame		
10	Soil data • Type of soil • Design safe bearing capacity		IS: 1893 Cl. 6.3.5.2 IS: 1904
11	Dead loads (unit weight adopted) • Earth • Water • Brick masonry • Plain cement concrete • Reinforced cement concrete • Floor finish • Other fill materials • Piazza floor fill and landscape		IS: 875 Part 1
12	Imposed (live) loads		IS: 875 Part 2

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

Government of Bihar
Department of Disaster Management

BIHAR DISASTER RISK REDUCTION ROADMAP 2015-2030

PARTNERSHIP OF ENGINEERS

30 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: ▪ 28 districts prone to floods ▪ 17% flood-prone area	**Earthquake:** 7 dist. in Seismic zone V EQ in 1934, 1988 & 2015 63 lost life in 2015 EQ in Bihar
Drought: 13 dist.) suffer from drought drought in 2002, 2007, 2008, 2009, 2010, 2011 & 2013	**Cyclonic storms:** 27 dists fully affected killed 59 people in April, 2015
Severe Cold wave, Heat Wave, Lightning, Hailstorm	**Village fires in summer:** 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

EARTHQUAKE ADVISORY CELL

1. Earthquake advisory cell shall be constituted in each district of Bihar, by the respective Executive Engineer, Building Construction Division.
2. Advisors shall be outsourced in the advisory cell.
3. Any person having queries regarding earthquake resistant construction / retrofitting of his / her house can approach to the advisory cell and get suggestion.
4. This will promote earthquake safe construction in Bihar.

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.

THANK YOU

(15)

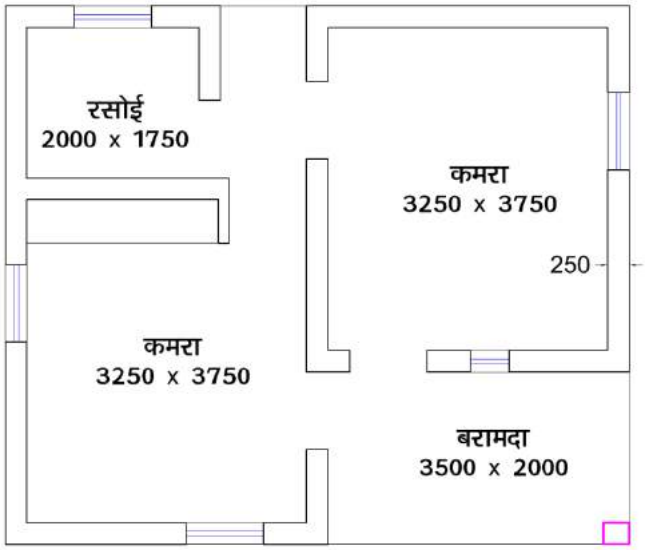
Bihar Building Bye-Laws 2014, SDBR, DRR Road Map, EQ Advisory Cell

POINTS FOR CONSIDERATION AND DISCUSSION

1. What is the main content of Bihar municipality act and Bihar urban planning act?
2. Enlist the area and activities, where Bihar building byelaws 2014 is applicable.
3. As per building byelaws, who will certify that earthquake safety requirements will be complied?
4. Who will perform structural design and supervise the structural part, as per byelaws?
5. What are the safety provisions to be observed for issuing occupancy certificate as per byelaws?
6. What are the provisions of unsafe buildings as per byelaws?
7. What is the content of Appendix A of Bihar building byelaws 2014?
8. Enlist the forms to be submitted for ensuring seismic safety as per byelaws.
9. Who will prepare the Structure Design Basis Report and when?
10. In which office the Structure Design Basis Report may be sumitted?
11. Explain the layout of SDBR Form and its Contents.
12. Differentiate between General data and Building Type Data, in the context of SDBR.
13. Explain the process of development DRR roadmap 2015-2030.
14. What DRR Initiatives have been taken in Bihar and achieved till 2015?
15. Enlist A, B and C districts in view of multi-hazard profile of Bihar.
16. What are the targets of DRR Roadmap 2015-2030?
17. What are the milestones to be achieved as per DRR roadmap?
18. What are the general points for all departments/ agencies as per DRR roadmap?
19. Specify the actions to be taken by BCD as per DRR Roadmap?
20. What is the function of Earthquake Advisory Cell in the districts?

APPENDIX

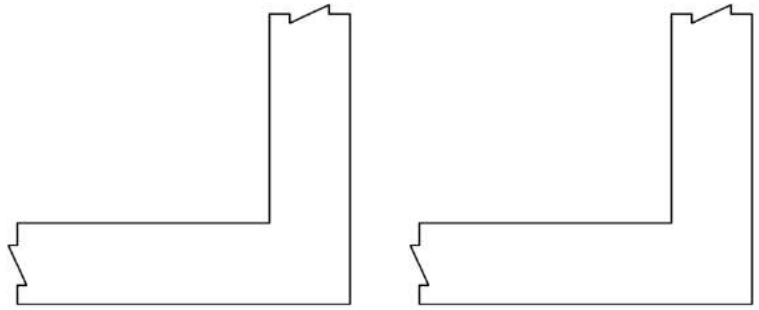
Qn. 1. Show RCC band and Corner Vertical steel reinforcement in a Masonry Building



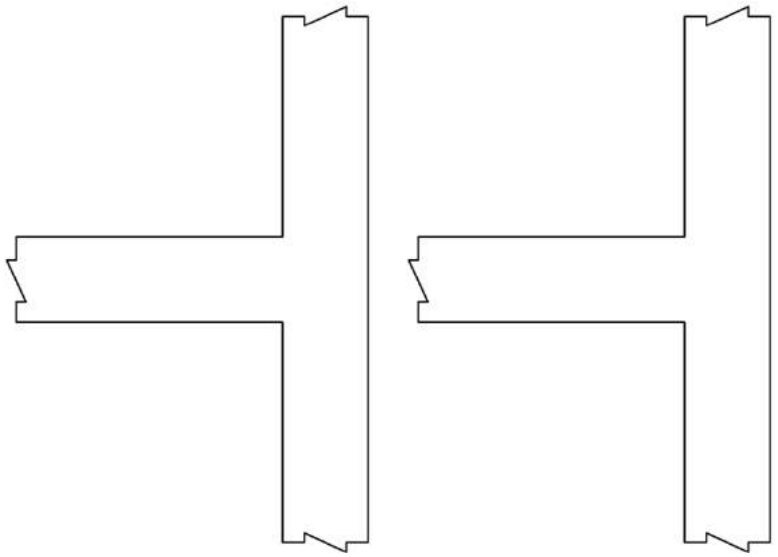
मकान का प्लान

सामने से एलीवेसन

Qn.2. Create a pocket in 2 consecutive layers of brickwork to provide vertical reinforcement at L joint. (walls are 250 mm thick)

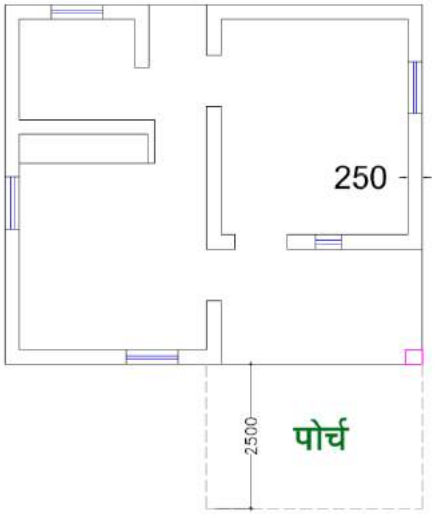


Qn.3. Create a pocket in 2 consecutive layers of brickwork to provide vertical reinforcement at T joint. (walls are 250 mm thick)

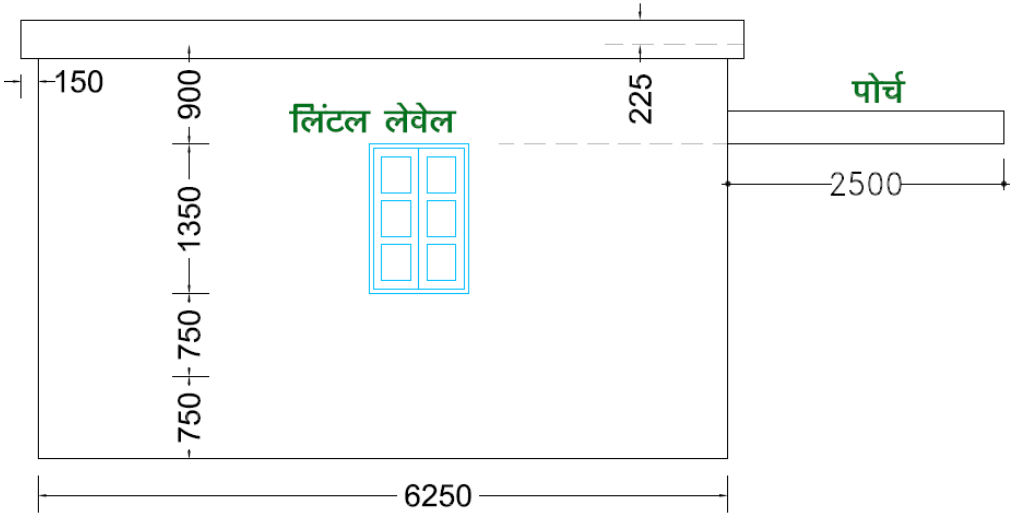


APPENDIX

Qn. 4. Show reinforcement details of a Cantilever Porch in a Masonry Building (Counterweight Requirement and proper fixing).

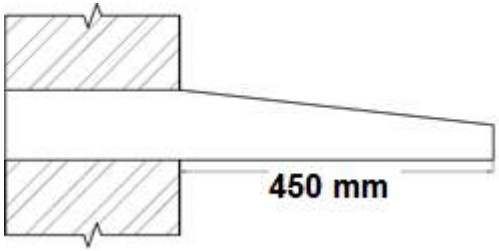


मकान का प्लान

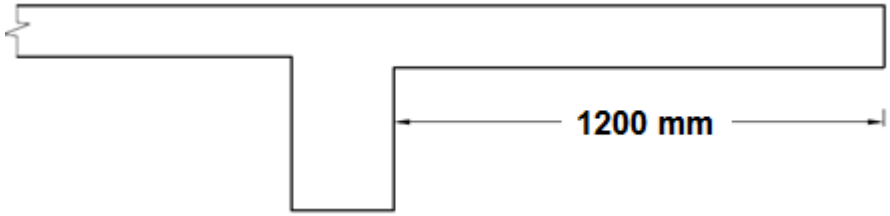


बाऐं से एलीवेसन

Qn. 5. Show reinforcement details in chajja and balcony below :-

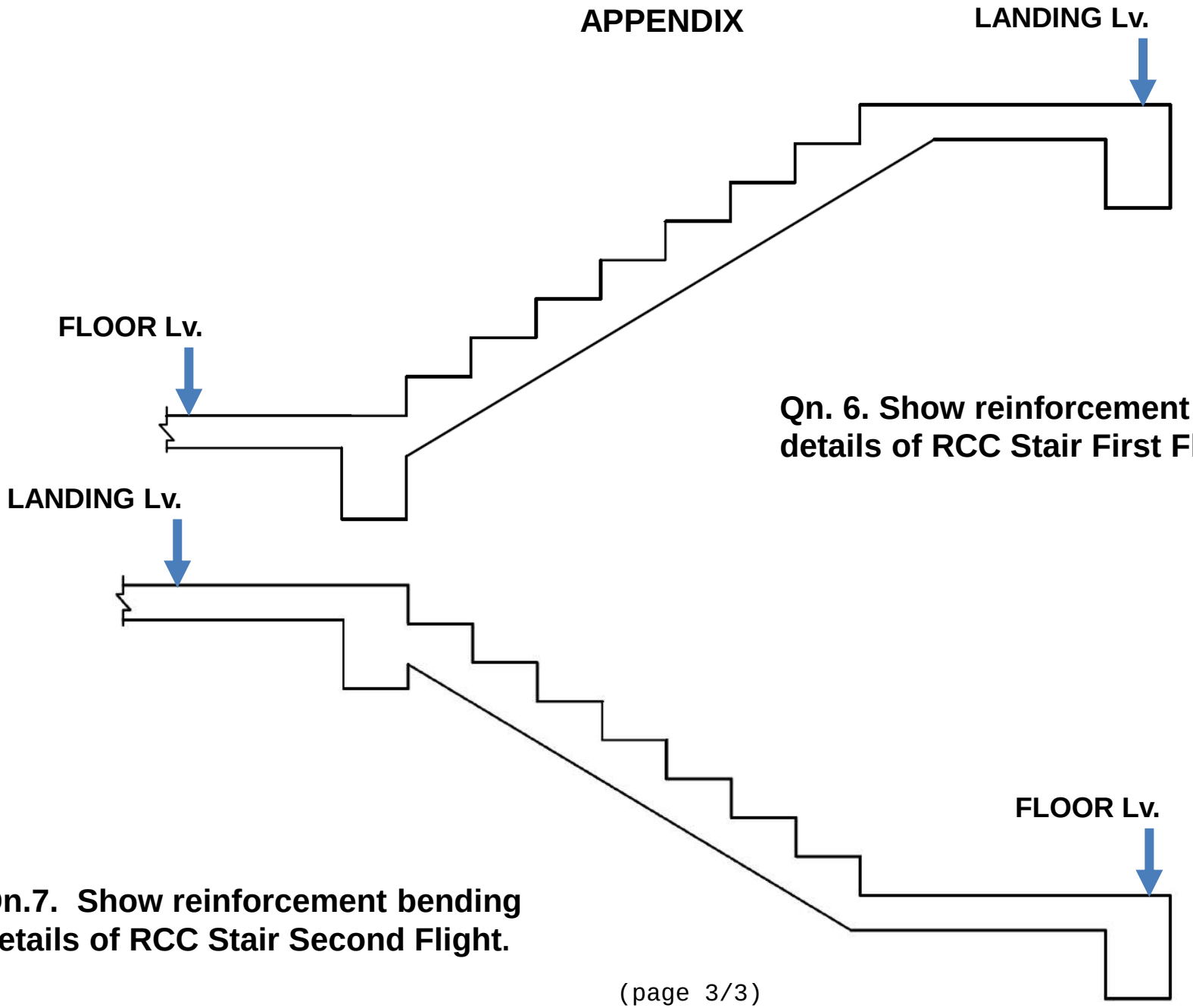


A cantilever chajja from brickwork



A projected balcony slab

APPENDIX



Qn. 6. Show reinforcement bending details of RCC Stair First Flight.

Qn.7. Show reinforcement bending details of RCC Stair Second Flight.

भूकम्प से बचाव के लिए क्या करें, क्या न करें।

भूकम्प से पहले


घर को सुदृढ़ कर भूकम्परोधी बनाएं।

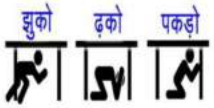
भारी एवं शीशा का सामान निचले खाने में रखें।

अलमारी को क्लैम्प से दीवार में जकड़ दें।

बचाव एवं प्राथमिक उपचार का प्रशिक्षण लें।

आवश्यक सामान के साथ सुरक्षा किट तैयार रखें।

अपने आस-पास सुरक्षित स्थलों की पहचान कर लें।



झुको-ढ़को-पकड़ो का नियमित अभ्यास करें।

भूकम्प के दौरान

हड़बड़ाकर मत भागें।

कमरे के अंदरूनी कोने के पास रहें।

मजबूत टेबुल या उँचे पलंग के नीचे छिप जाएं।

गिरने वाली चीजों से दूर रहें।

सिर को बचाएं।

यदि मजबूत मकान में हैं, तो वहीं बने रहें।

यदि किसी ऊँची इमारत में हैं तो वहीं बने रहें।

यदि निकास द्वार के पास हैं तो शीघ्र बाहर निकल जाएं।

यदि कमजोर मकान में हैं तो शीघ्र बाहर निकलें।

लिफ्ट का उपयोग मत करें।


यदि गाड़ी चला रहे हों, तो सड़क के किनारे रूकें, पुल पर न चढ़ें।


यदि सिनेमा या मॉल में हों, तो अपनी जगह पर शांत रहें, झटका रूकने पर, क्रम से बाहर निकलें।

इमरजेंसी फोन नं :-

पुलिस – 100
अग्निशमन – 101
एम्बुलेंस – 102, 108
आपदा नियंत्रण कक्ष, पटना – 0612 2217301 से 2217305

भूकम्प के बाद

गैस सिलिन्डर बन्द करें।

मेन स्वीच ऑफ करें।

घर से बाहर निकलें।

सीढ़ी से उतरें।

गिरने वाली चीजों से सिर को बचाएं।

शीशे की खिड़कियों से दूर हो जाएं।

बिजली पोल, विज्ञापन बोर्ड, पेड़ से दूर रहें।

खुले मैदान में आ जाऐं, घायलों की सहायता करें।

AGENDA	
Day - 1	
1000 Hrs - 1015 Hrs	*Registration, Distribution of Resource Materials*
1015 Hrs - 1100 Hrs	*Inauguration*
1100 Hrs - 1130 Hrs	*Necessity of and Introduction to Training Program*
1130 Hrs - 1145 Hrs	Tea Break
1145 Hrs - 1315 Hrs	*(1) Disaster Management & Disaster Damage Scenario*
1315 Hrs - 1400 Hrs	Lunch Break
1400 Hrs - 1530 Hrs	*(2)Engineering Seismology and Types of seismic hazards*
1530 Hrs - 1600 Hrs	Tea Break
1600 Hrs - 1730 Hrs	*(3) Ground failure, Soil liquefaction, Land Zone Plan, Site Selection, Sub surface Investigations, Construction of Foundations*
Day - 2	
1000 Hrs - 1130 Hrs	*(4) Principles of Earthquake Resistant Buildings (IS:1893) and Architectural Considerations*
1130 Hrs – 1145 Hrs	Tea Break
1145 Hrs - 1315 Hrs	*(5) Masonry Buildings: Failures and Integrity*
1315 Hrs - 1400 Hrs	Lunch Break
1400 Hrs - 1530 Hrs	*(6) Masonry Buildings: EQ Resistant Design (IS:4326) & Confined Masonry*
1530 Hrs - 1600 Hrs	Tea Break
1600 Hrs - 1730 Hrs	*(7) Inclined Roof Buildings, Bamboo housing, Hazard Resistant housing*

AGENDA continued	
Day - 3	
1000 Hrs - 1130 Hrs	*(8) RVS of masonry buildings*
1130 Hrs– 1145 Hrs	Tea Break
1145 Hrs - 1315 Hrs	*(9) Practical RVS of a masonry buildings*
1315 Hrs - 1400 Hrs	Lunch Break
1400 Hrs - 1530 Hrs	*(10) Masonry Buildings: Seismic Retrofitting*
1530 Hrs - 1600 Hrs	Tea Break
1600 Hrs - 1730 Hrs	*(11) RC Buildings: Failures and Recommendations*
Day - 4	
1000 Hrs - 1130 Hrs	*(12) Ductile Details of RC Members (IS:13920) & Other essential Details*
1130 Hrs– 1145 Hrs	Tea Break
1145 Hrs - 1315 Hrs	*(13) Construction Materials, Precautions in Construction, Quality Assurance & Quality Audit*
1315 Hrs - 1400 Hrs	Lunch Break
1400 Hrs - 1530 Hrs	*(14) Mitigation of Non-Structural Hazards, Fire Safety, Safety of services, Green Building, Lightening Arrester*
1530 Hrs - 1600 Hrs	Tea Break
1600 Hrs - 1700 Hrs	*(15) Bihar Building Bye-Laws 2014, SDBR, DRR Road Map, EQ Advisory Cell*
1700 Hrs - 1730 Hrs	*Valedictory and Distribution of Certificates*