

Earthquake
Damage to Building & Rehabilitation
Research

For Kurdistan Engineering Union
With my Respect

Civil Engineer

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UKE : ID (4682)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ
قَوْلُ اللَّهِ سُبْحَانَهُ وَتَعَالَى ﴿هُوَ أَنْشَأَكُمْ مِنَ الْأَرْضِ وَاسْتَعْمَرَكُمْ فِيهَا﴾
[هود، آية 61]

In the name of Allah, the Merciful
He initiated you from the earth, and settled you in it.
[Hud - 61]

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1. INTRODUCING MY SELF

Mr. Meran Kamil Ameen

Working as Consultant Civil Engineer & Chief Executive Officer (CEO) for
General Contract

He has managed and executed over '12' different projects successfully,

He has designed many different projects in limited period of time, and received many
Certificates, Support, Thanks and Appreciation Letter from them (Iraq - KRG).

He was punctual to deliver the construction projects based on the specifications American
Concrete Institute (ACI Codes) of Iraqi business contracts, in order to produce the best
quality of work, throughout a period of exceeds two decades.

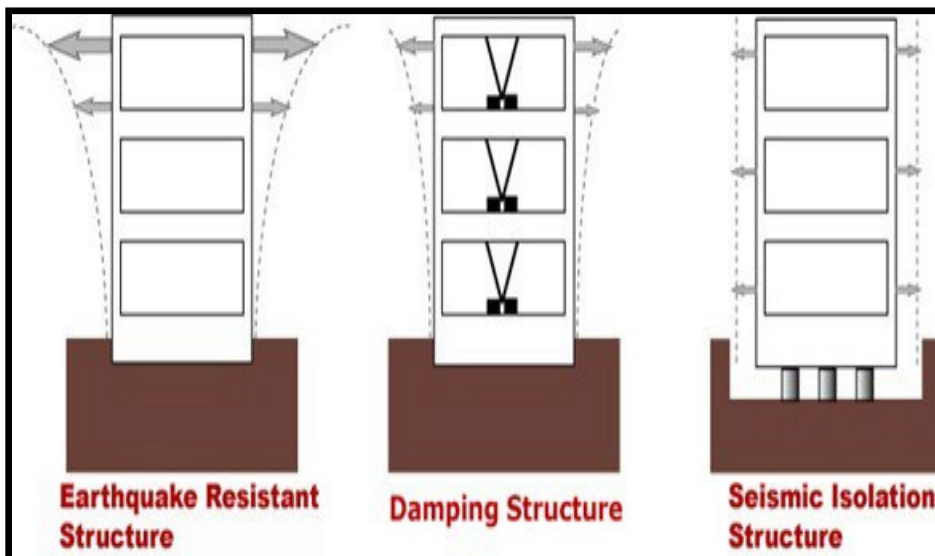
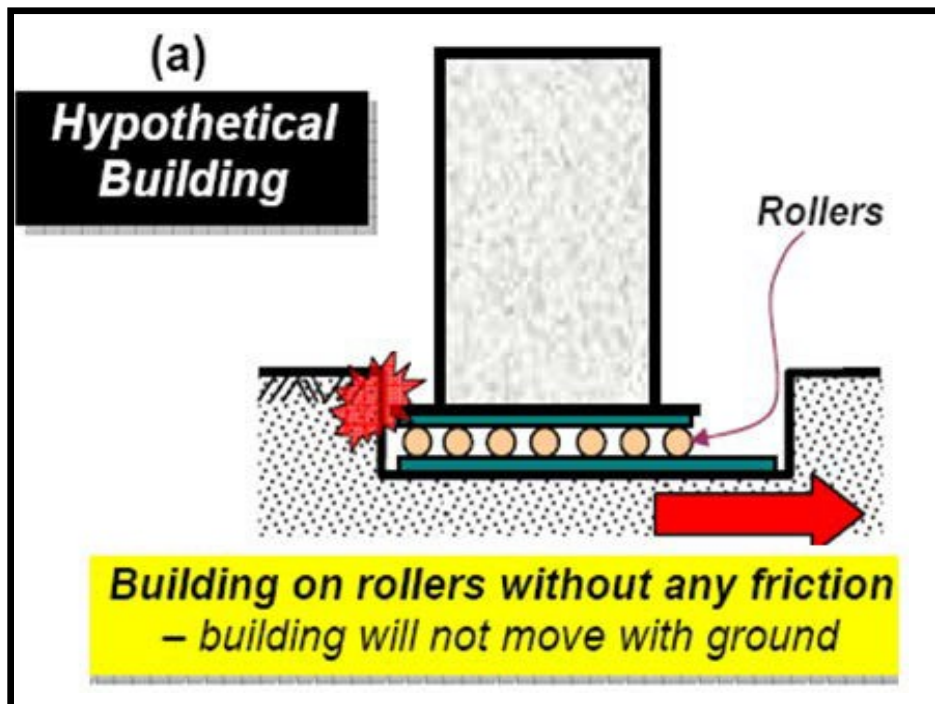
Besides Quality, the most important matter in our business is safety, during our period of
contracting work which exceeds two decades.

2. EARTHQUAKE INTRODUCTION



In Buildings Horizontal Loads can be generally resisted by:

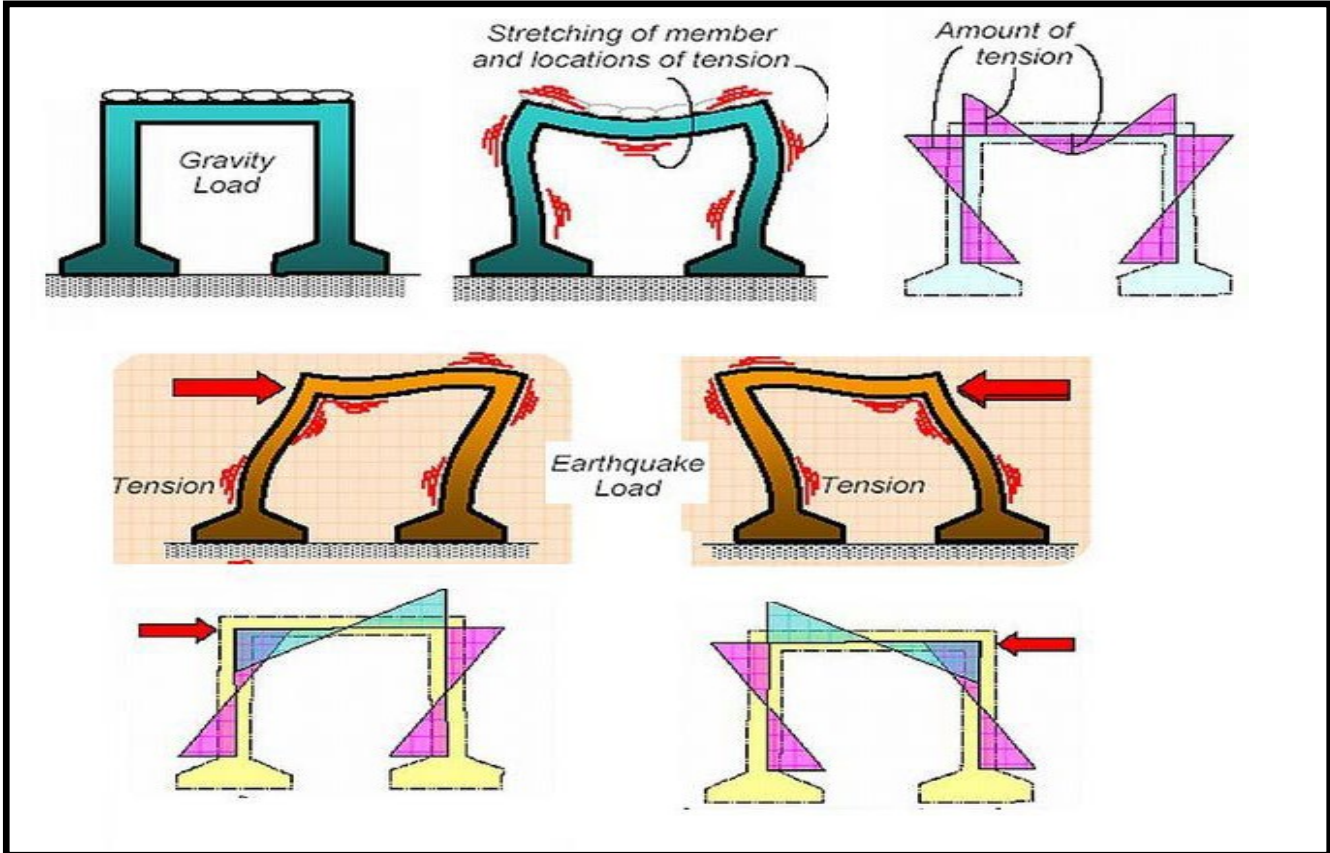
- Moment-resisting frames
- Braced frames
- Shear walls
- Frames in filled with masonry.
- Masonry walls in (one or two) story buildings



3. FACTORS AFFECTING STRUCTURAL DAMAGE

- **Site Condition.**
- **Earthquake Resistant Building Configuration Regularity.**
- **Symmetry in the overall shape of a building dimensions of opening.**
- **Rigidity Distribution.**
-
- **All building components, must be tied to each other ductility.**
- **Foundation.**
- **Construction Quality.**

4. BUILDING BEHAVIOR UNDER LATERAL LOADING



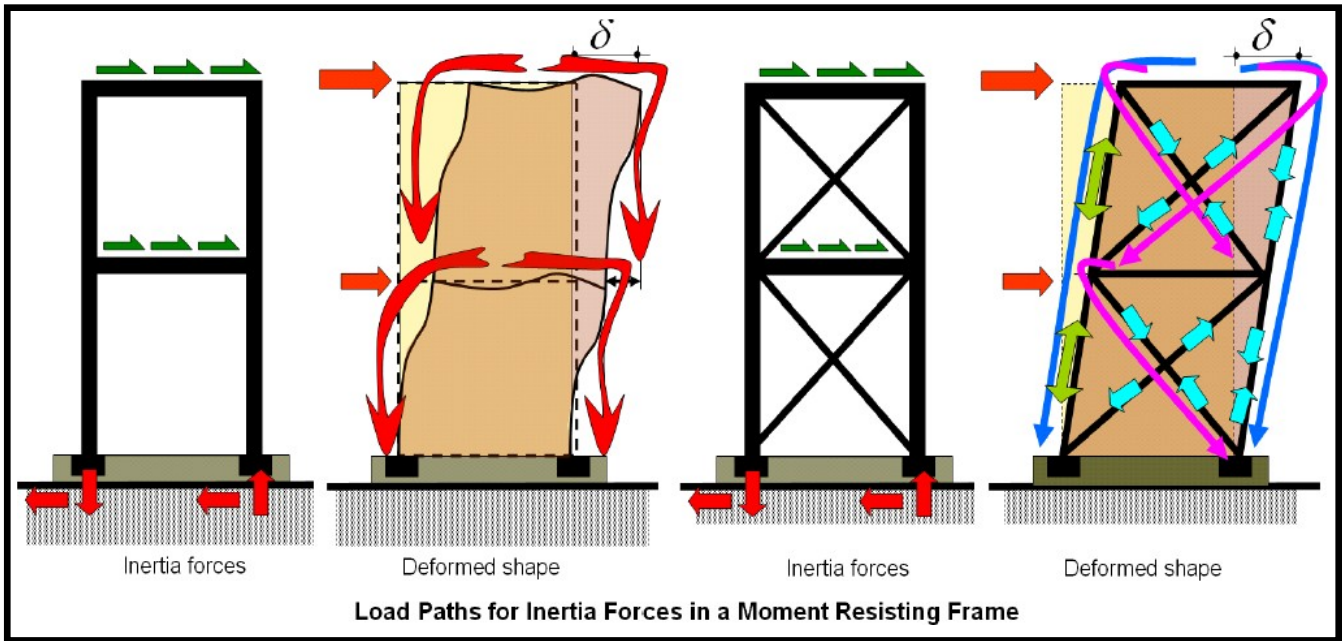
short columns



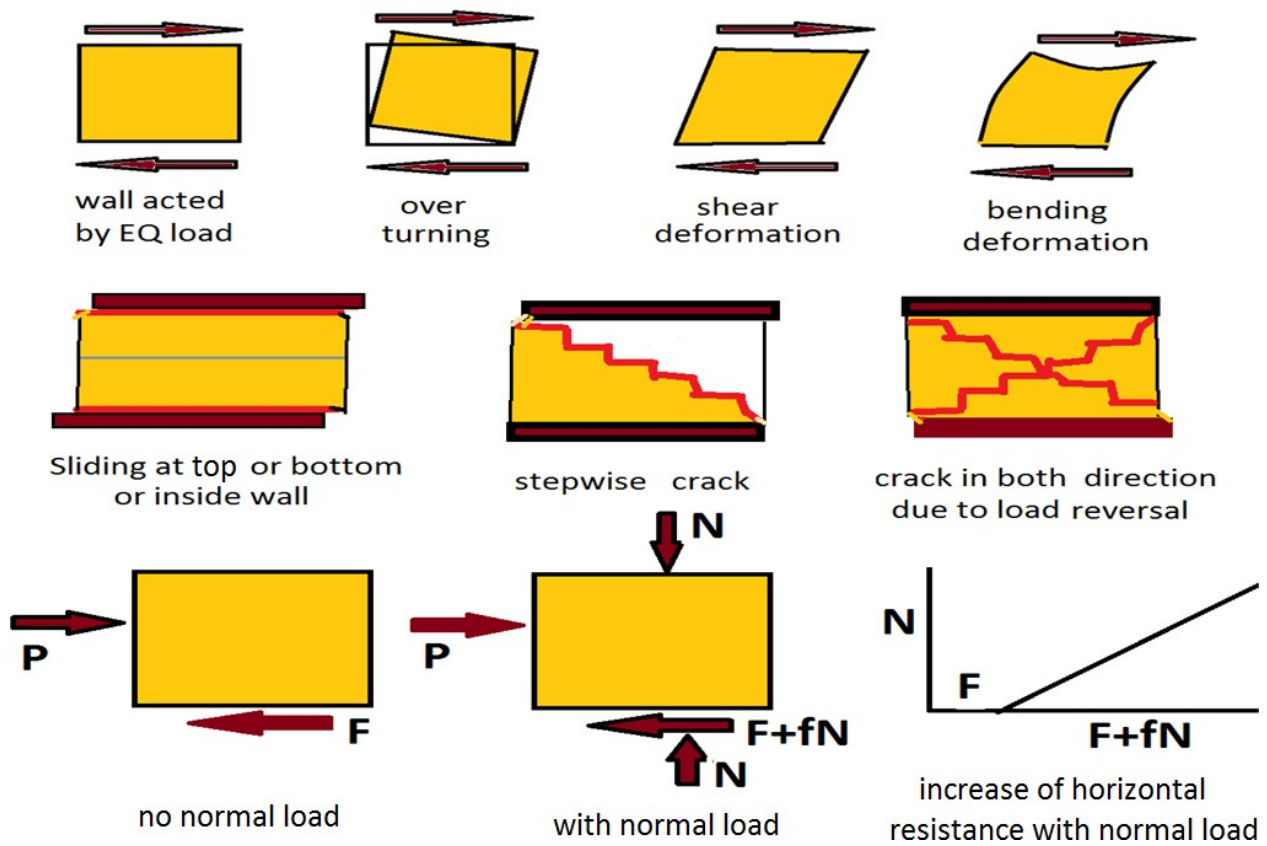
frames with masonry infills!







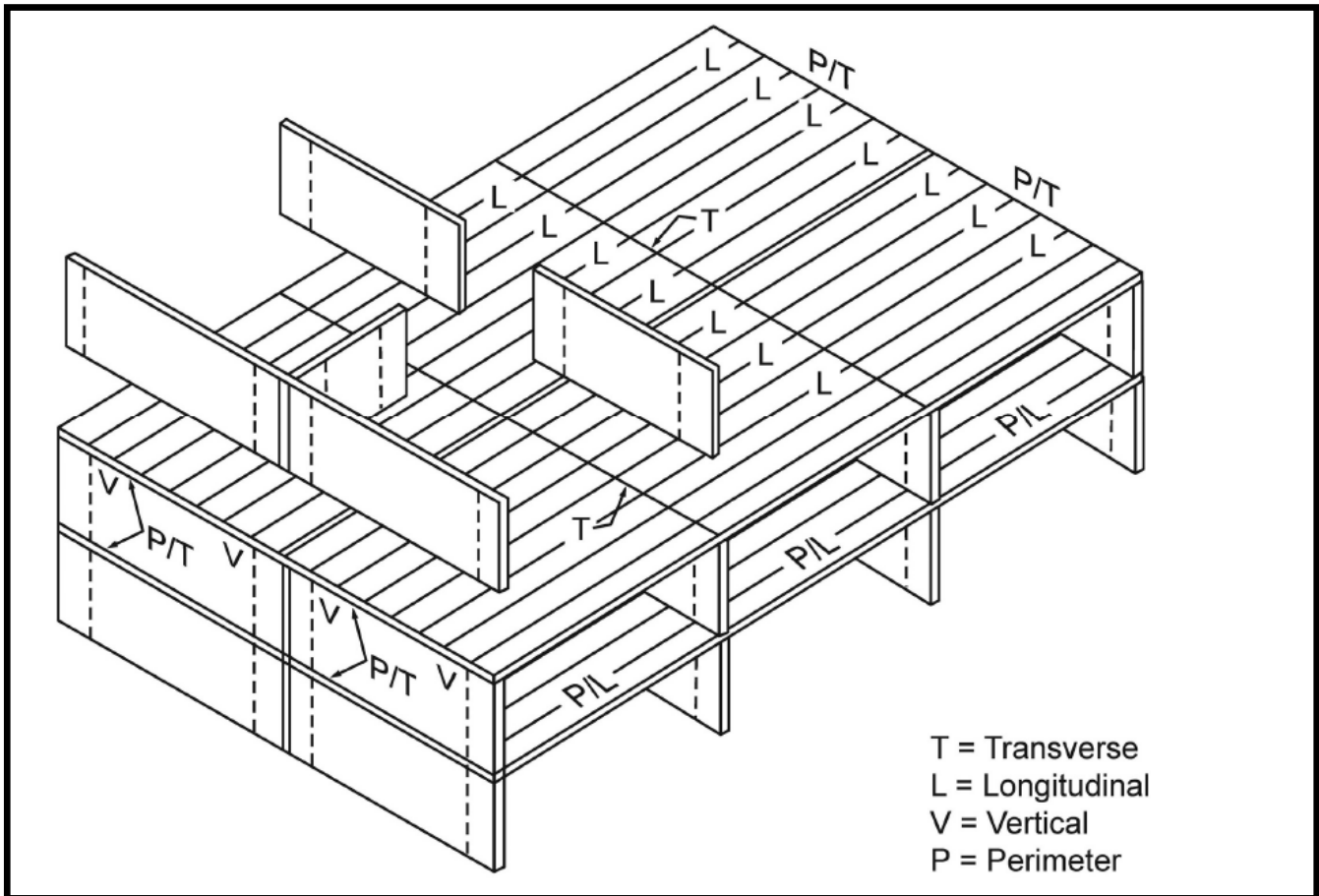
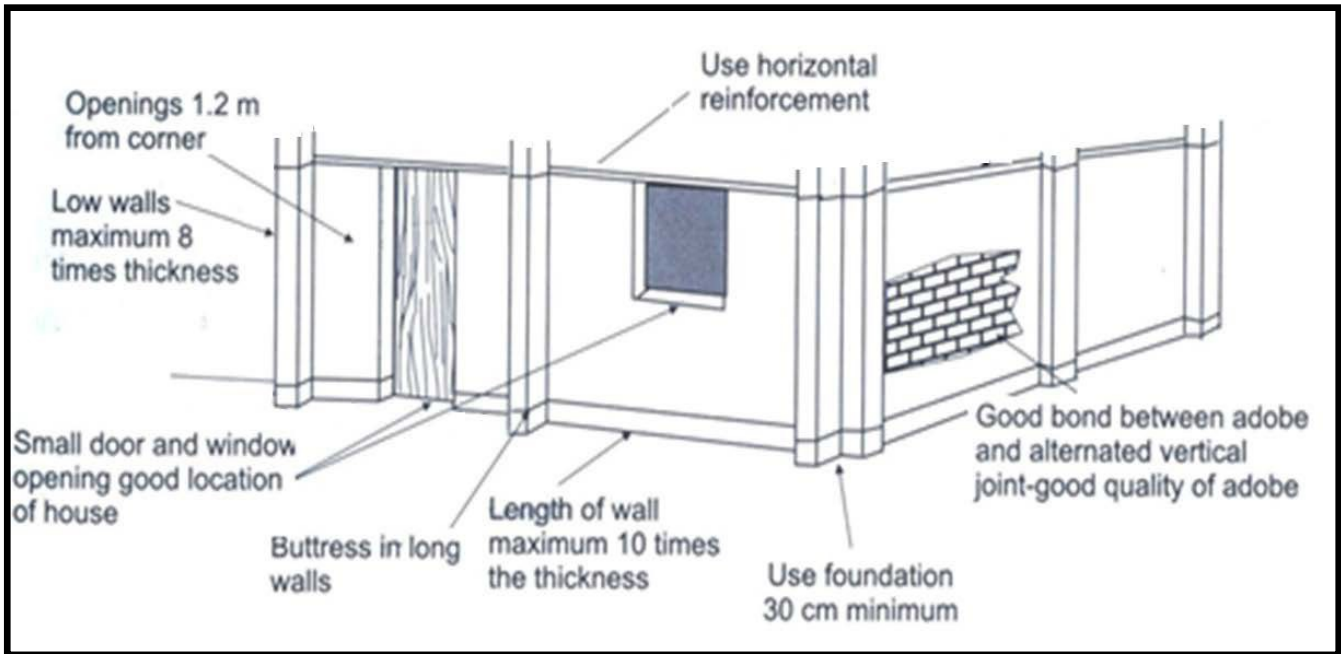
Cracks Due to Horizontal movement ..Earthquake load

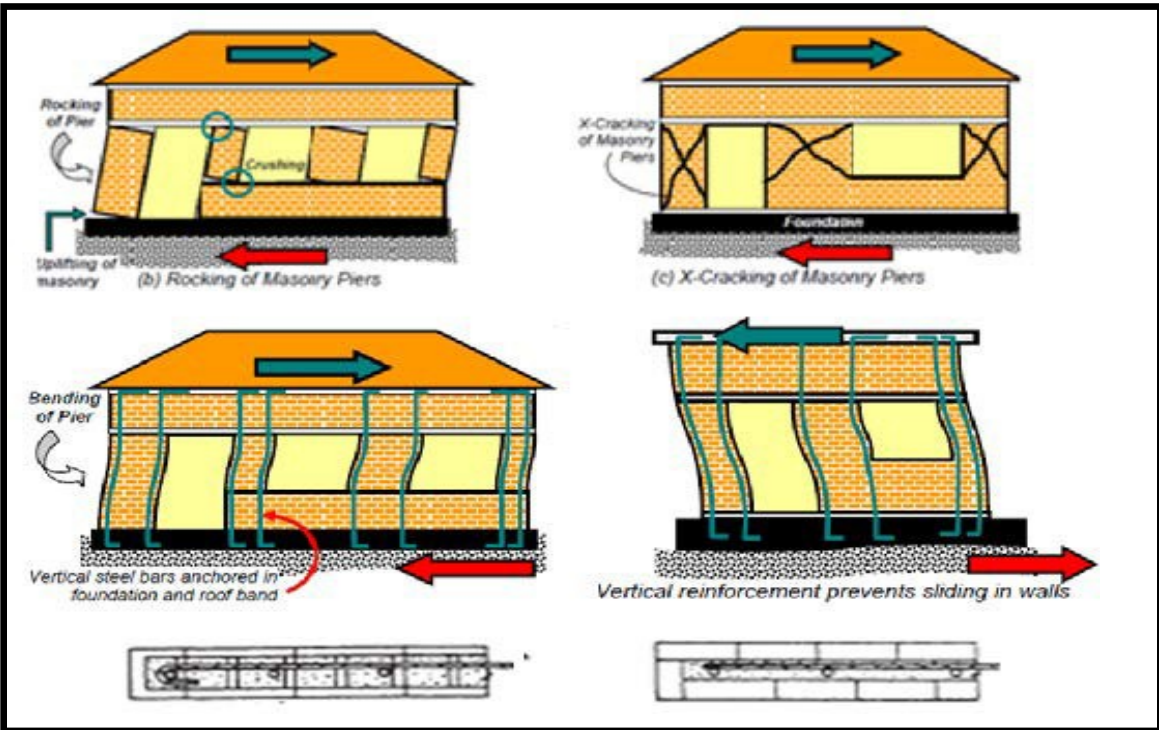
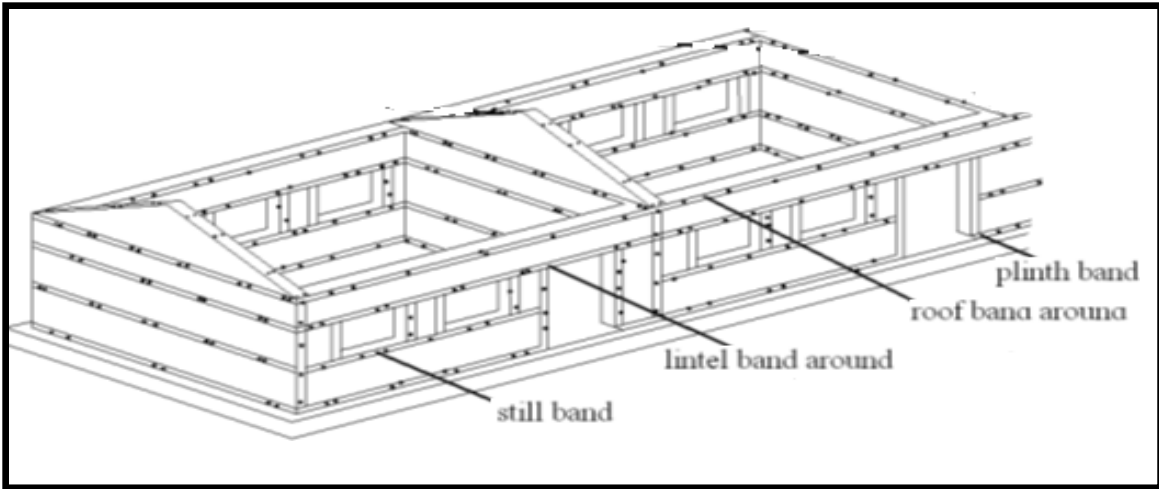




5. IDEAL EARTHQUAKE RESISTANCE BUILDING

- 1-Small Mass.**
- 2-Low height – to – base ratio.**
- 3-Low Center of Mass.**
- 4-Balanced Lateral Resistance.**
- 5-Direct Load Path.**
- 6-Symmetrical Path.**
- 7-Uniform Section & Elevation.**
- 8-Uniform Floor Height.**
- 9-Maximum Rotational Resistance.**
- 10-Short Span.**
- 11-Must have resisting elements in two directions.**
- 12- Columns must be stronger than beams.**
- 13-R.C. columns must have adequate number of ties.**
- 14-All Building Elements must be Tied Together.**
- 15-Roofs should preferably be of light weight.**



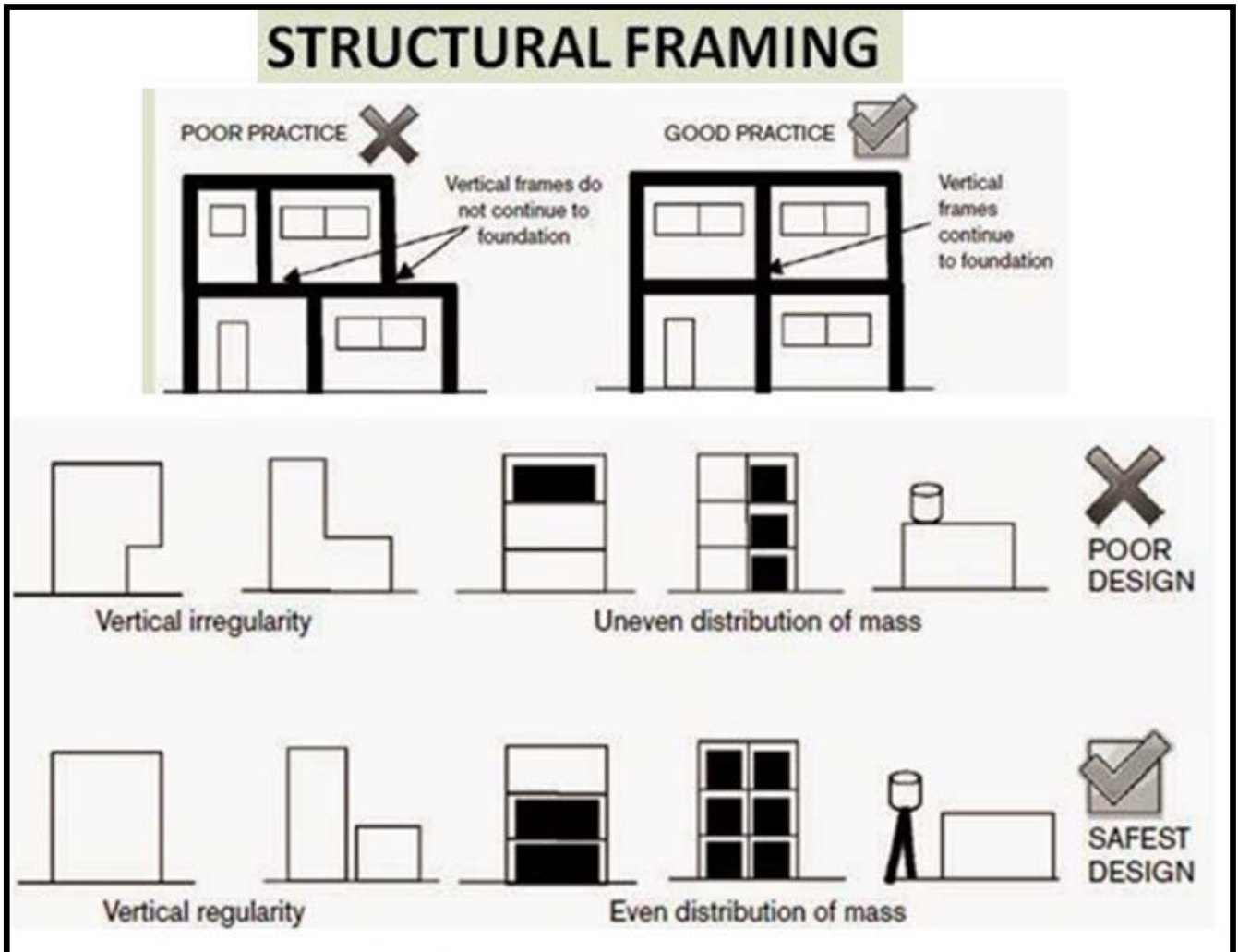
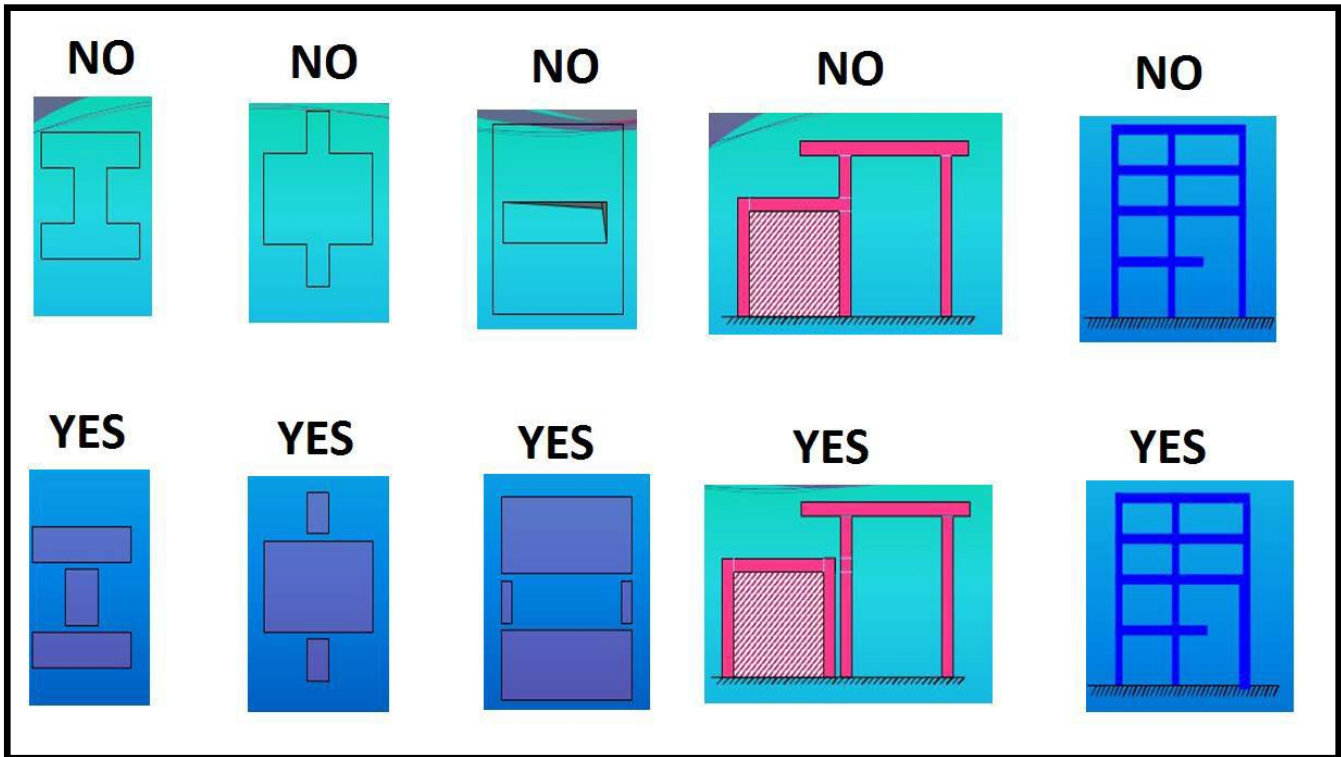


Reinforce structural masonry



AVOID:

- 1-Soft Story, often the ground Floor.
- 2-Short Column effect, where stiff part at height infill panels.
- 3-Stiff non – Structural elements that attract loads – this results in different loads paths to those assumed in design.
- 4-Asymmetry in plan leading to torsional eccentricity.
- 5-Asymmetry in Elevation.
- 6-Pounding from neighboring building, especially when floor heights do not coincide.
- 7-Large openings adjacent to the corners of the building.
- 8-Large openings in diaphragm walls.
- 9-Heavy, weak & brittle materials.
- 10-Heavy Roofs.
- 11-Drainpipes placed within slender columns.
- 12-Building on sloppy foundations.



6. REHABILITATION & STRENGTHENING

6.1-Crack Treatment:

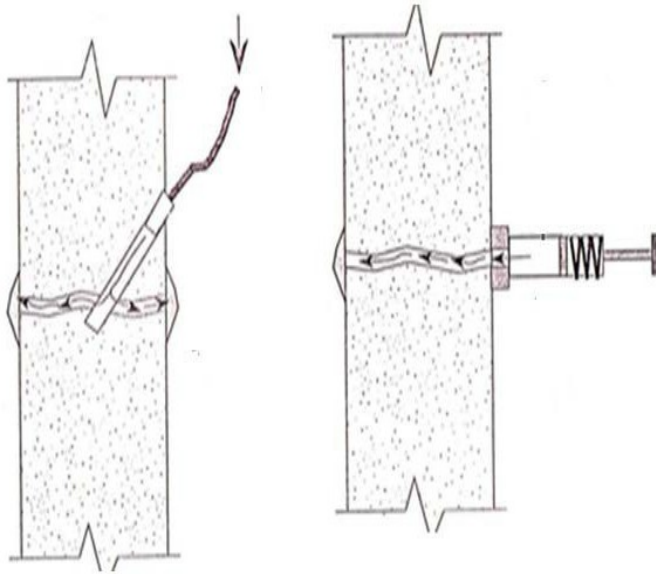
- Repointing with mortar.
 - Injecting the cracks & covering with mortar.
 - Structural Repointing with Steel bar in Joints.
 - Using Steel pins: Stitching – Sewing.
-

6.2-External Surface Treatments:

- The shot – Crete technique.
- The Ferro Cement technique.



epoxy and grouting



stitching



6.3- External reinforcement:

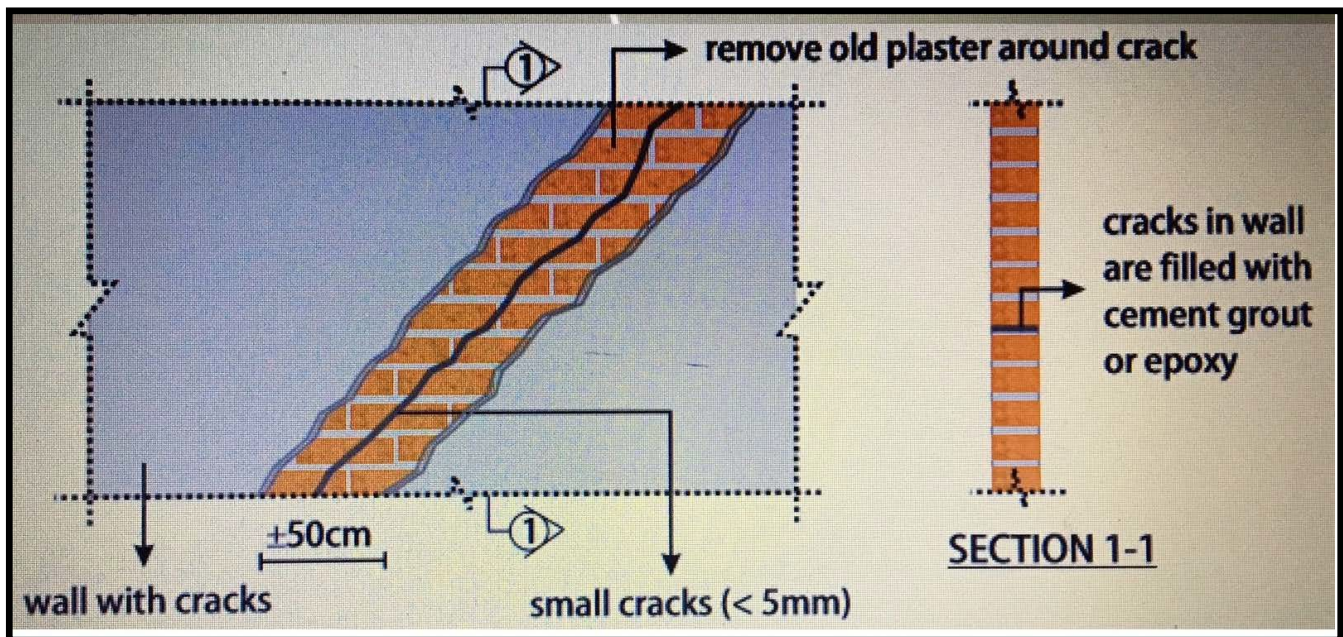
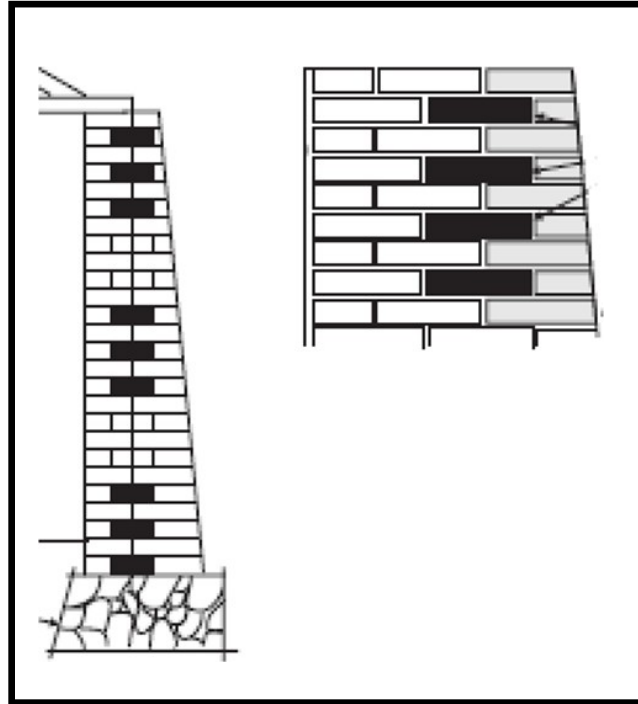
- Strengthening with steel plate reinforcement.
- Strengthening with strips of Fiber reinforced polymer.
- Walls reinforcing overlays: jacketing with R. concrete.
- Seismic bands technique: applying a continuous band
- External reinforcement using post-tensioning steel tie- rods.

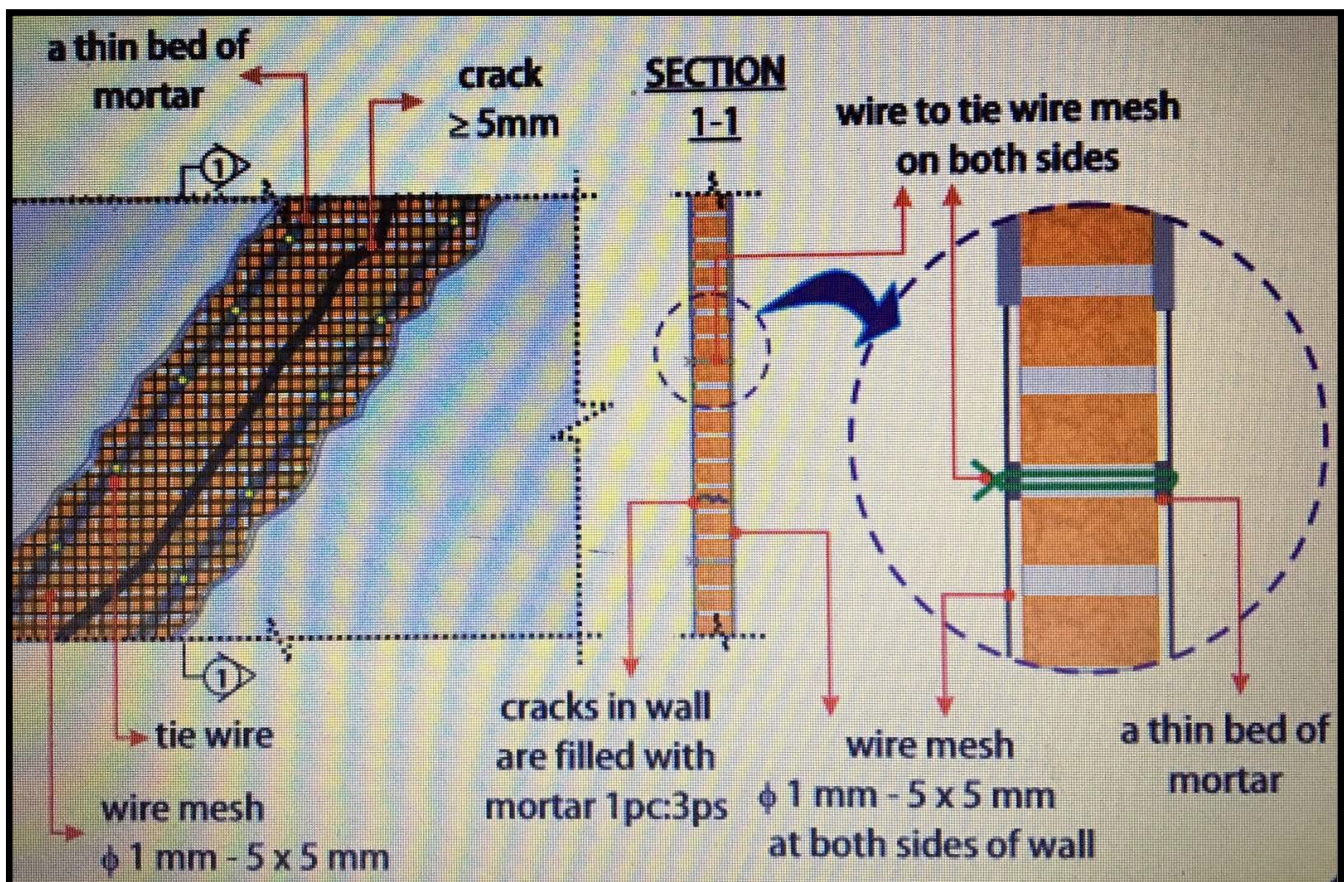
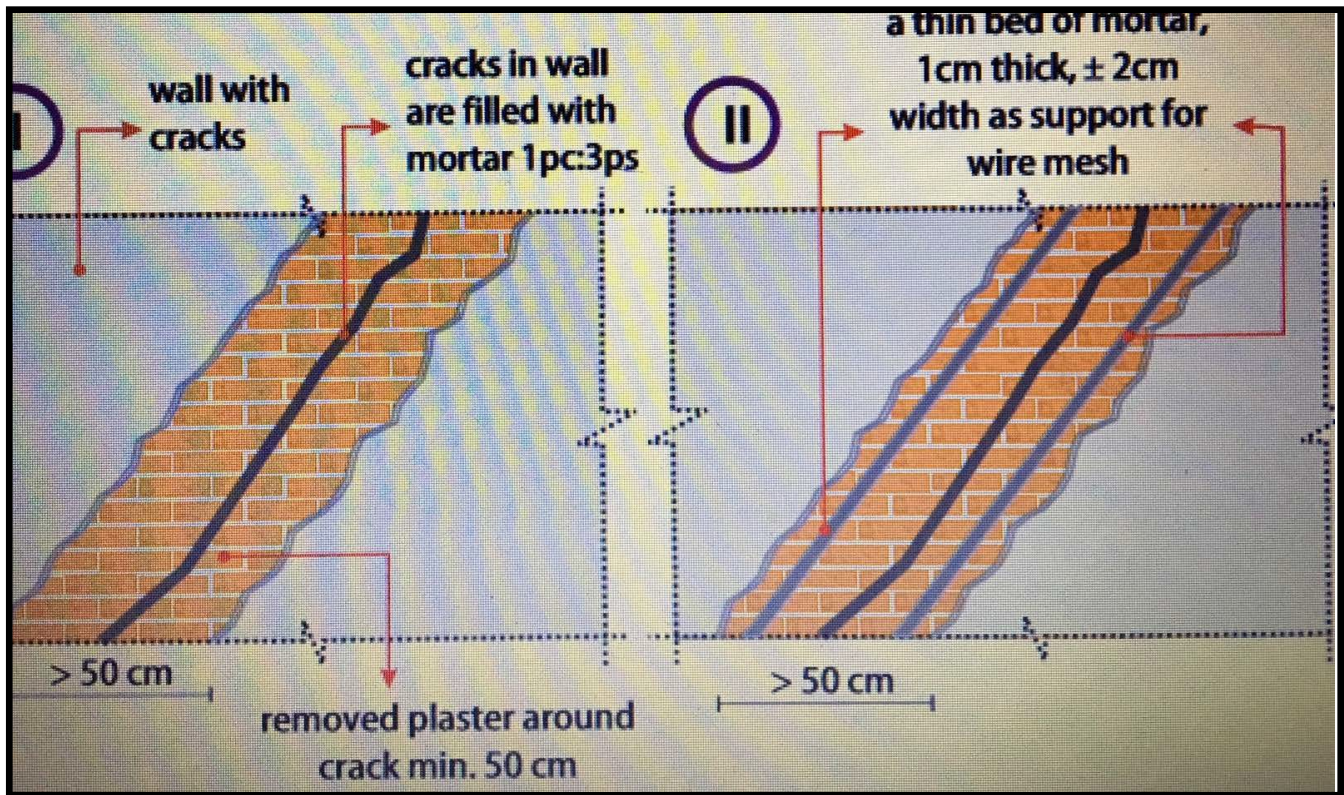
6.4-Confinement Technique:

Masonry reinforcement using reinforced concrete tie columns.

6.5- Wall replacement:

- Rebuilding Wall with similar material
- External Wall buttresses.







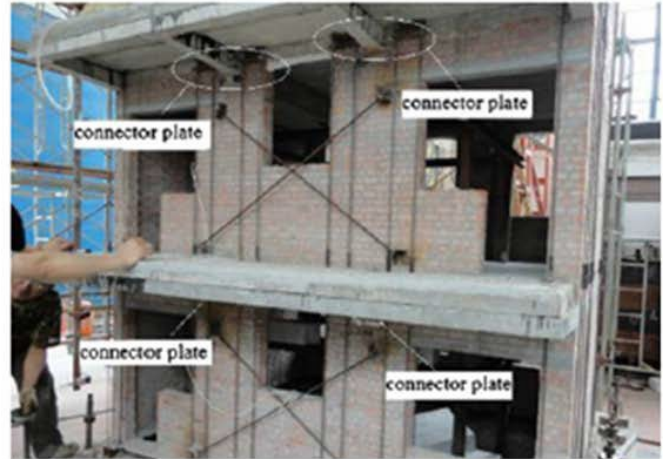
masonry
steel mesh outside **steel mesh inside**



shotcrete over steel mesh



Application of CFRP / GFRP on a building wall

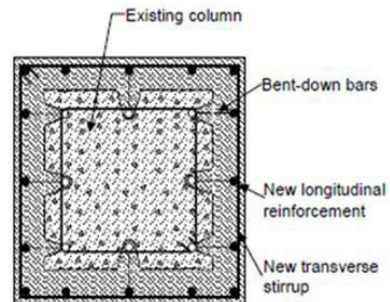
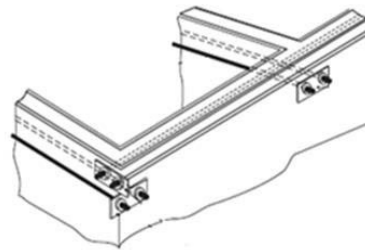


Strengthening with GFRP strengthening with tie rods

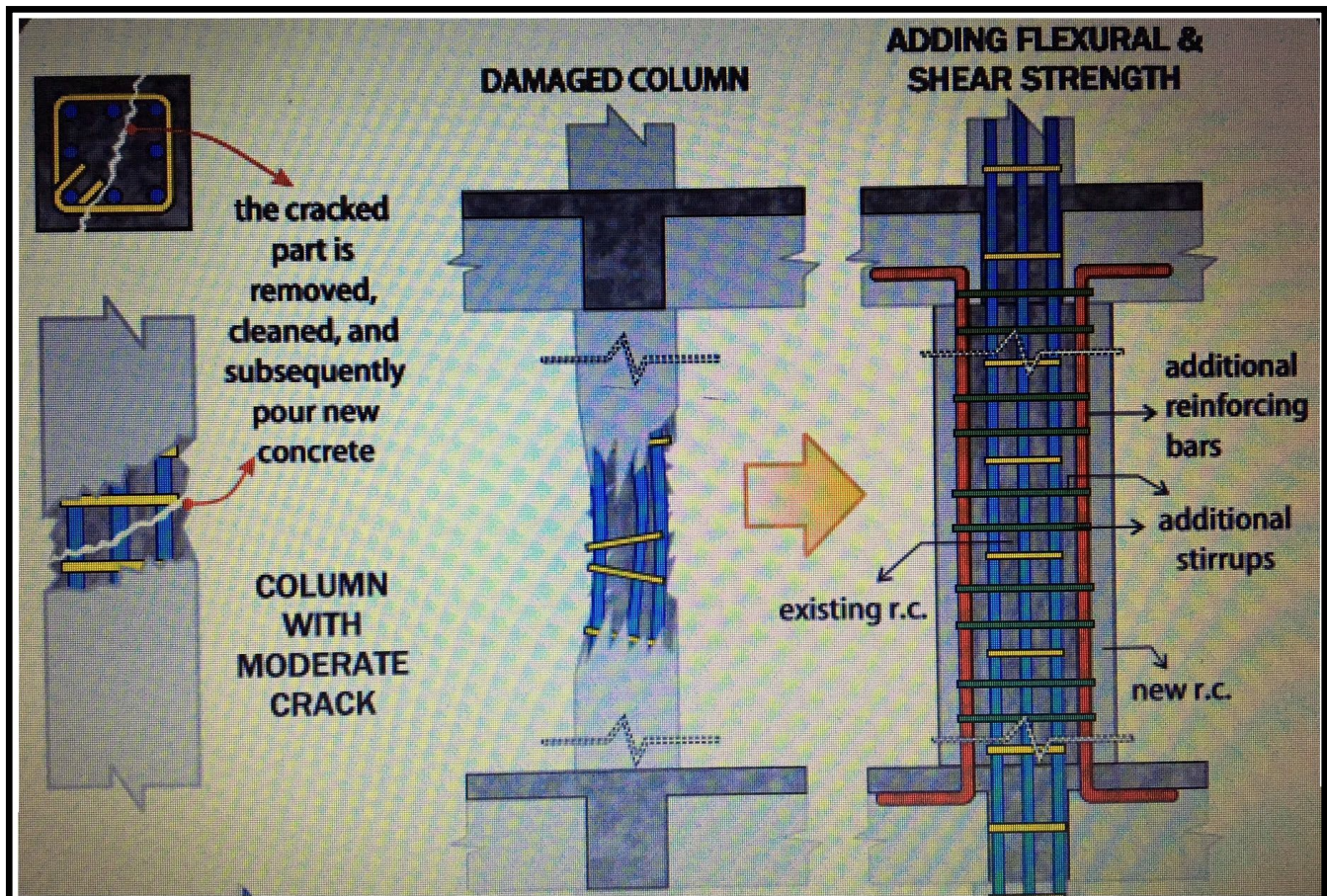
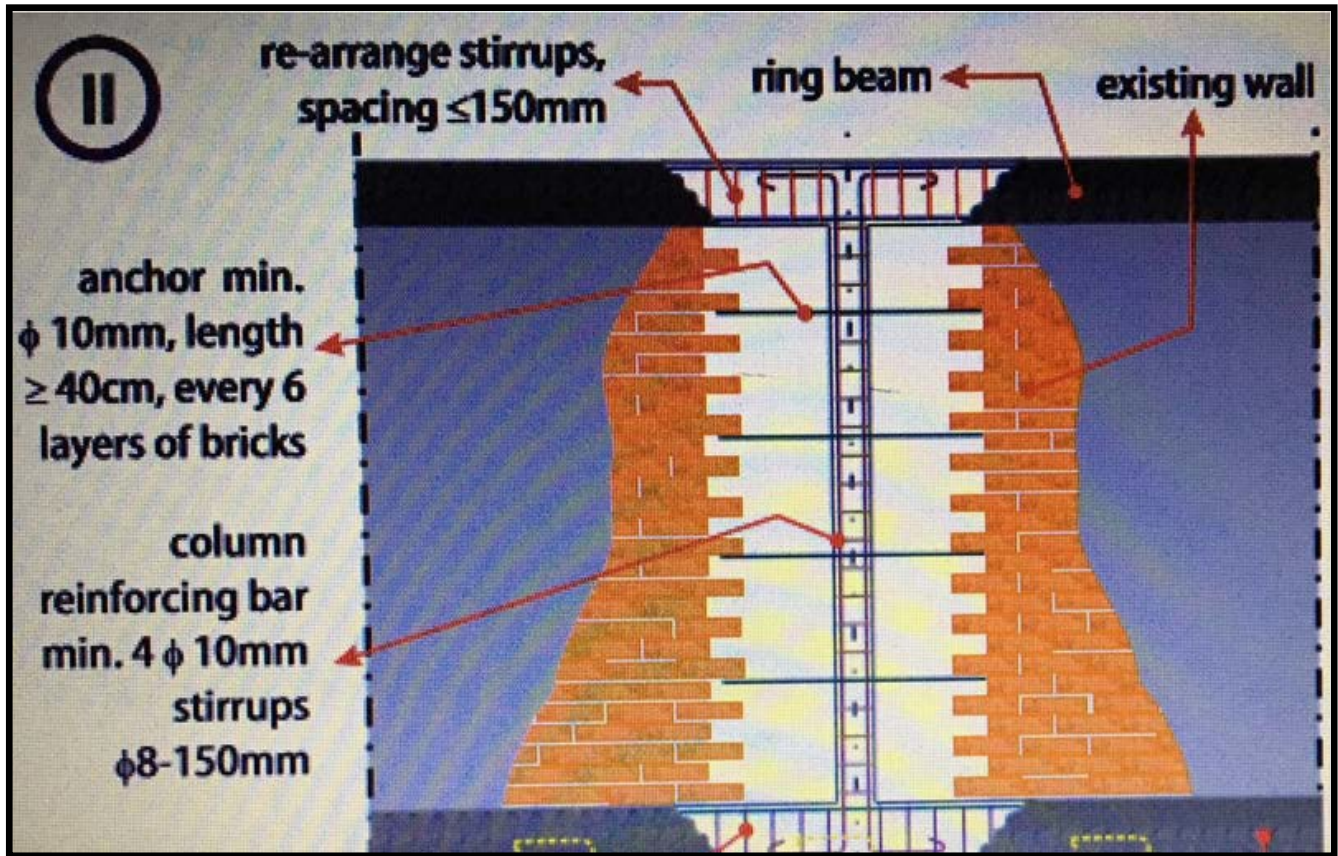


strengthening with tie rods

strengthening with tie rods



jacketing with concrete



7. GOOD DESIGN & CONSTRUCTION

How good is your house against earthquake?

- 1. Who has built your house?**
- 2. The house is old or new?**
- 3. Has it been damaged before due to EQ, settlement, fire, etc.?**
- 4. Is it regular in plan or elevation?**
- 5. Has it been expanded horizontally or vertically?**
- 6. What is the least thickness of the walls?**
- 7. Are the walls reinforced or not?**
- 8. How long is longest wall without cross wall.**
- 9. Is the foundation reinforced?**
- 10. Is it built on soft soil or hard soil?**
- 11. Is the general condition of the house good or deteriorated?**

Recommendation for housing construction with masonry in Kurdistan

1-Foundation must be reinforced unless on rock layer.

2-Tie beams must be provided at ground level, openings level, & slabs level.

3-Vertical tie must be provided at corners and other proper places and tied to the tie beams.

4-Walls should be provided in both directions.

5-Plan to be kept symmetrical as much as possible.

6-Openings should be as small as possible and at center of walls.

7-Reinforced masonry to be used if possible.

8-All floor should be of similar structural system.



8- CONTACT US

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Contract

Consultant Civil Engineer

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References:

One of my projects that executing in 2008

1-GUIDELINES FOR EARTHQUAKE RESISTANT NON – ENGINEERED CONSTRUCTION ... Anand S. Arya Teddy BOEN & Yuji ISHYAM

2- IMPROVING THE EARTHQUAKE RESISTANCE OF SMALL BUILDINGS, HOUSES, & COMMUNITY INFRASTRUCTURE. Gregory A. J. Szakats.

3- RETROFITTING SIMPLE BUILDINGS DAMAGED BY EARTHQUAKE. Teddy boen & Associates

Thank you very much for your reading