Selection of Buildings for FRP Retrofitting

Li Bing

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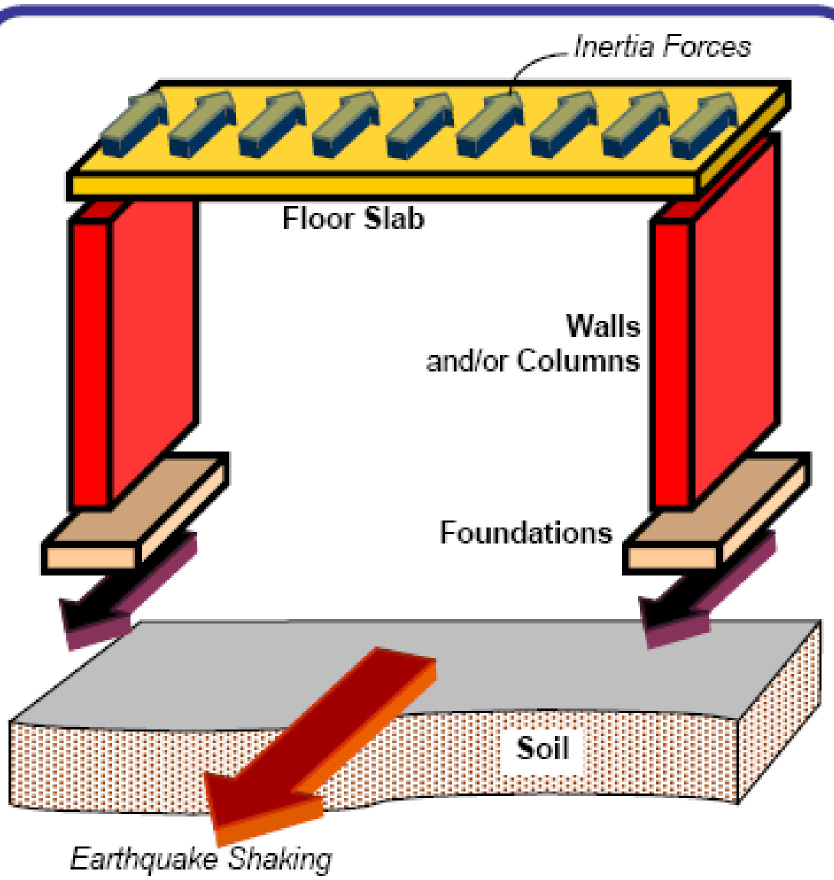

Figure 4: Flow of seismic inertia forces through all structural components.

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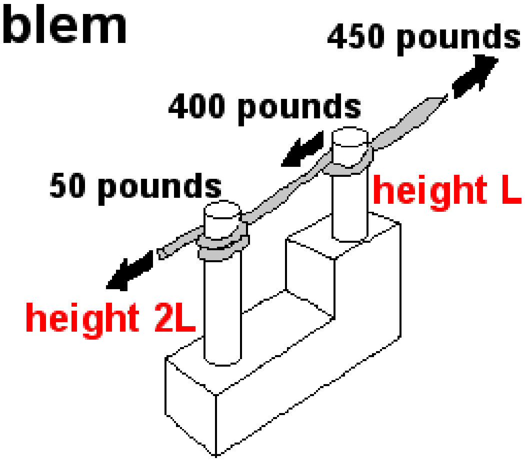
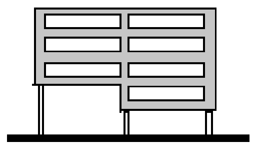
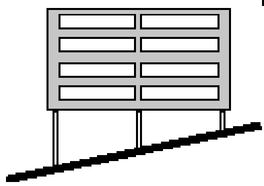
the SHORT COLUMN problem



the **stiffness** of a column varies approximately as a **cube of its length**

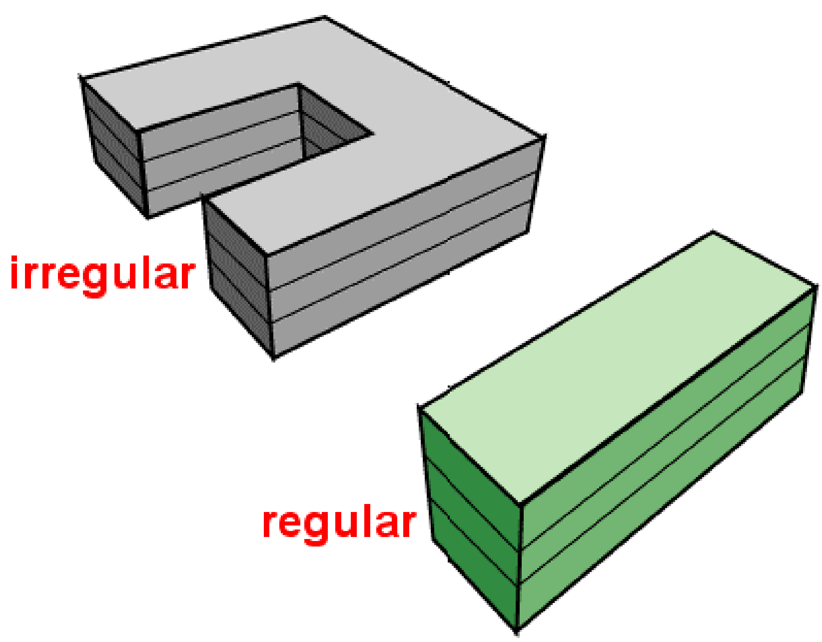




the short column is **half** the height but takes **8 times** the load of the long column

A very important aspect of stiffness in lateral force design is that earthquake forces are distributed in proportion to the stiffness of the resisting elements

CONFIGURATION
regular and irregular



Regular configurations are essentially symmetrical in plan and elevation, with no setbacks in elevation or complications in plan. An irregular building has geometrical complexities of plan, elevation, or

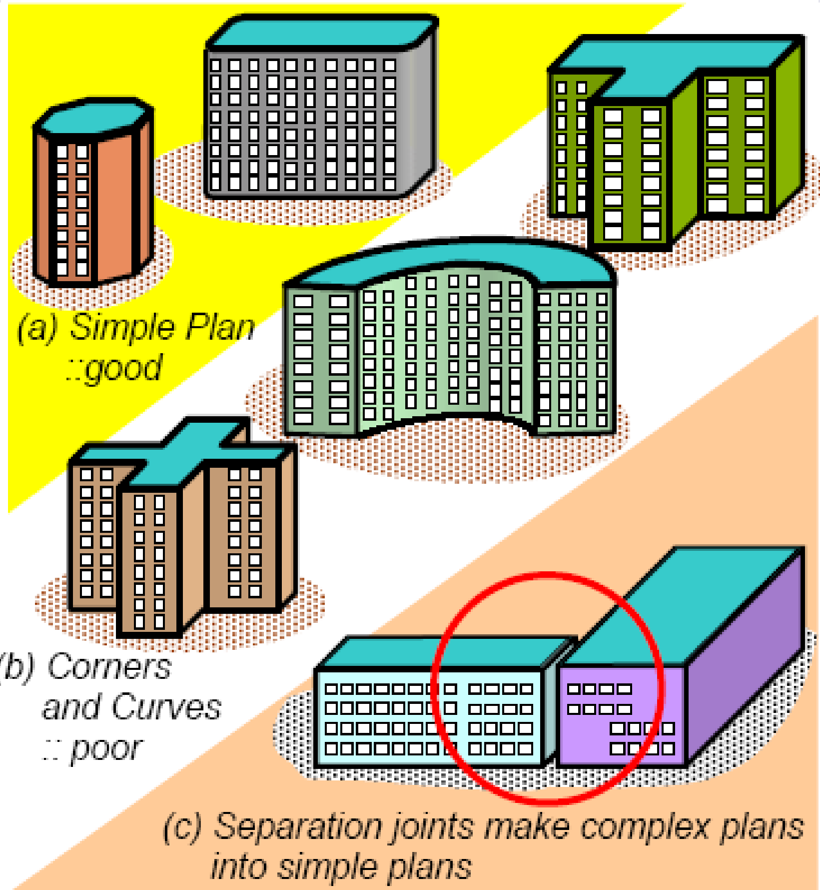


Figure 2: Simple plan shape buildings do well during earthquakes.

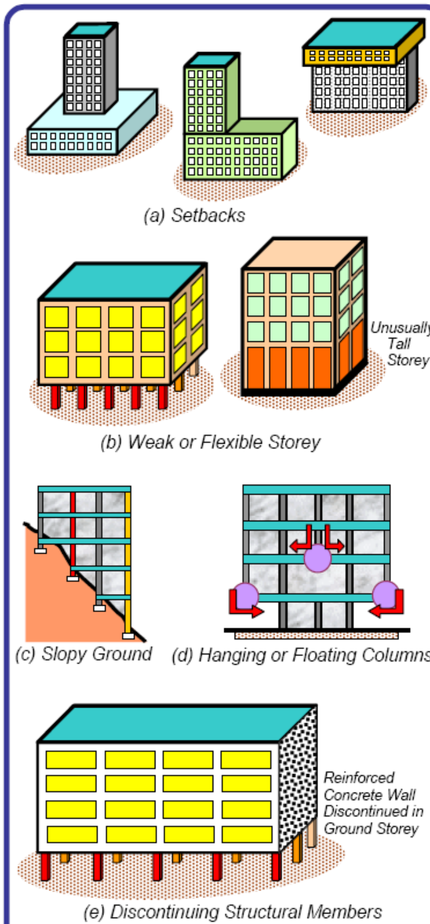
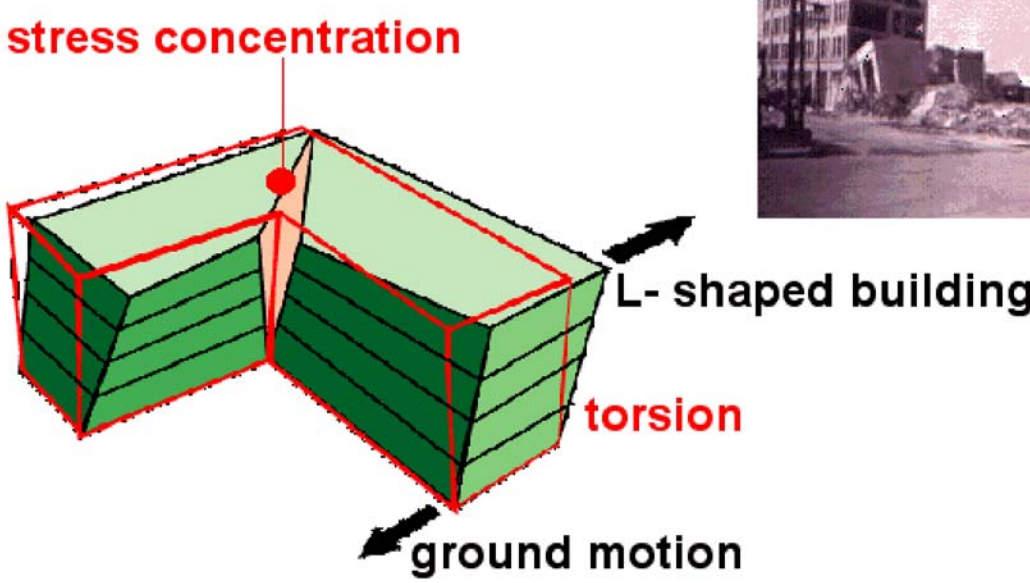


Figure 3: Sudden deviations in load transfer path along the height lead to poor performance of buildings.

TORSIONAL FORCES and STRESS CONCENTRATION



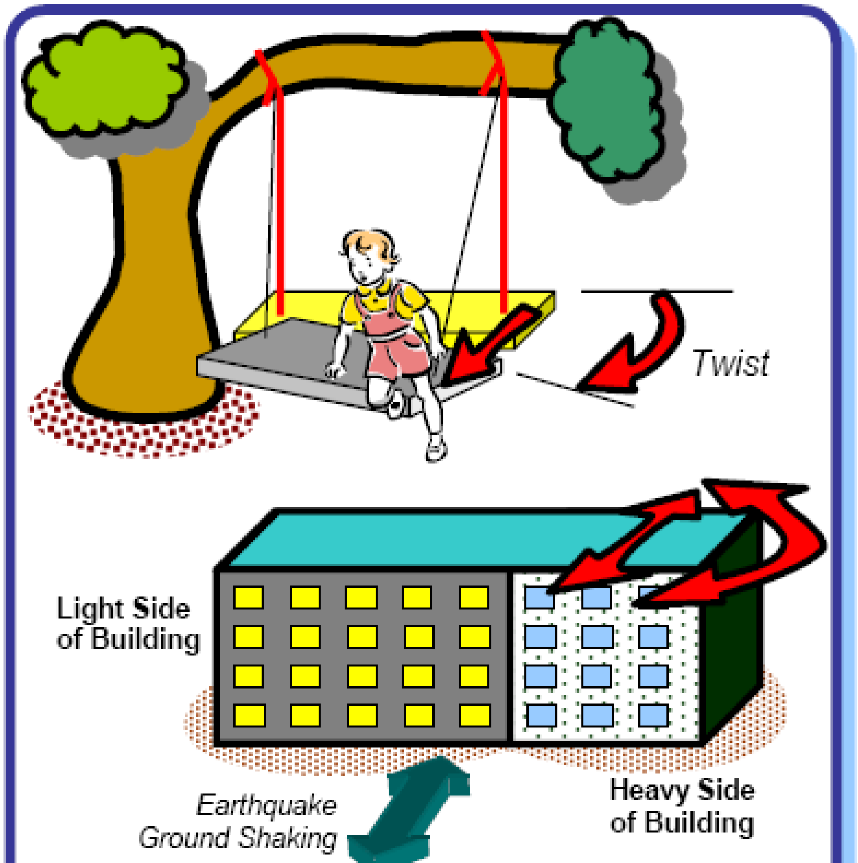


Figure 3: Even if vertical members are placed uniformly in plan of building, more mass on one side causes the floors to twist.

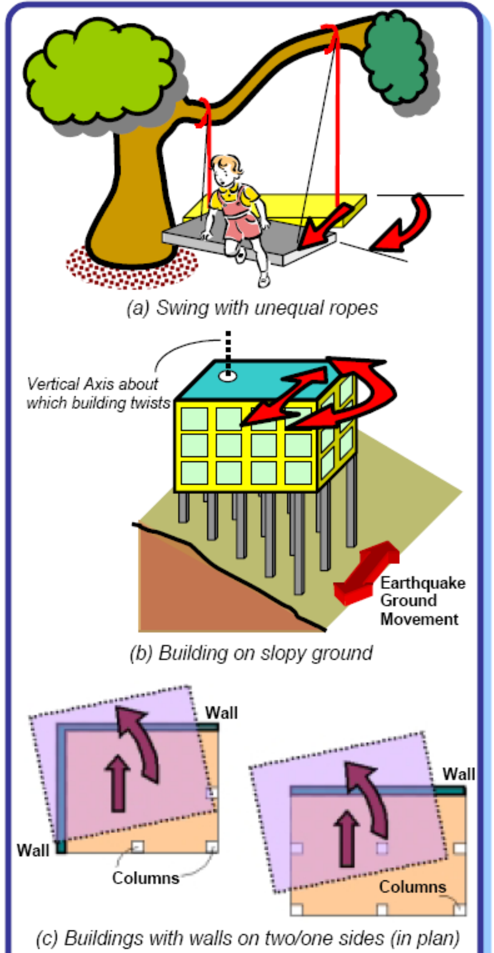
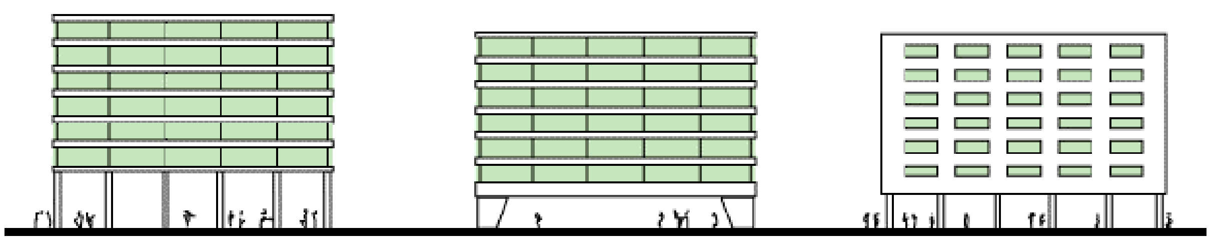


Figure 4: Buildings have unequal vertical members; they cause the building to twist about a vertical axis.

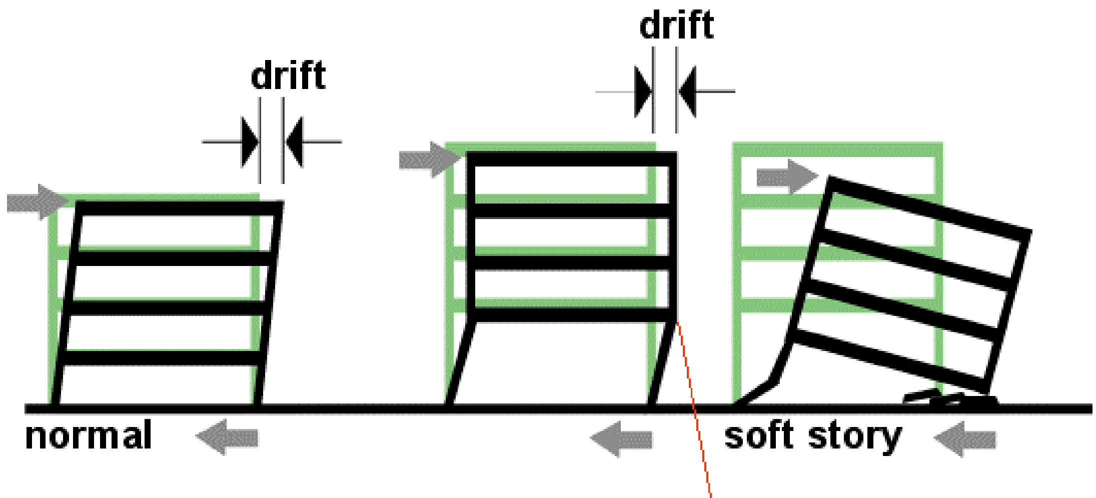
STRESS CONCENTRATIONS

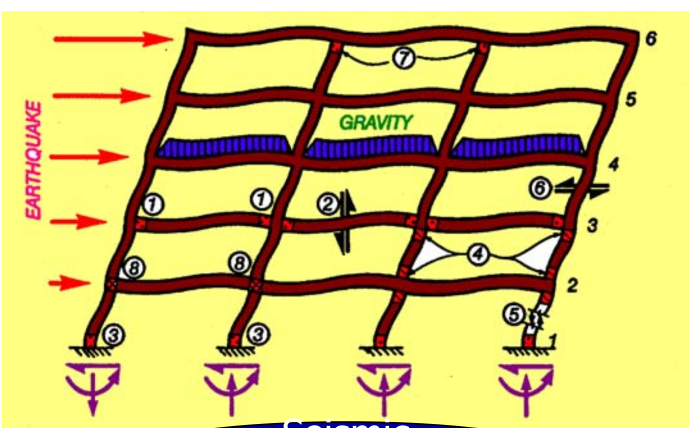
The most serious condition of vertical irregularity is the soft or weak story, in which one story, usually the first with taller, fewer columns, is significantly weaker or more flexible than the stories above.



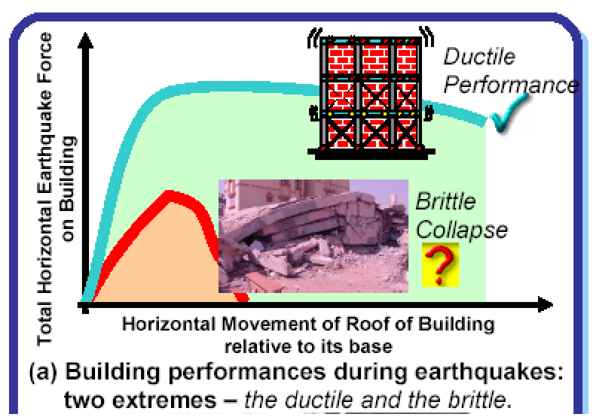
STRESS CONCENTRATIONS

the soft story collapse mechanism

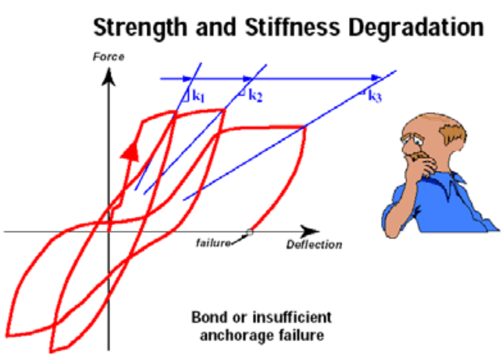




Seismic Demand

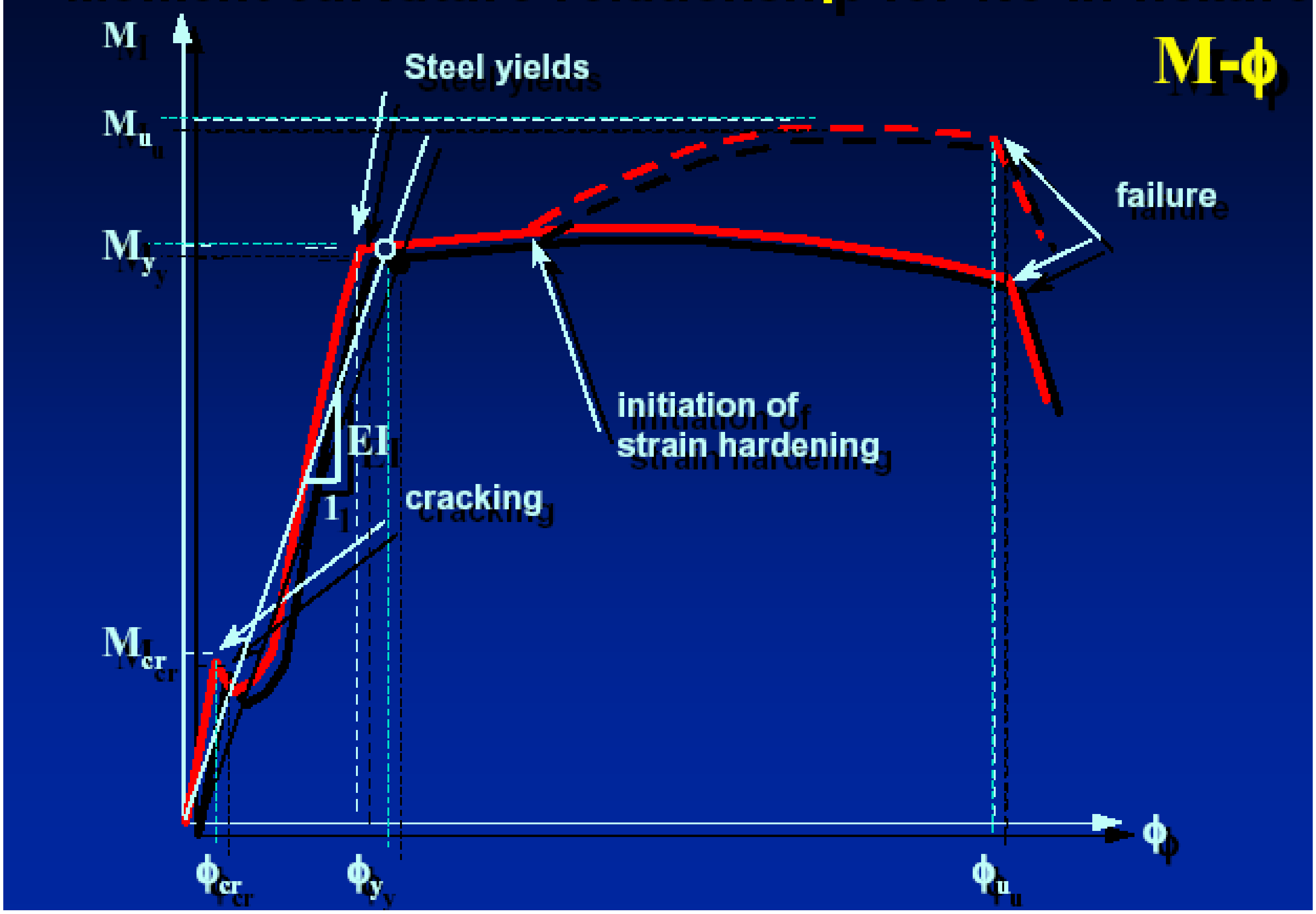


Structural Detailing

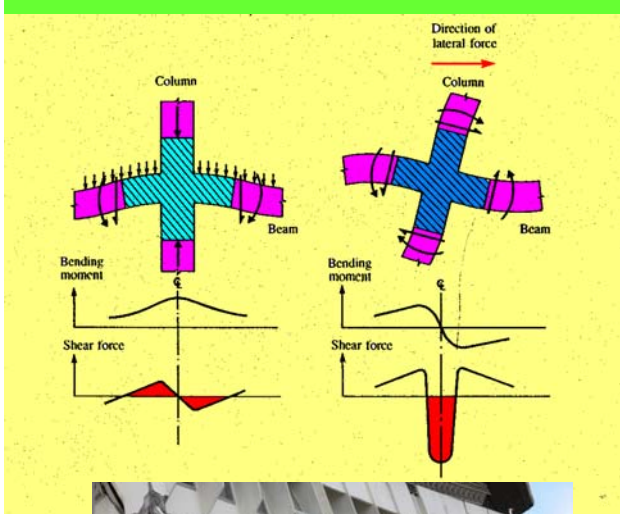


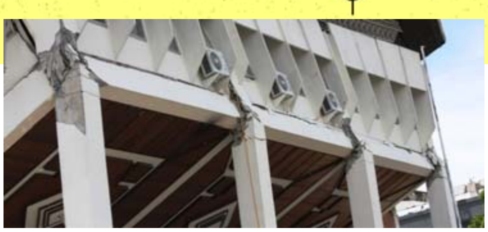
Problem Statement

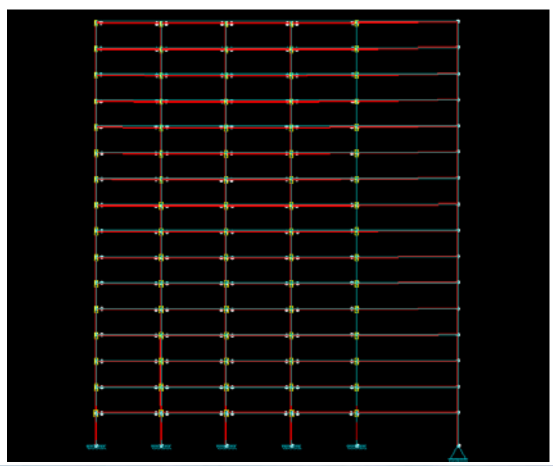
Moment-curvature relationship for RC in flexure



Primary force transfer in gravity and moment-resisting frames







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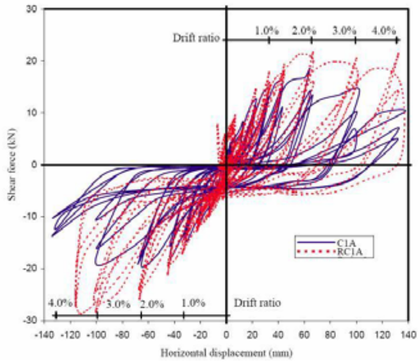
To maintain ductile behavior, it is important for the joint zones to have: (1) Sufficient strength to sustain the maximum actions that can develop in the plastic hinges (2) Sufficient resistance to stiffness degradation



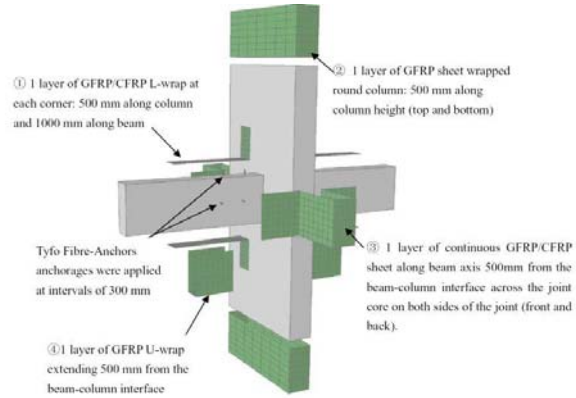
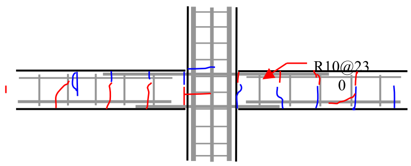
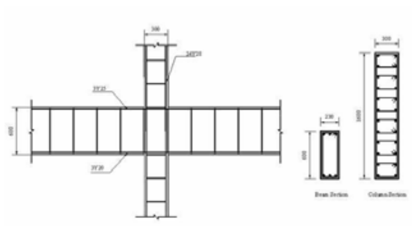


Figure 6. Typical rehabilitation schemes





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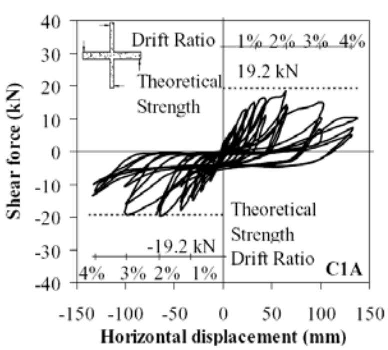
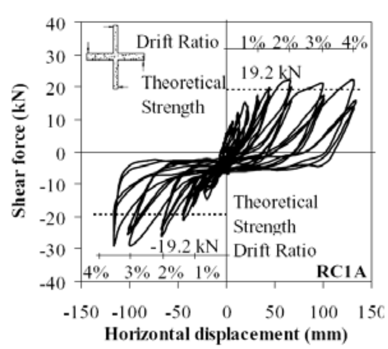
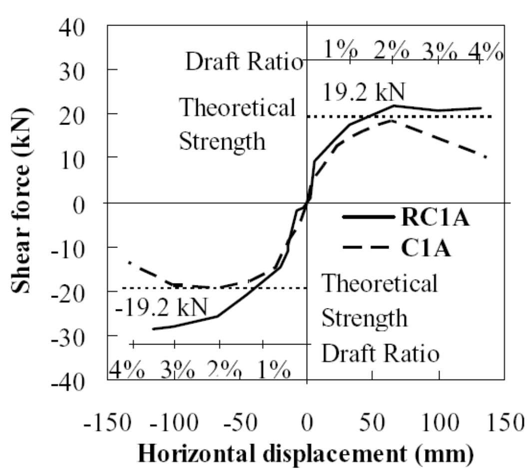
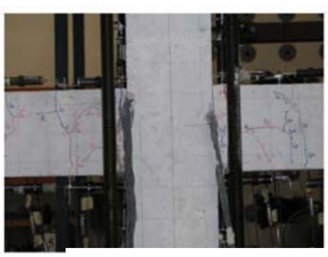
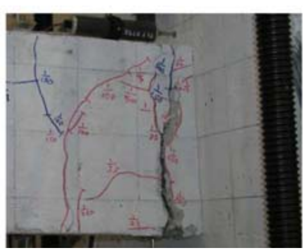
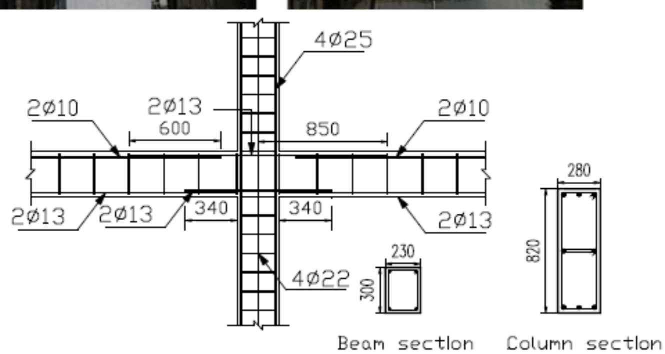












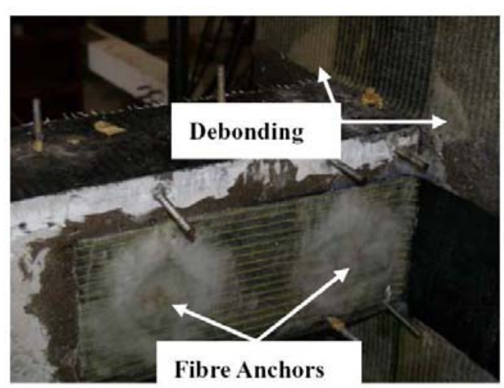
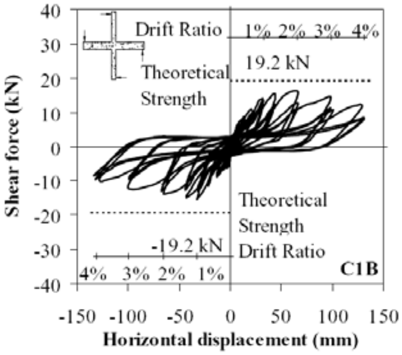
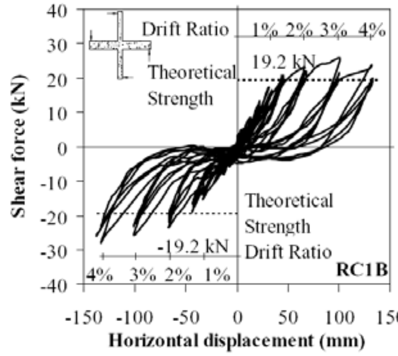
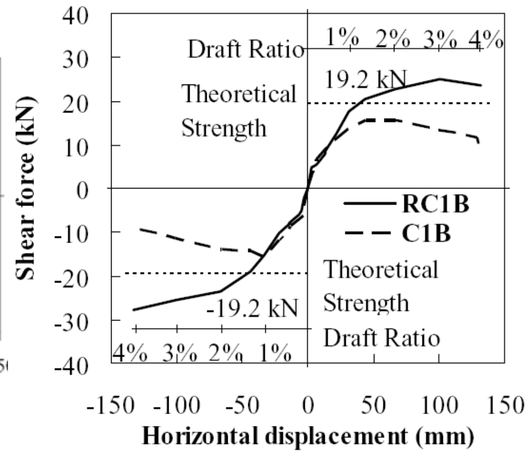
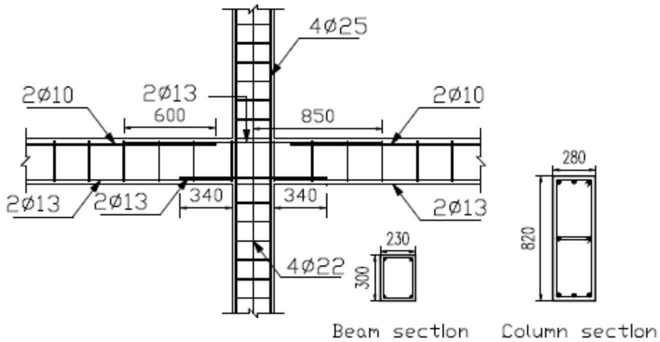


Figure 7. Final failure modes of Specimen RC1A



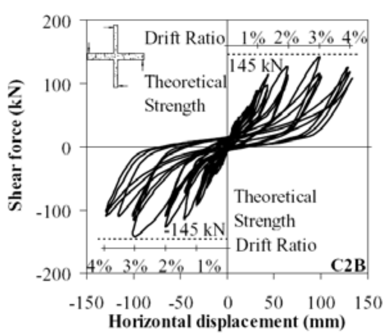


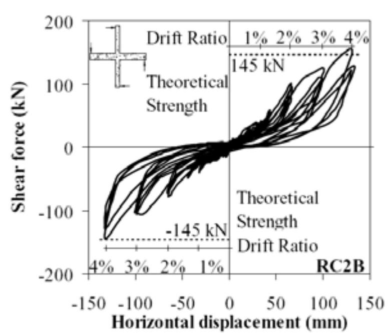


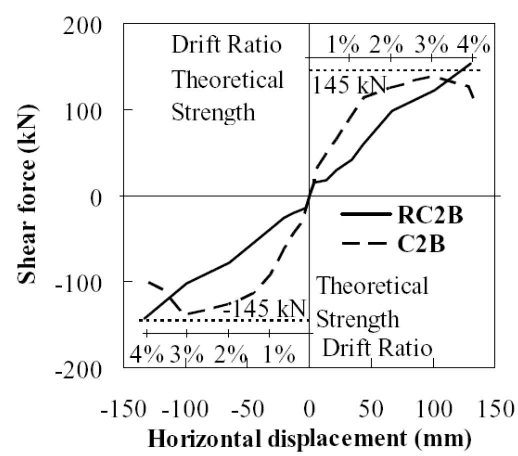


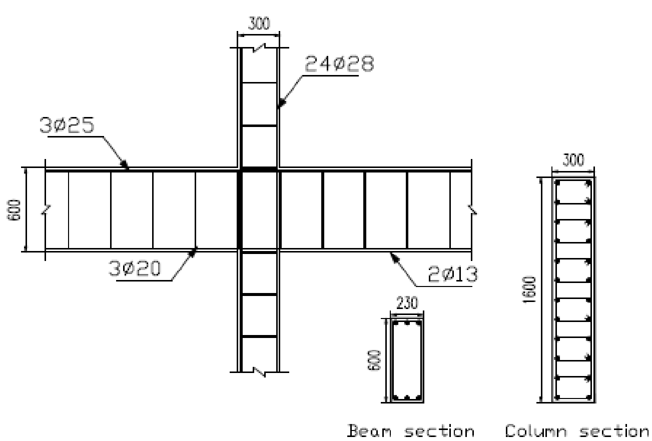
(a) (b)

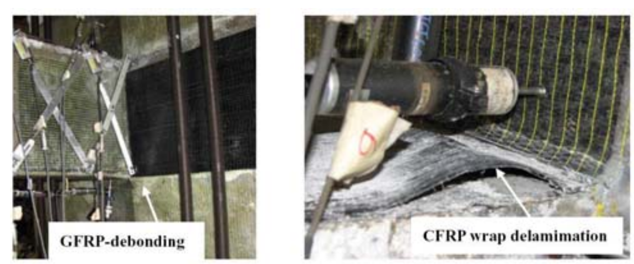
Figure 8. Final failure modes of Specimen RC1B





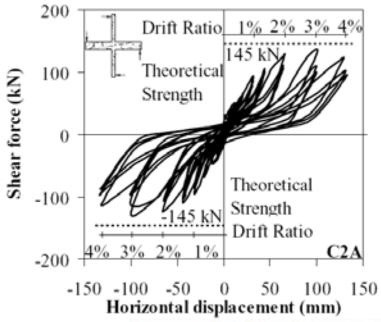


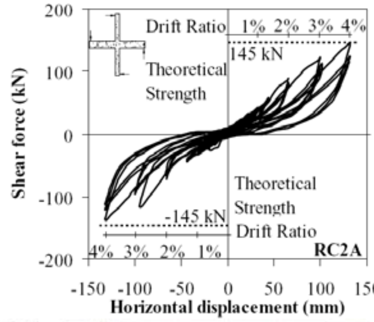


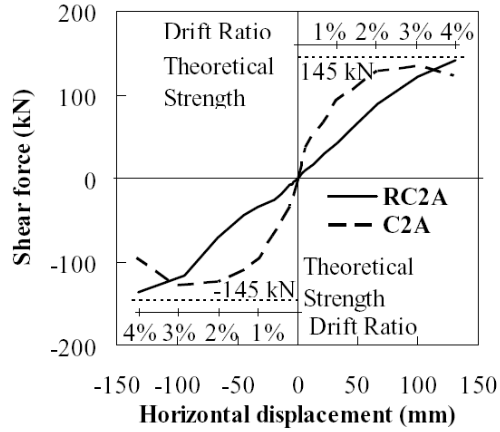


(a) (b)

Figure 10. Final failure modes of Specimen RC2B







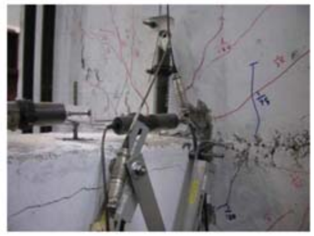
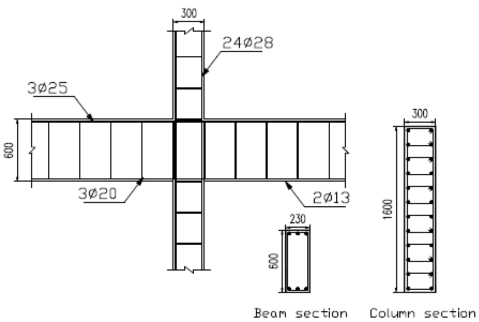


Figure 5. Typical cracking patterns of Specimen C2 at DR of 4 %



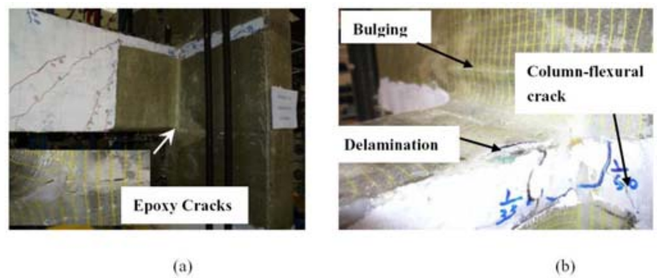
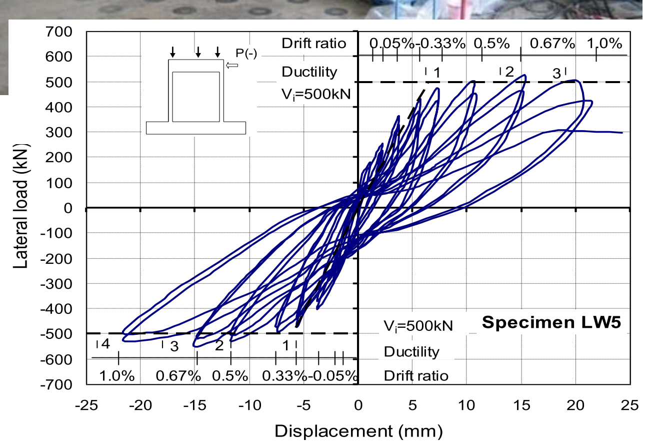
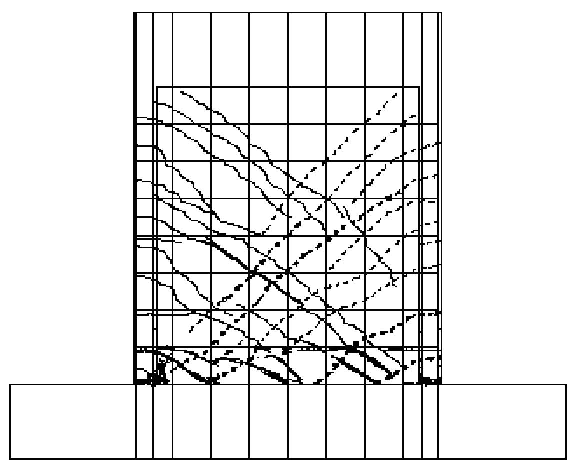
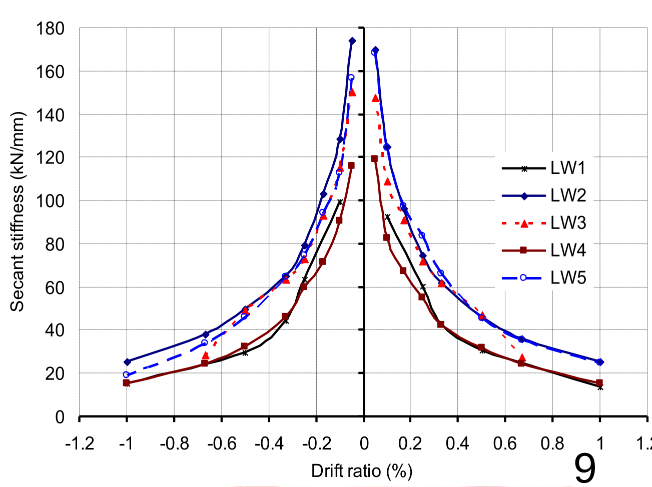
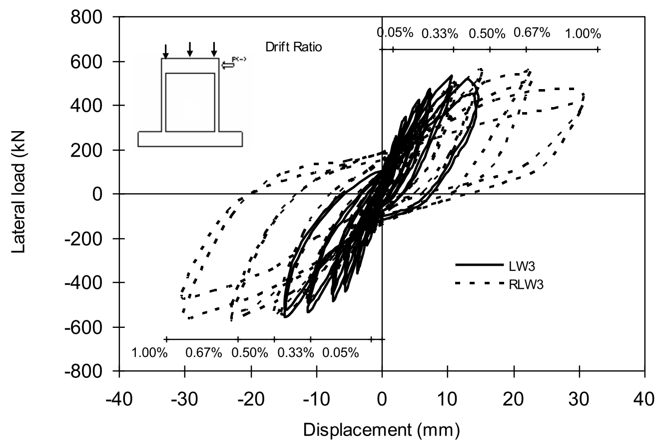


Figure 9. Final failure modes of Specimen RC2A









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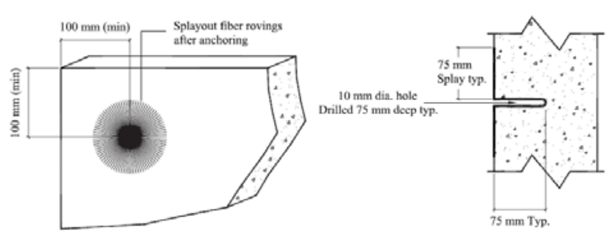

Isometric Detail

Typical Section

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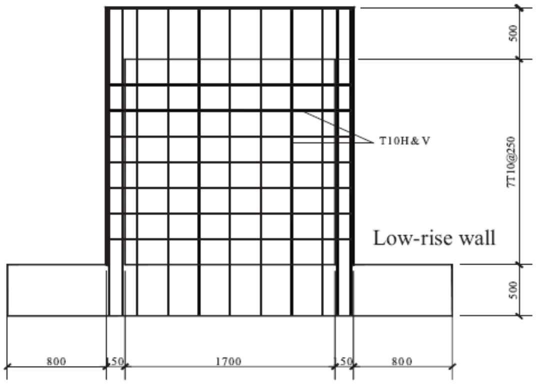
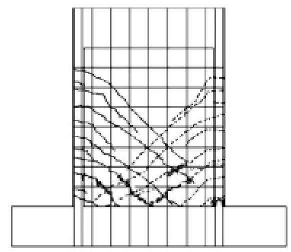
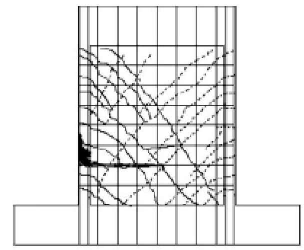
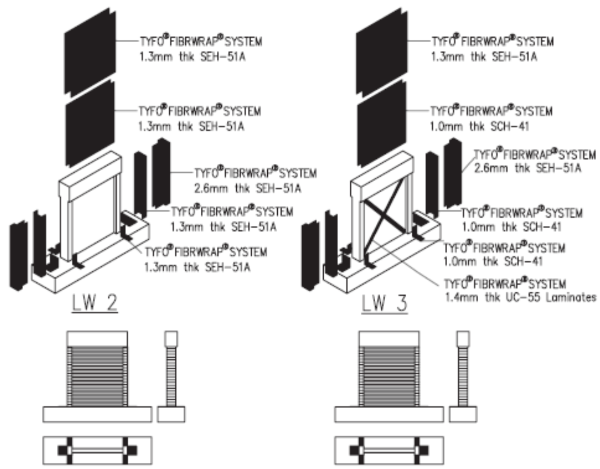


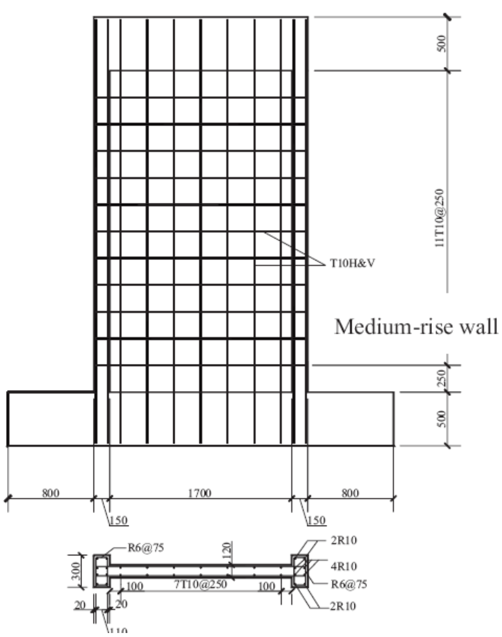


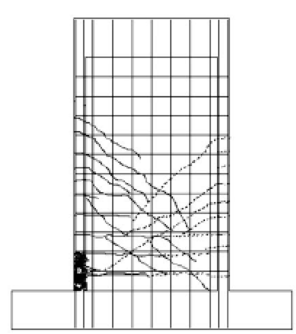
Specimen LW2 at DR= 1.33%



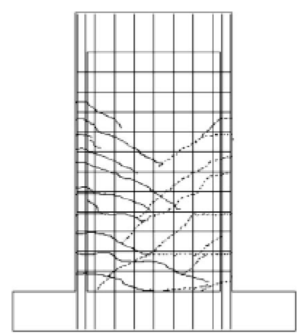
Specimen LW3 at DR= 0.67%



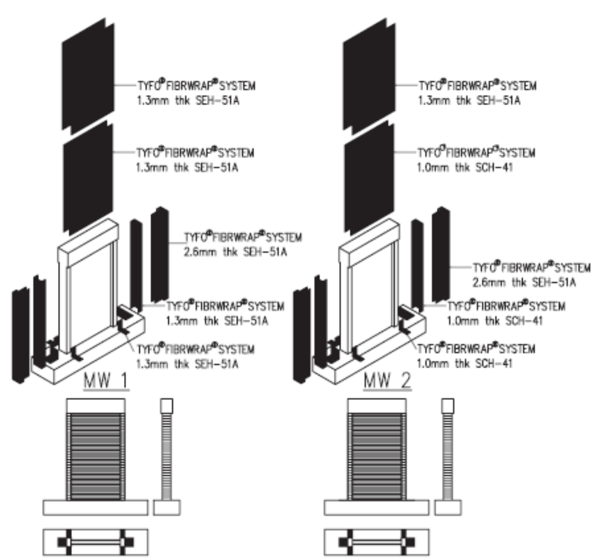




Specimen MW1 at DR= 1.00%



Specimen MW2 at DR= 1.00%



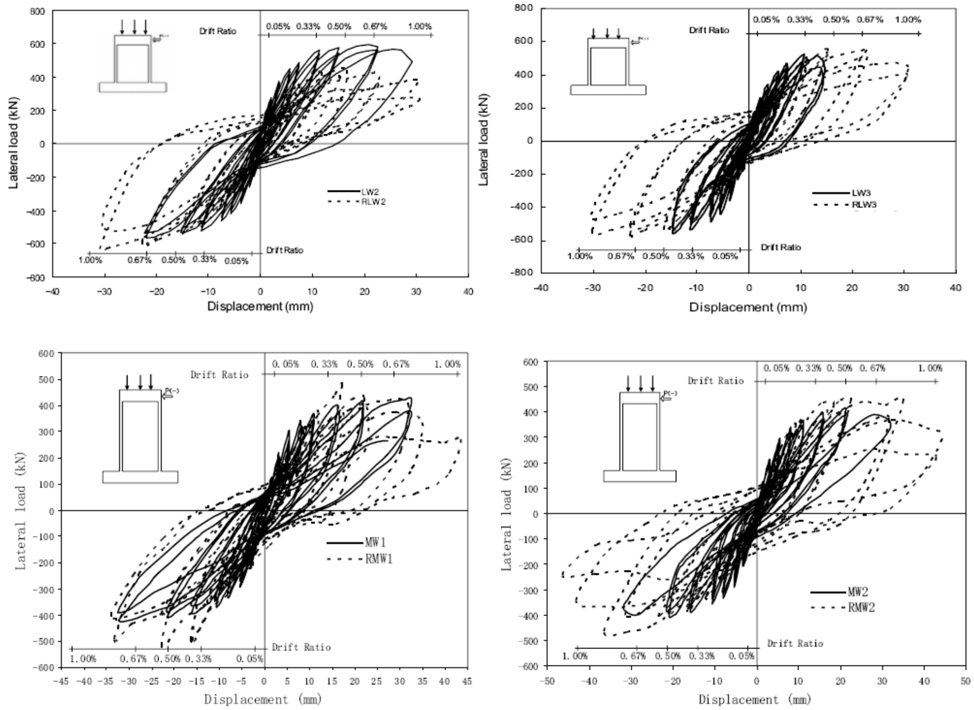
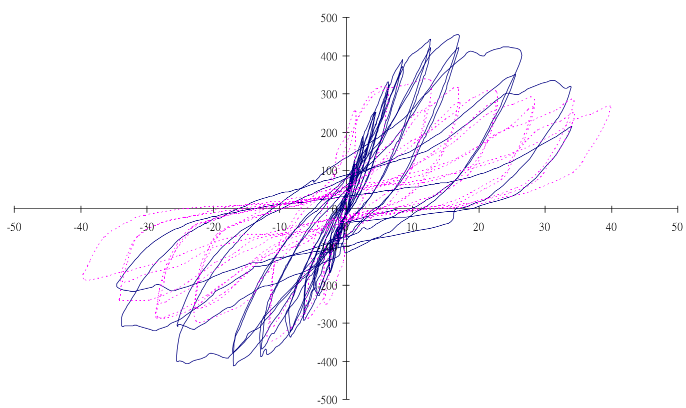
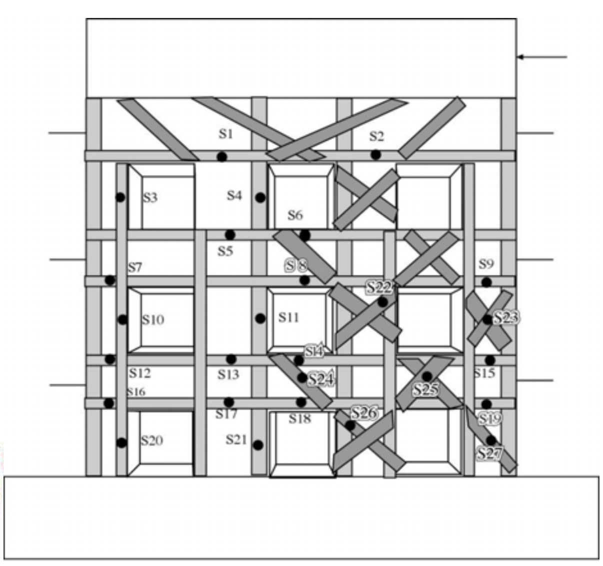
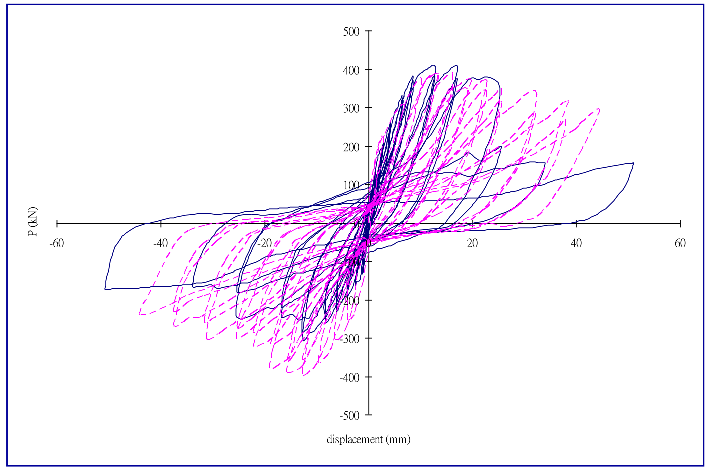
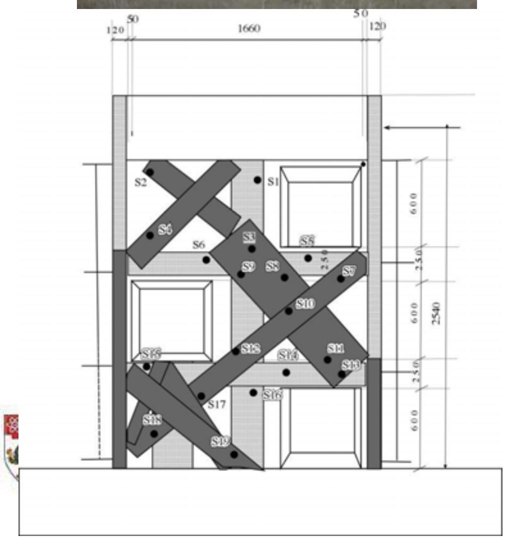


Fig. 12. Hysteresis loops of original and repaired wall specimens

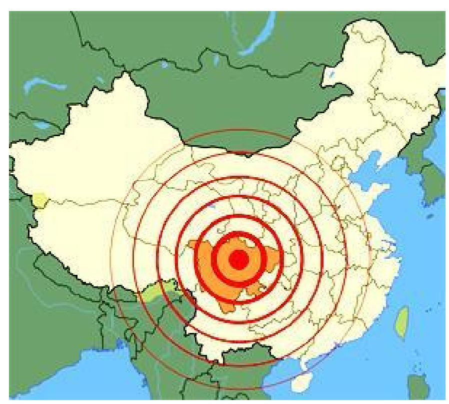








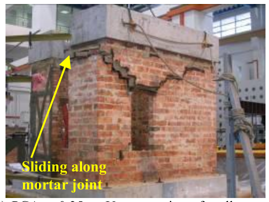
Causes for Failure of Buildings during Earthquakes



- Damage to load-bearing walls
- Doors and window openings
- Failure of ground
- Failure of roofs and floors
- Failure of columns and beam-column joints
- Material and Workmanship

Structural Strengthening

(a) PGA = 0.30 g: Cracks at upper portion



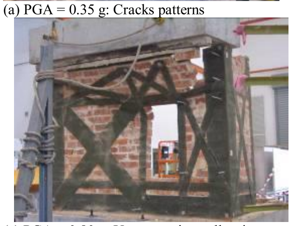
(b) PGA = 0.35 g: Upper portion of wall gave way

(c) PGA = 0.35 g – The left portion toppling

(d) PGA = 0.35 g: Total collapse

(a) PGA = 0.35 g: Cracks patterns

(b) PGA = 0.45 g: Ultimate crack pattern



(c) PGA = 0.80 g: Upper portion collapsing

(d) PGA = 0.8 g: Another view of collapse

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THE STRAITS TIMES, SATURDAY, 16 JUNE 2007, PAGE S10

Canvas can keep brick walls sturdy during quakes

NTU researchers find walls reinforced with canvas strips take longer to crumble than normal ones

By Melissa Tan

JUST a few well-placed strips of canvas can stop an entire brick building from falling apart during an earthquake.

technologies, and tries to use cheap and natural materials to assist Asian communities, where such help is most urgently needed, said Professor Pan Tso-Chien, chairman of Life's advisory board.

Prof Li added that the researchers had to find a solution that "could be applied easily and with minimal increase in cost", because "many regional rural communities may lack the resources to implement it otherwise".

The team, made up of NTU faculty, graduate students and undergraduates in their final year, tested other cheap materi-

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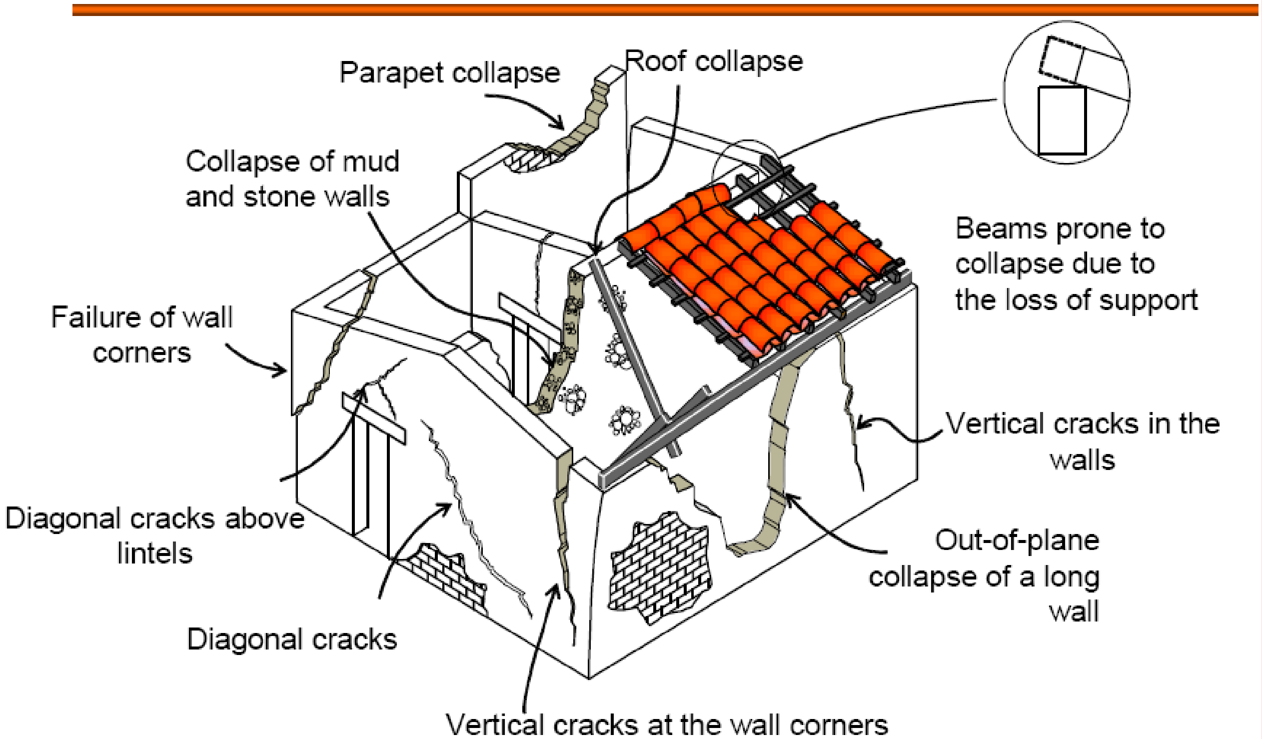

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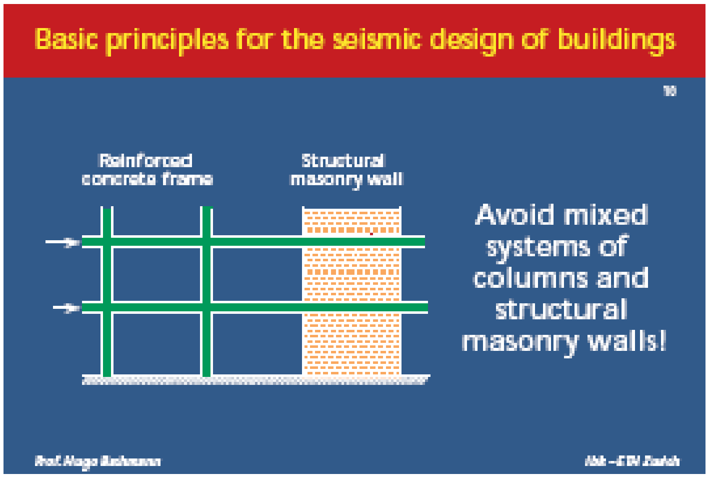

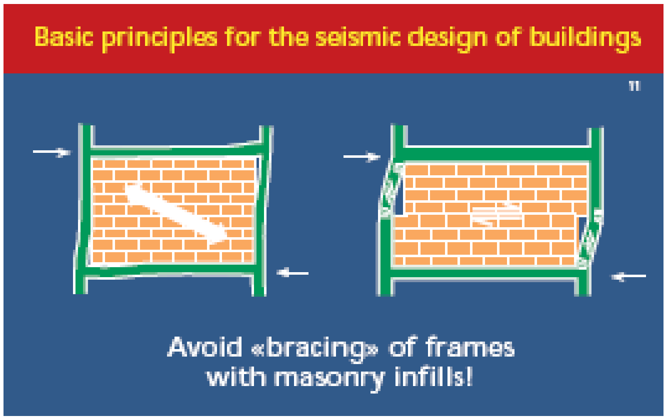

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Cracking and separation of adobe walls – 1997 Jabalpur, India earthquake (Report #23)

Out-of-plane wall collapse – 1996 Nazca earthquake, Peru (Report #52)

Total collapse of adobe walls – February 2001 El Salvador earthquake (Report #14)

Crushing of adobe walls – 1997 Jabalpur earthquake, India (Report #23)

Bhaktapur Darbar Square before and after 1934 Earthquake

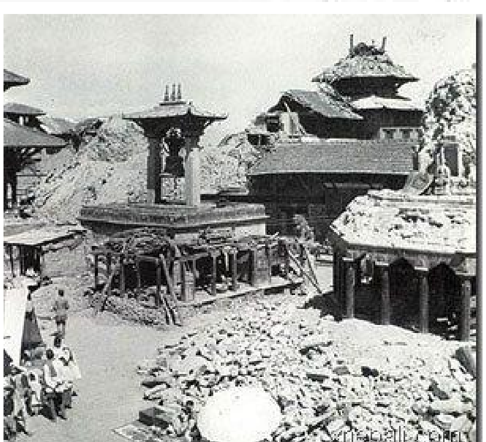


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Photo 13. Excavating around the footing.

Photo 14. hardening the surface and installing the dowels.

Photo 15. Installing the main steel.

Photo 16. Completing the jacket.

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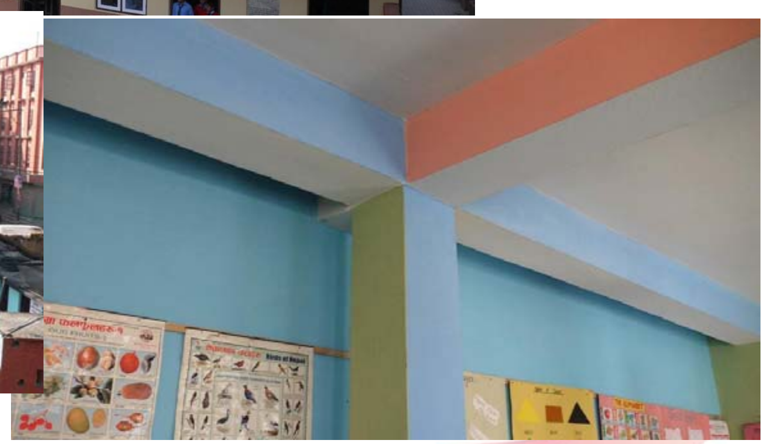

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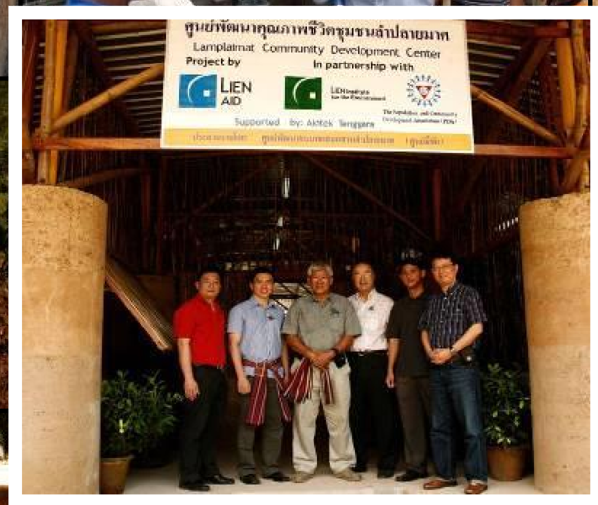
CANTEEN


2007
2005
2002



Thank You

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