

INVESTIGATION ON THE PERFORMANCE OF BUILDINGS WITH STRUCTURAL WALLS IN THE TOHOKU, JAPAN, EARTHQUAKE OF 2011

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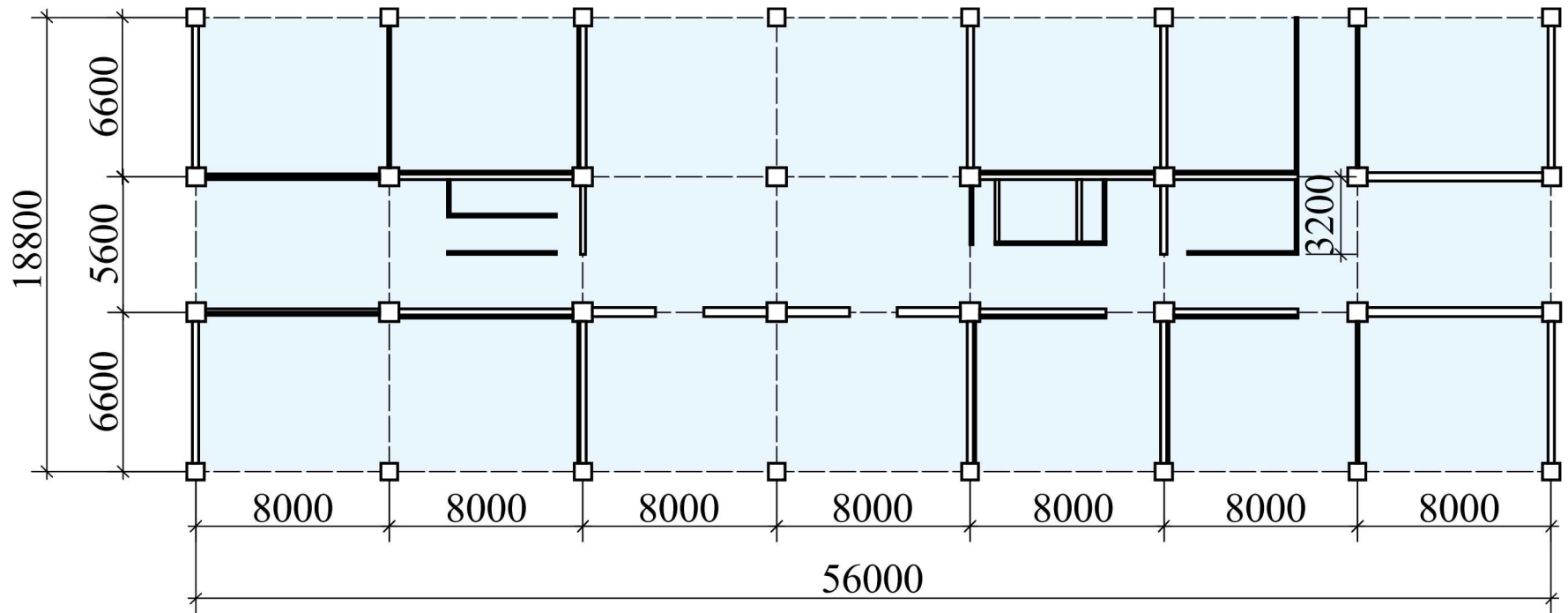
Susumu Takahashi, Nagoya Institute of Technology

Overview of the project

- Severe damage of RC buildings with structural walls were observed.
- Three retrofitted RC buildings are picked up and the damage are investigated.
- The reason of the damage and what happened during the earthquake are discussed.

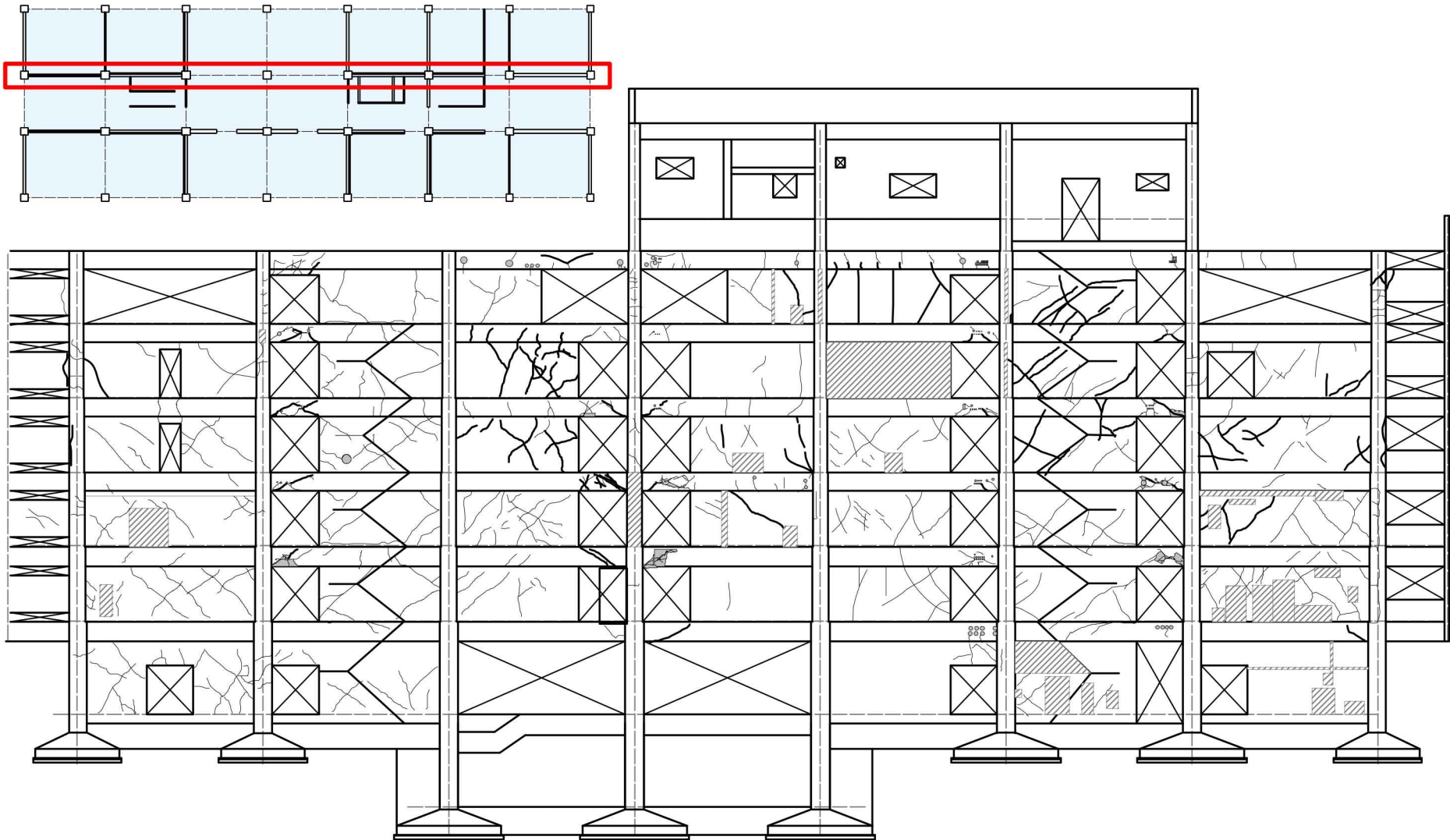
Material Building

- Built in 1968
- 6-story RC building
- Retrofitted in 1997



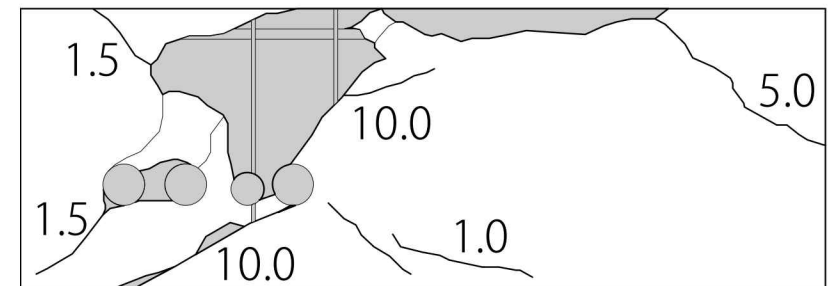
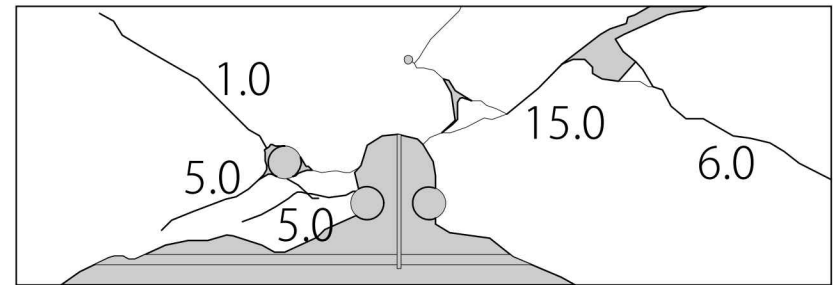
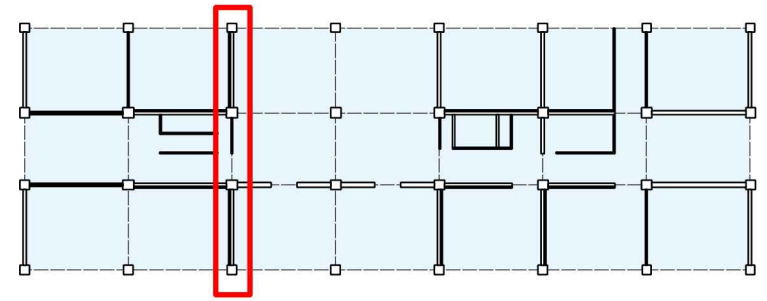
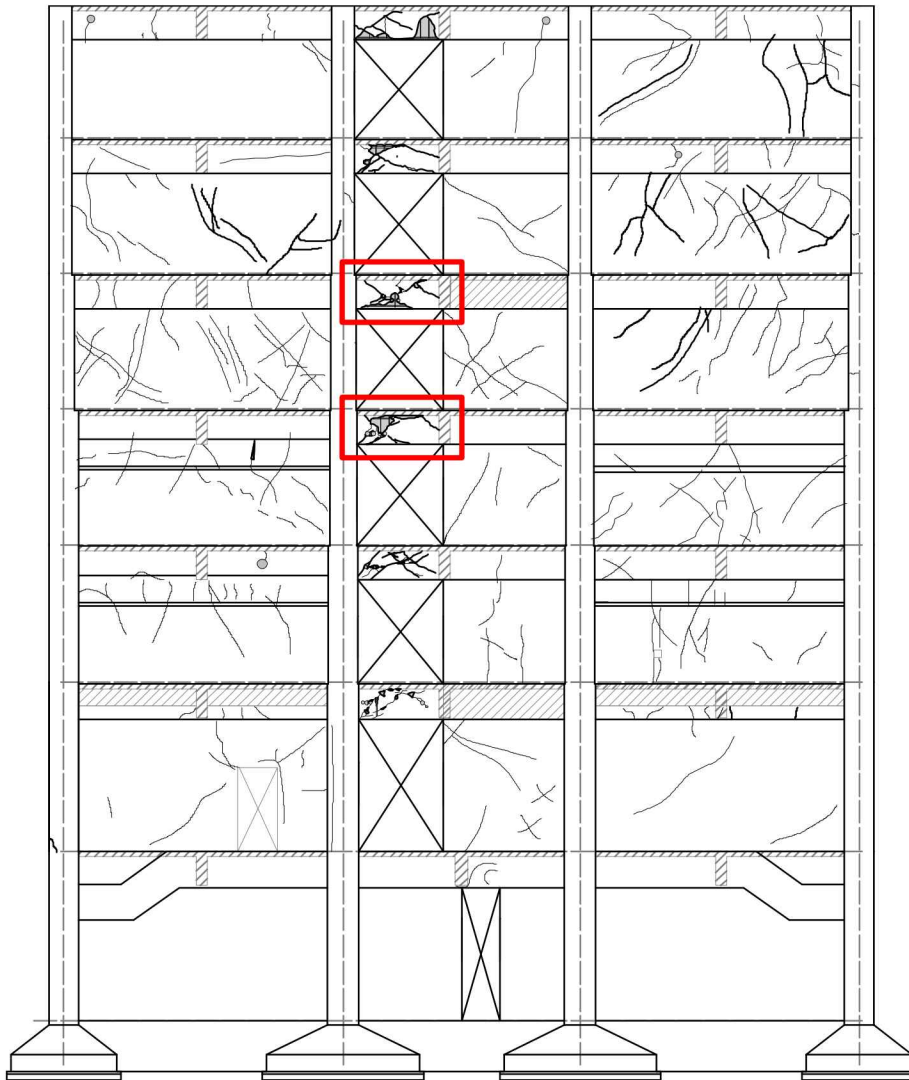
1st story plan

Material Building



Observed damage in longitudinal direction

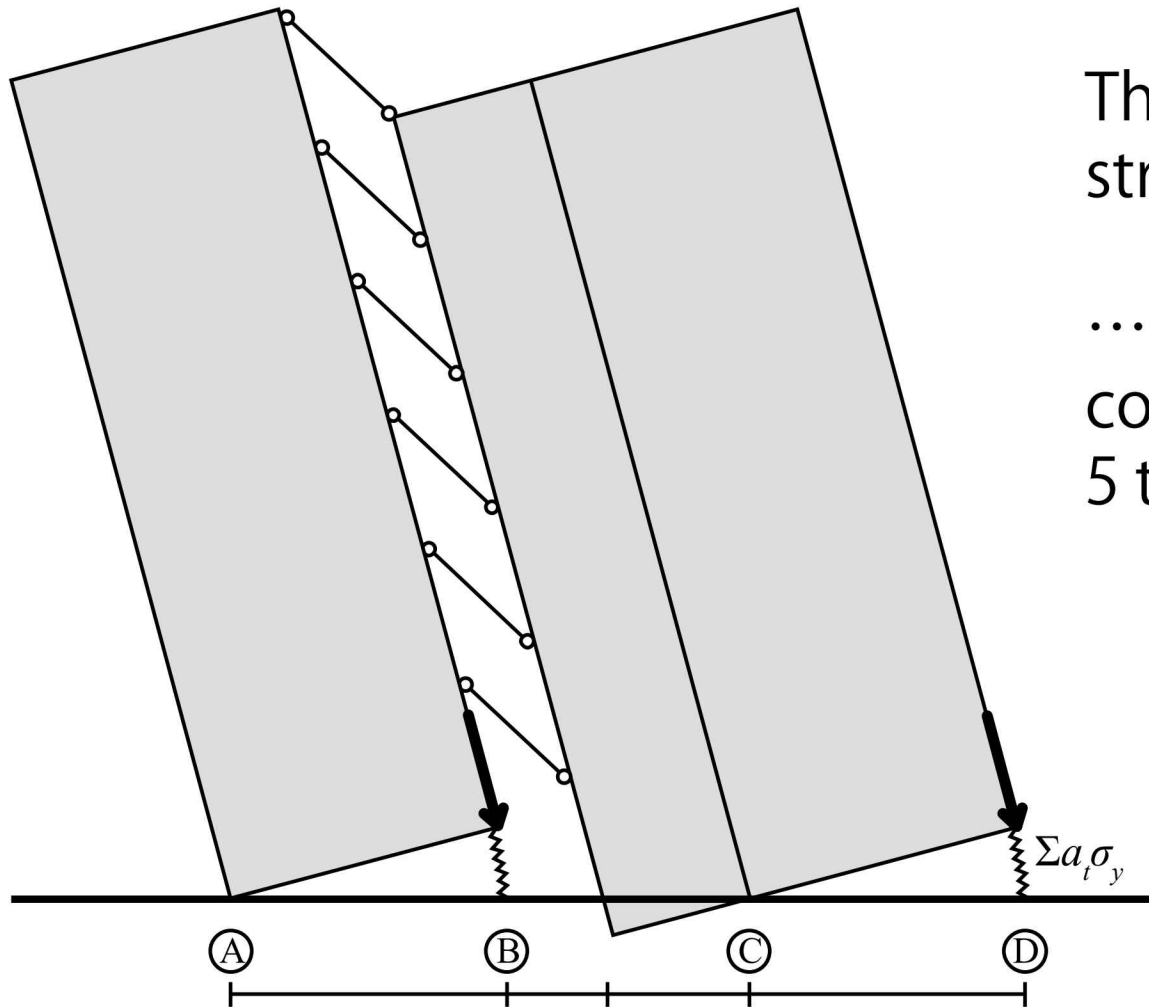
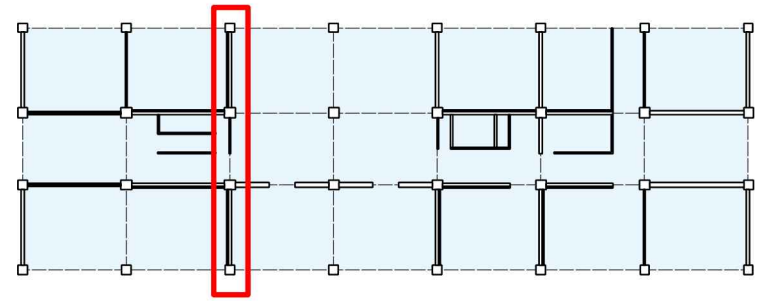
Material Building



Observed damage in longitudinal direction

Material Building

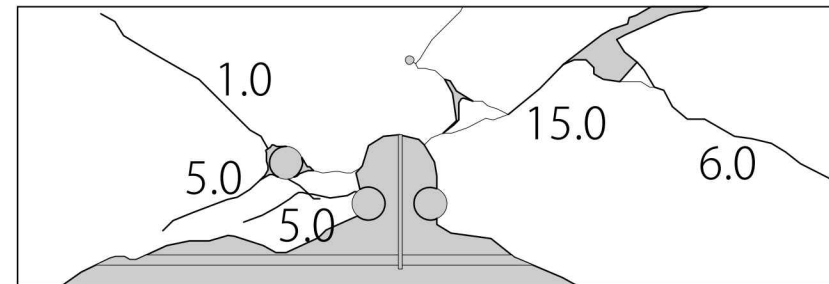
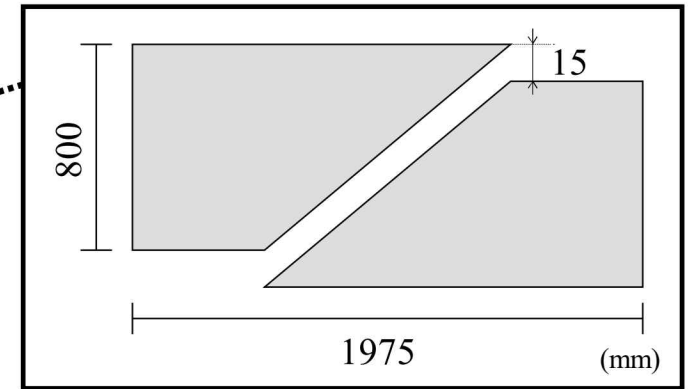
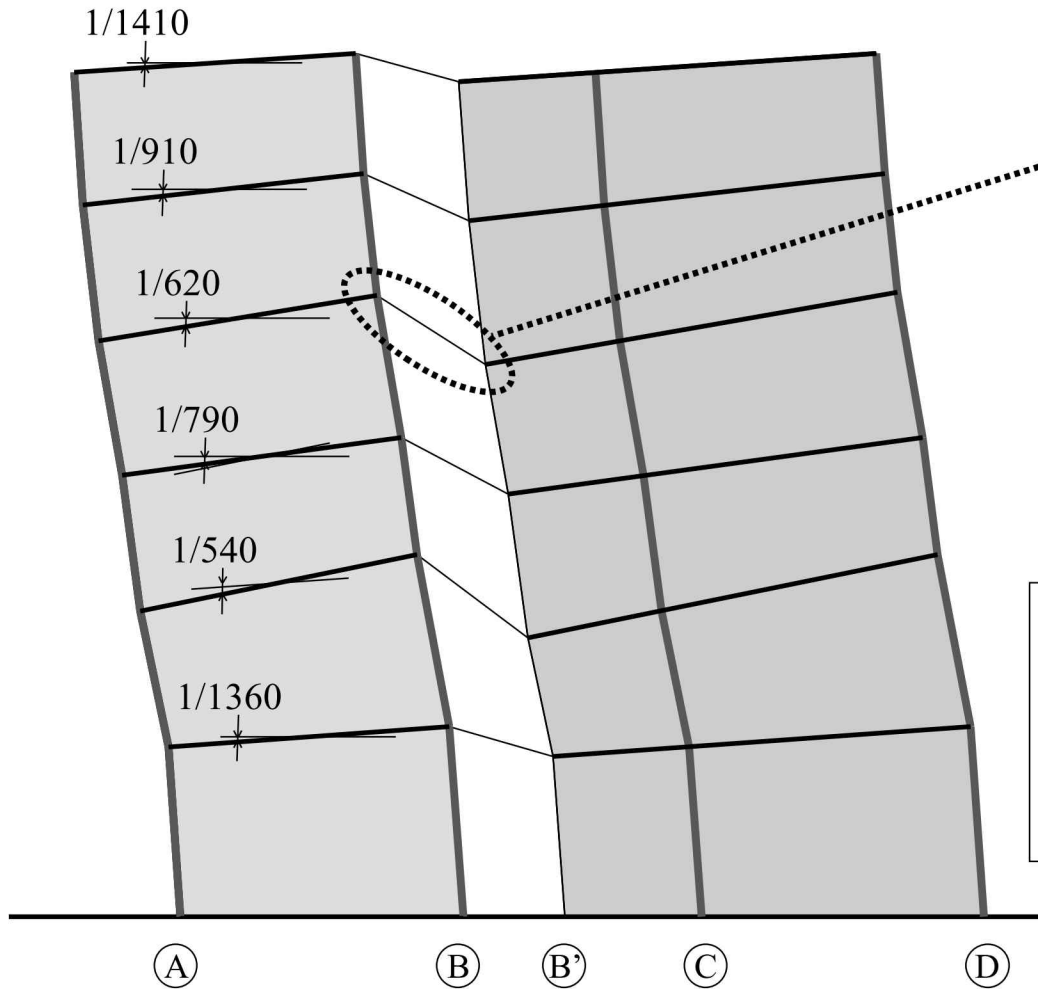
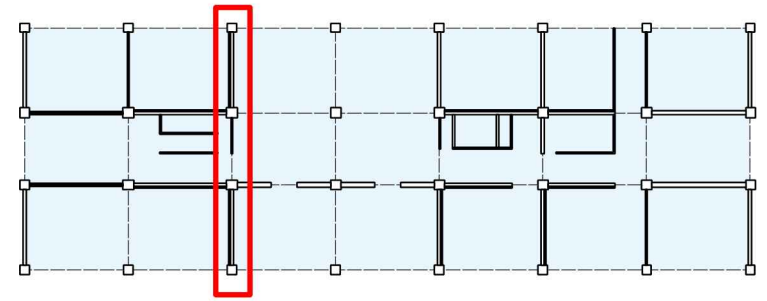
Limit analysis



This frame has large strength.

...But,
coupling beams deform
5 times as much as walls.

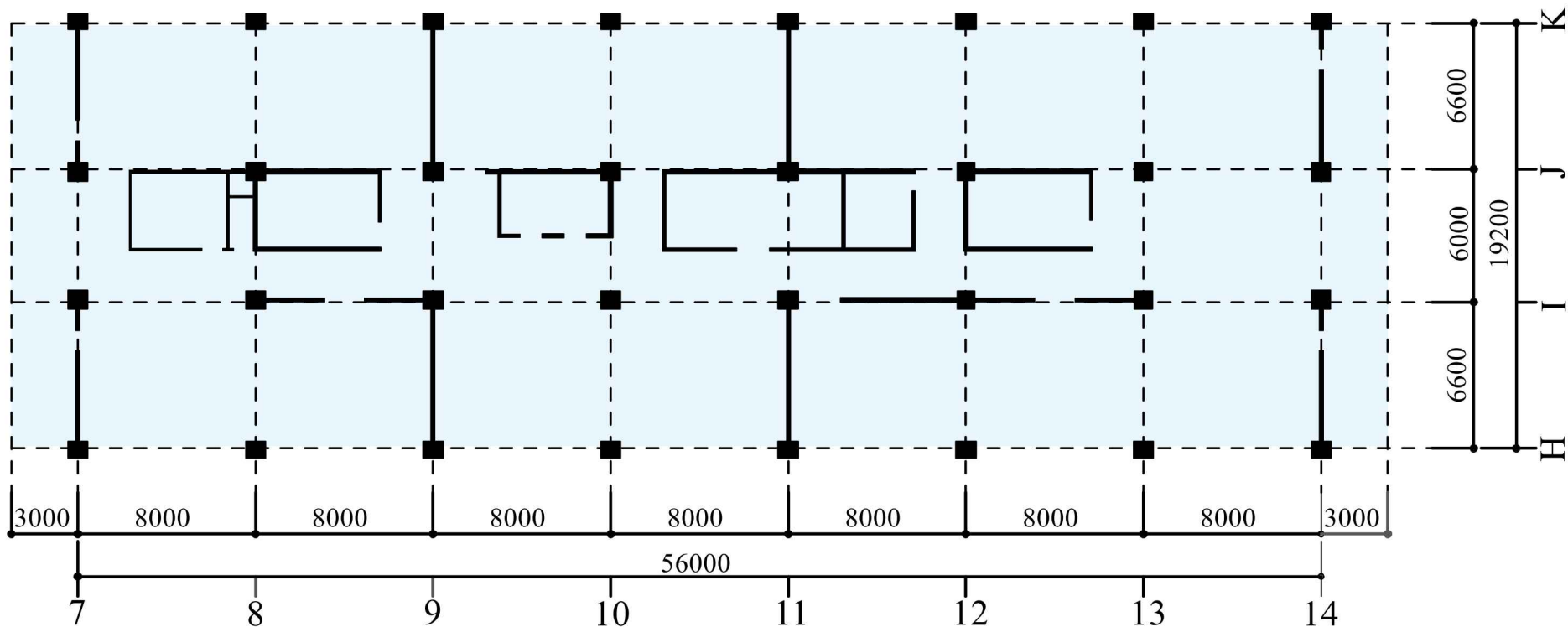
Material Building



Estimated deformation

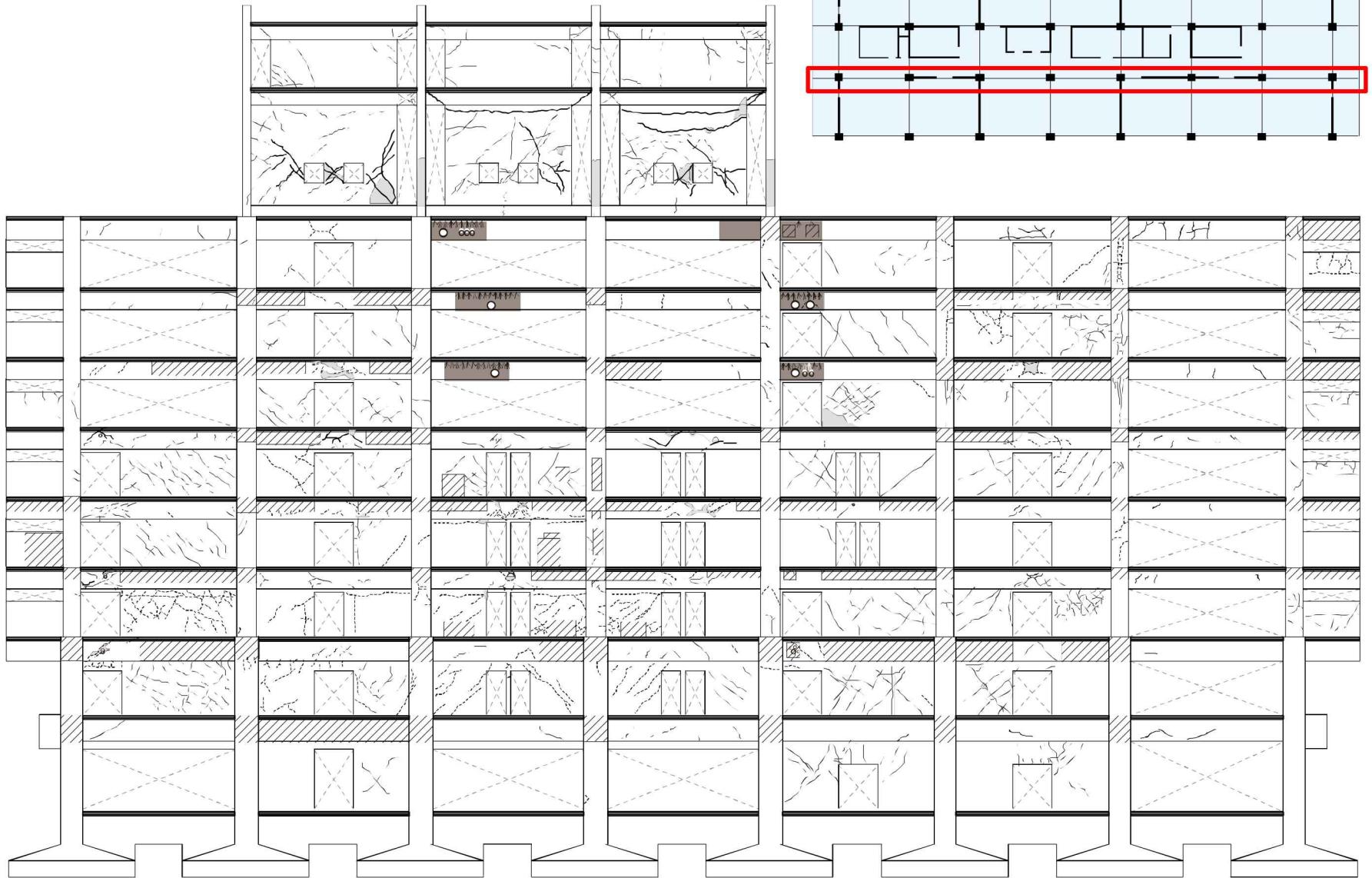
Electrical Building

- Built in 1966
- 8-story RC building
- Retrofitted in 1996



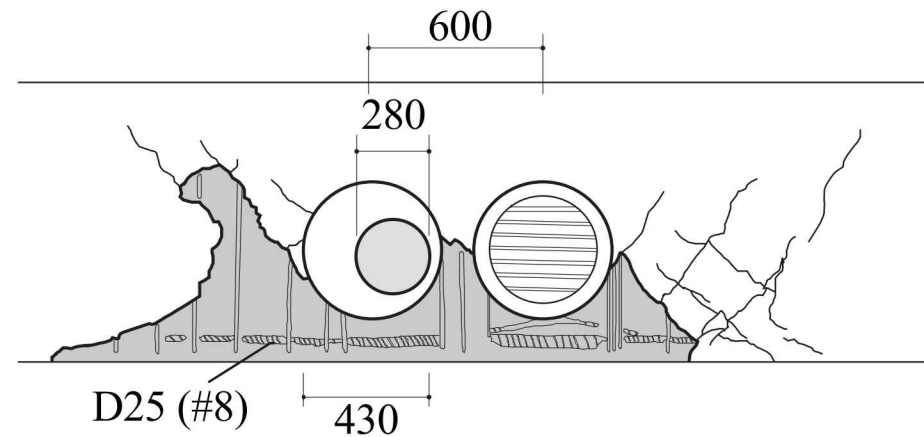
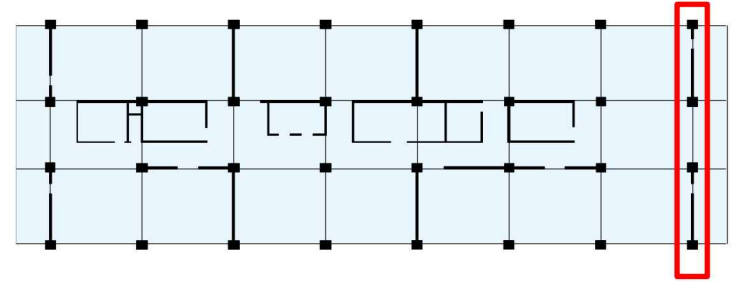
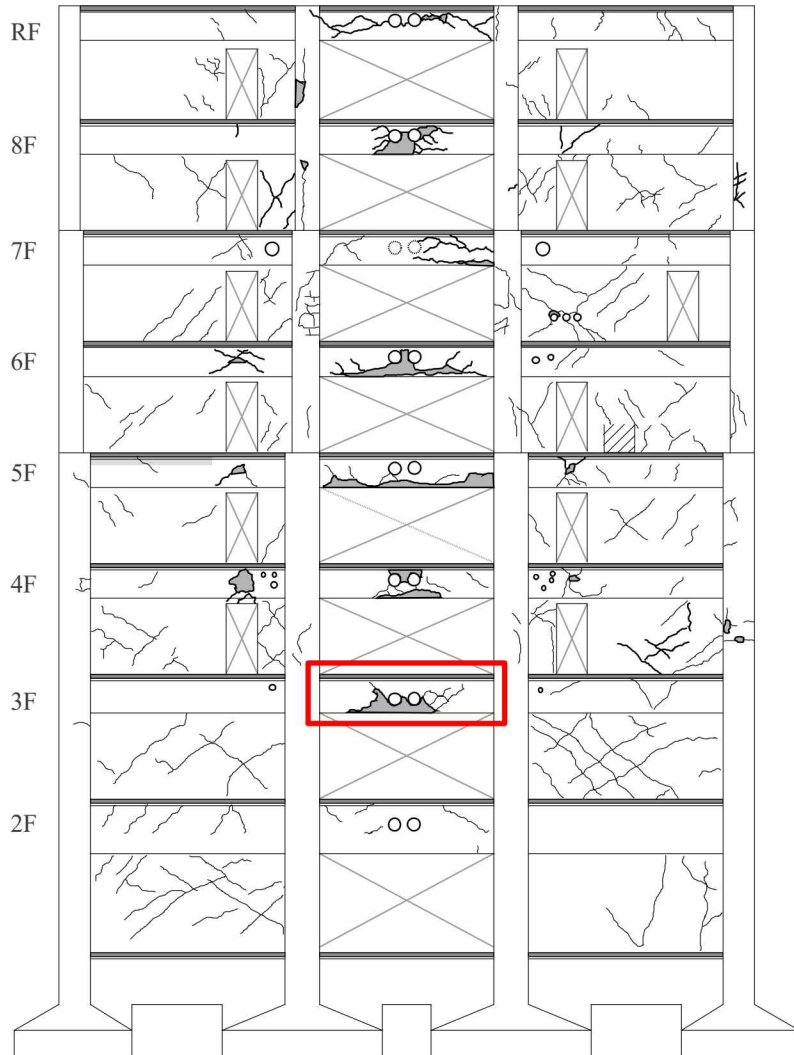
6th story plan

Electrical Building



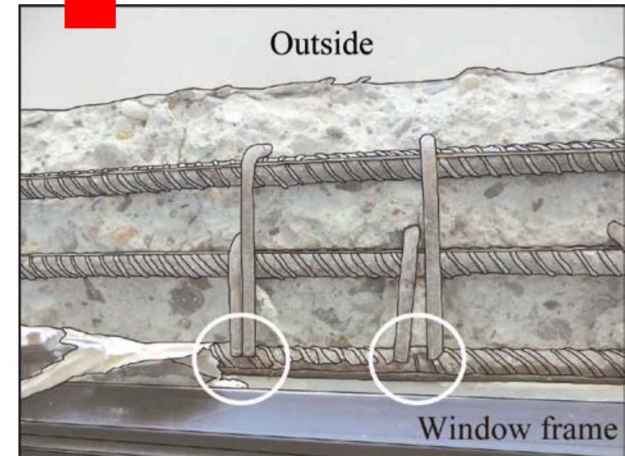
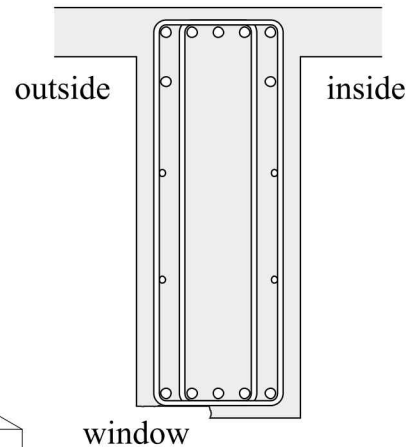
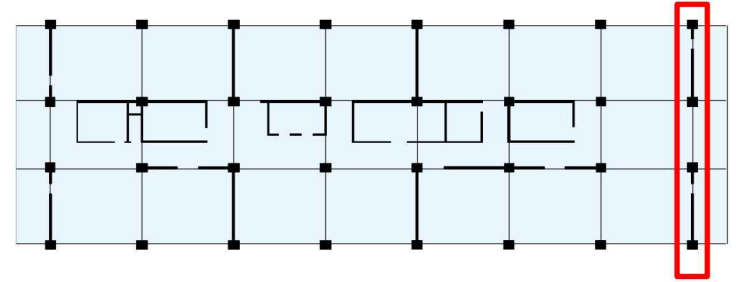
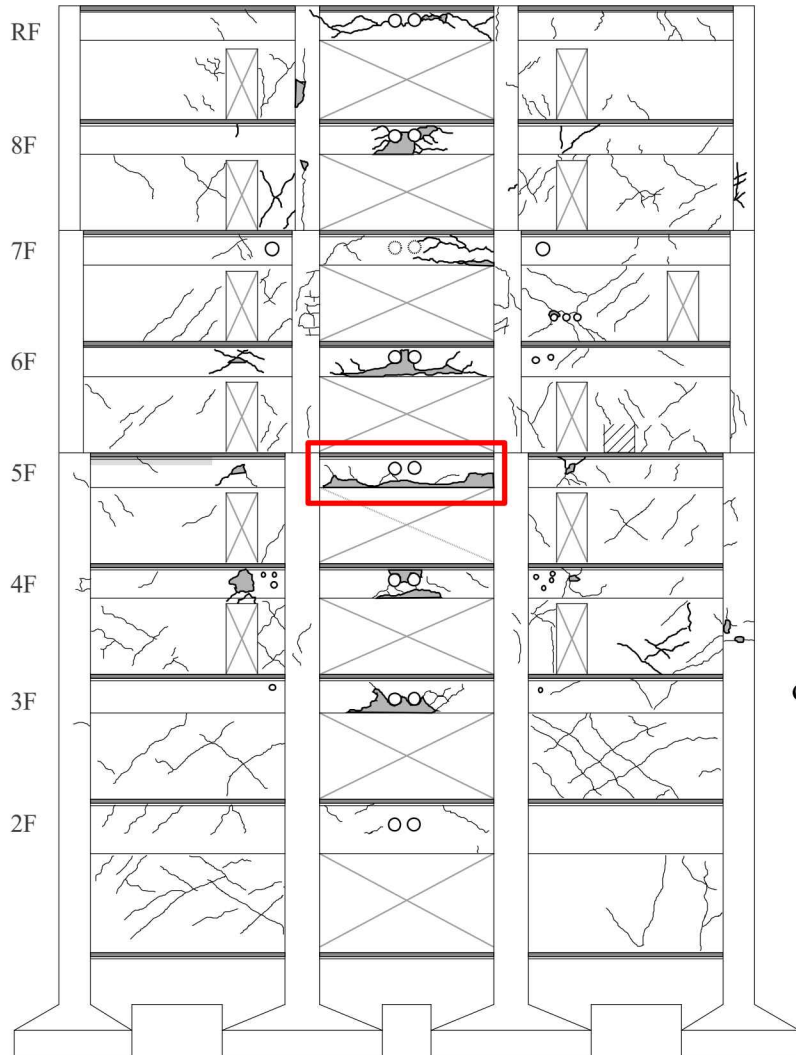
Observed damage in longitudinal direction

Electrical Building



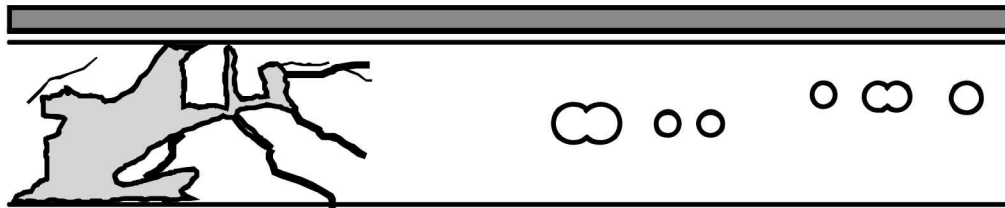
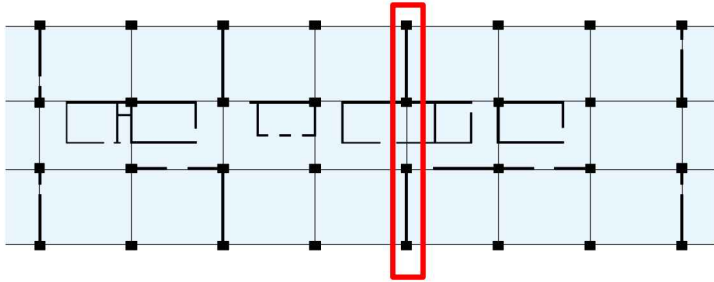
Observed damage in transverse direction

Electrical Building

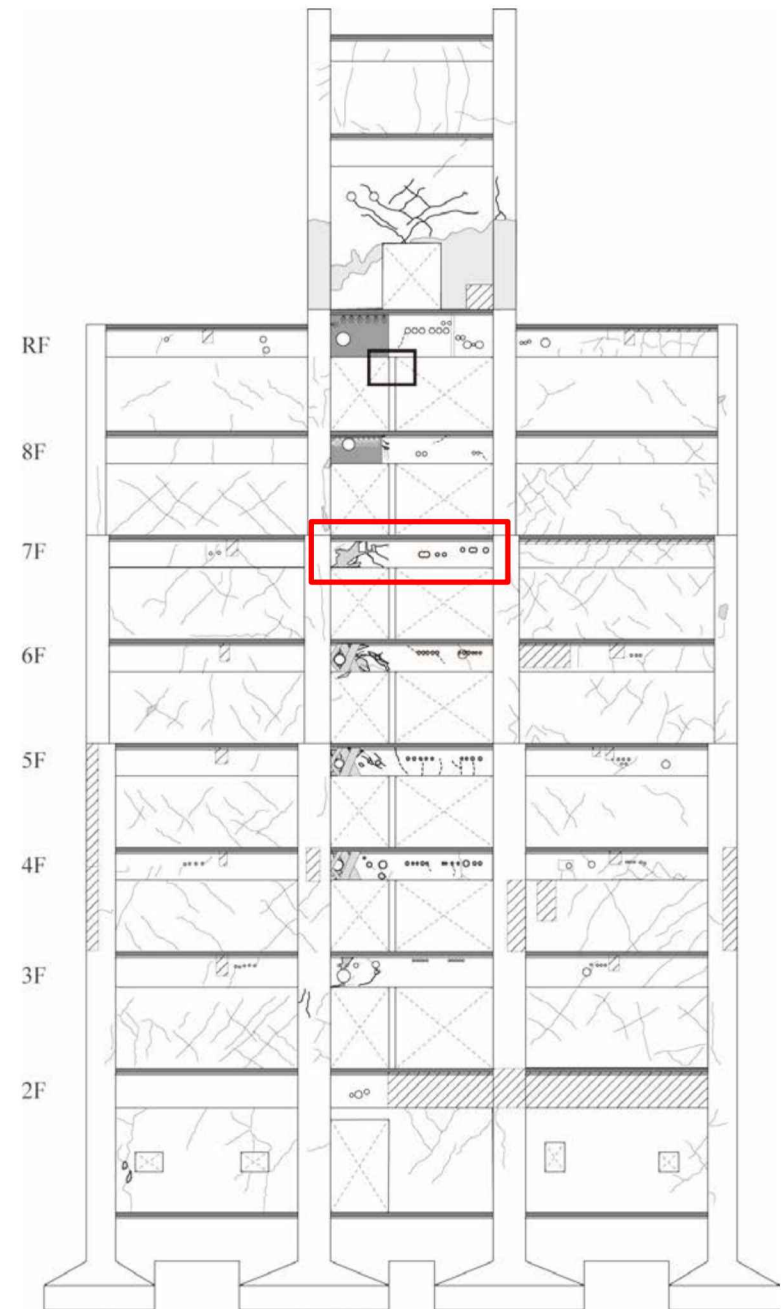


Observed damage in transverse direction

Electrical Building

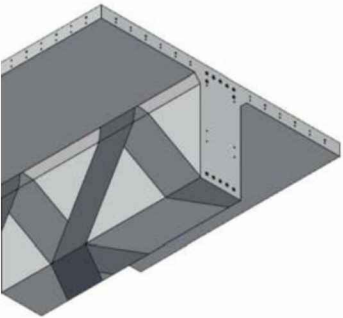
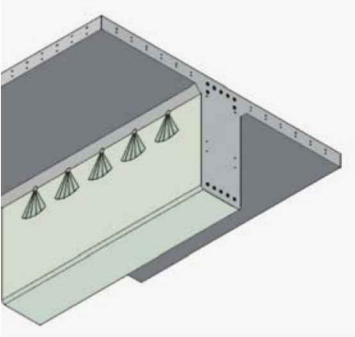


Damage in left hand side
was serious.

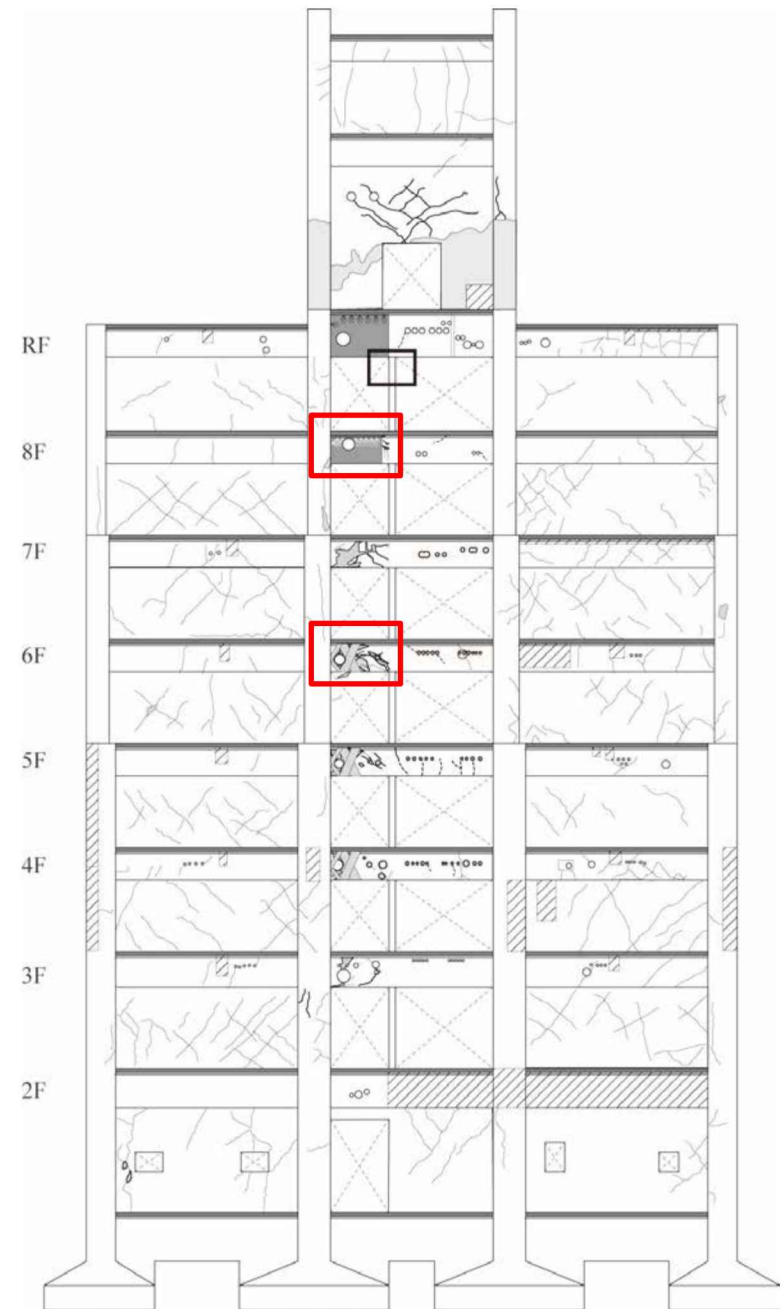


Observed damage in transverse direction

Electrical Building

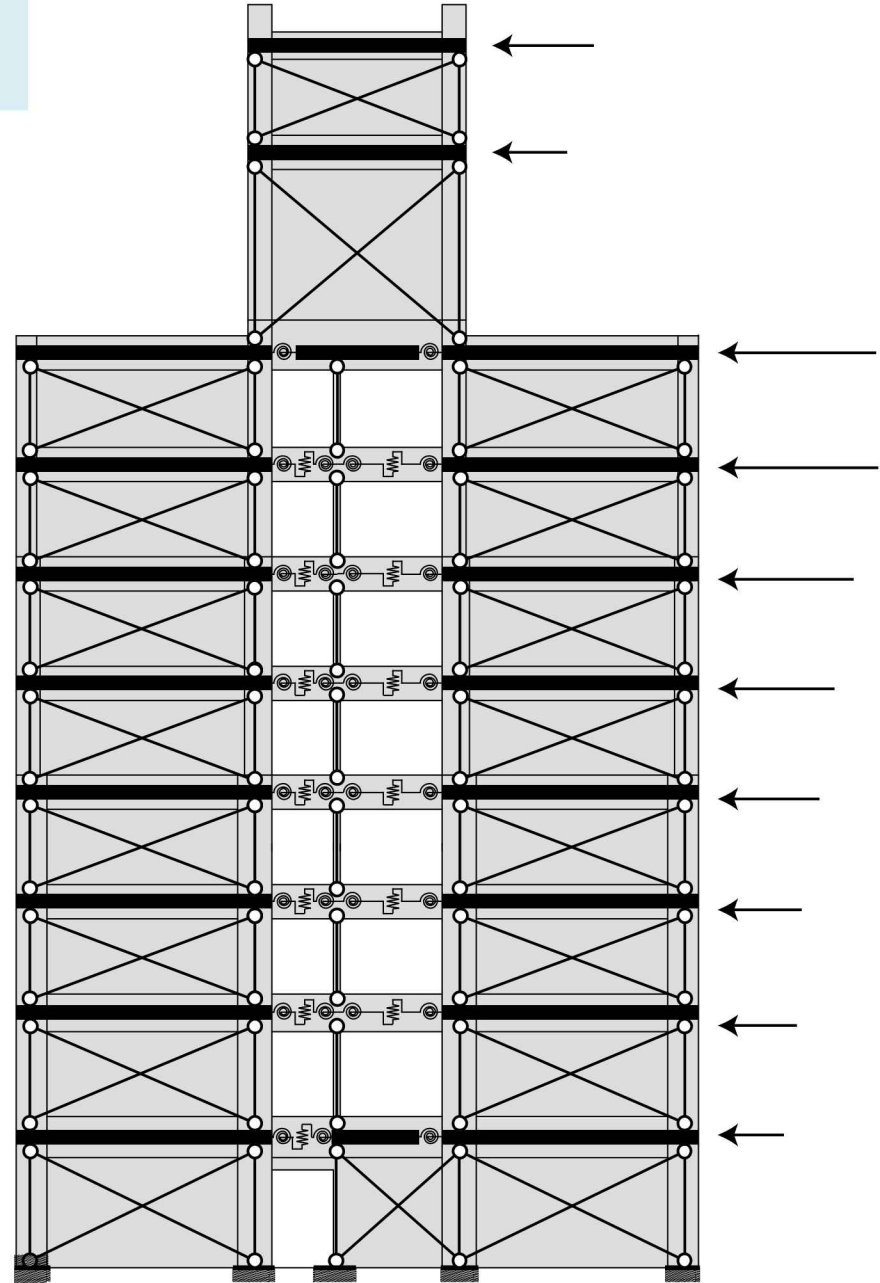
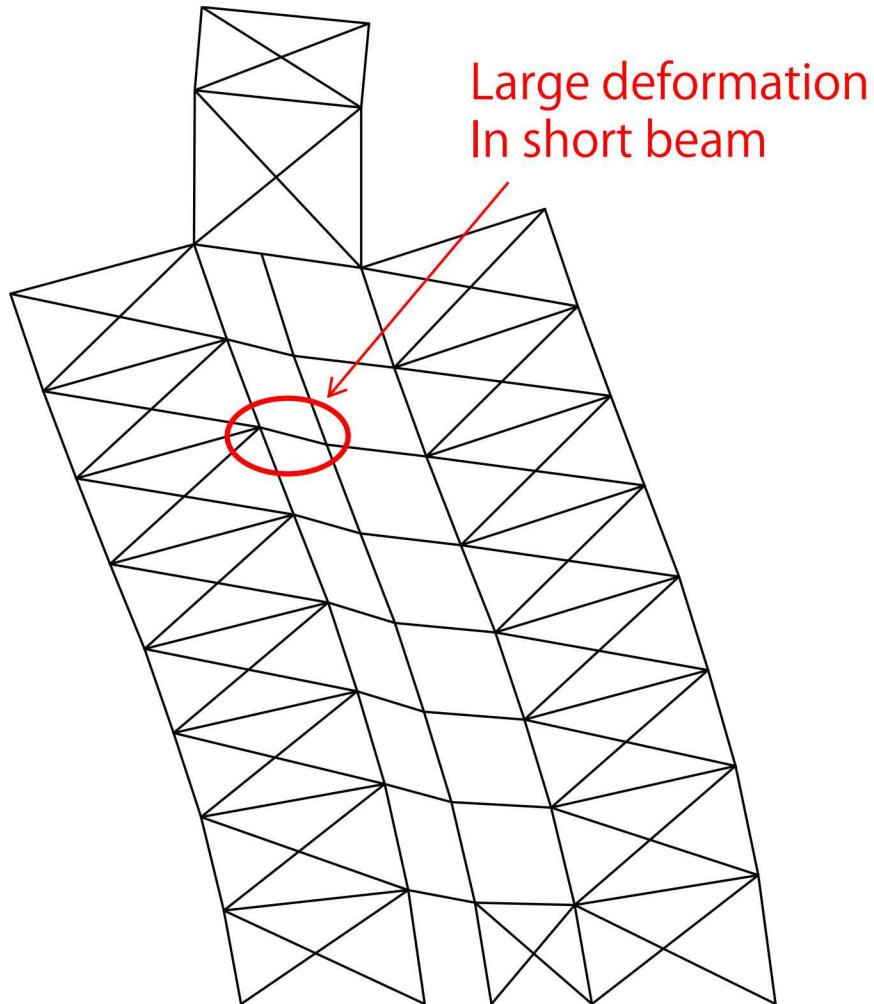


Reinforcement with carbon fiber

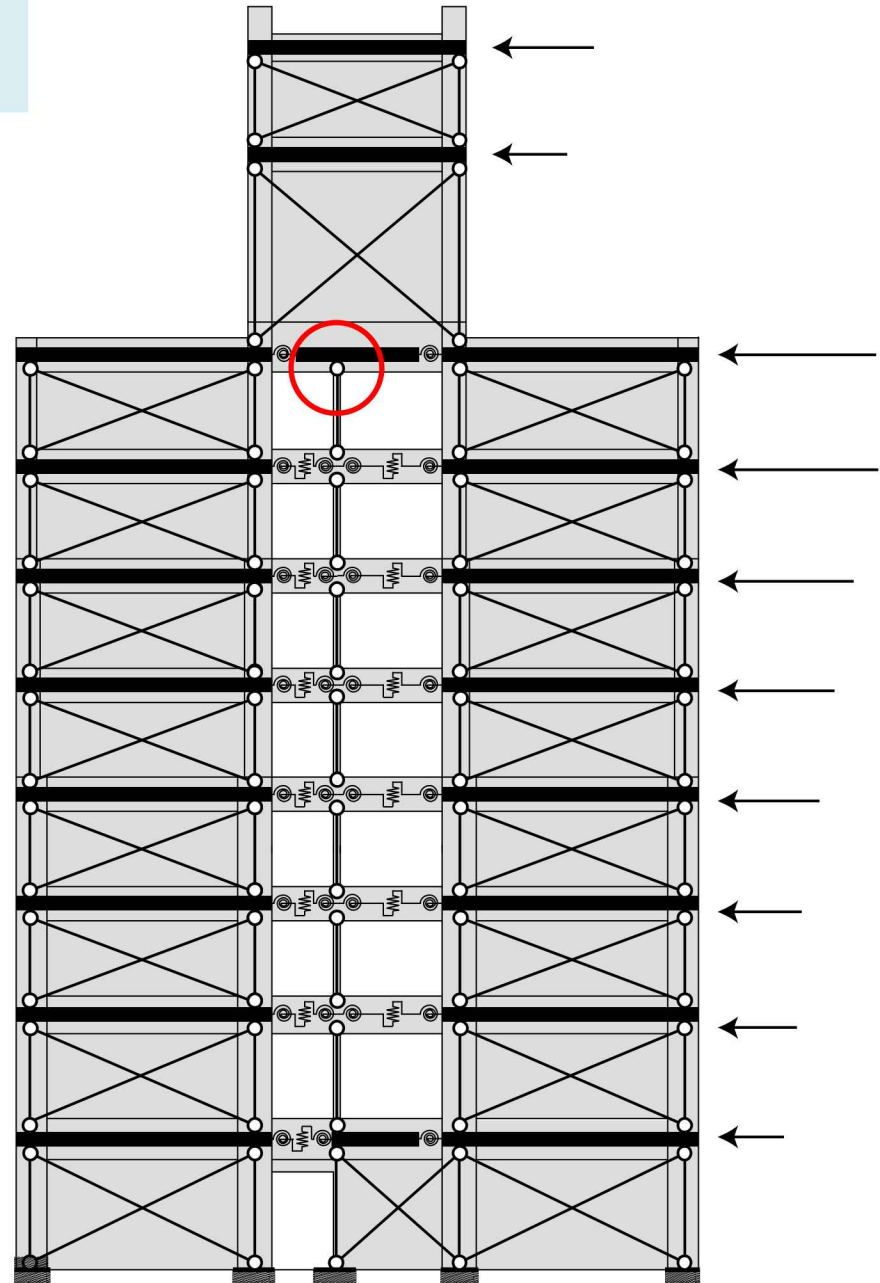
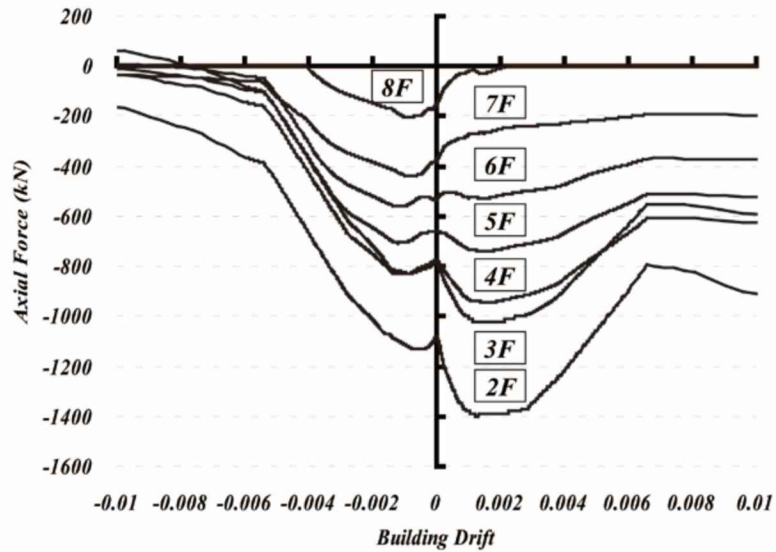


Electrical Building

Pushover analysis



Electrical Building



Effect of Longitudinal Web Reinforcement Discontinuities on the Drift Capacity of Structural Walls

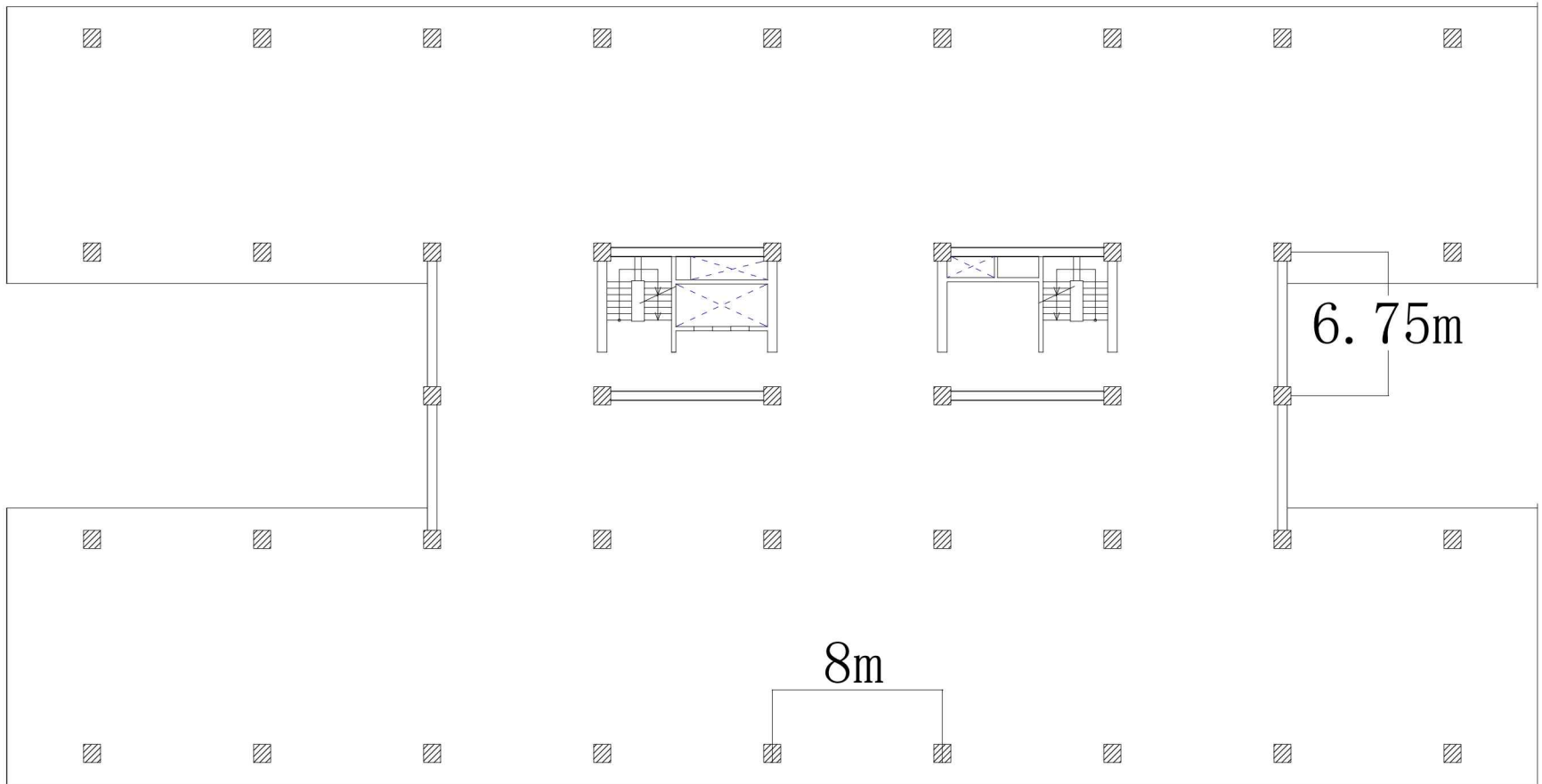
Ying Wang

Santiago Pujol

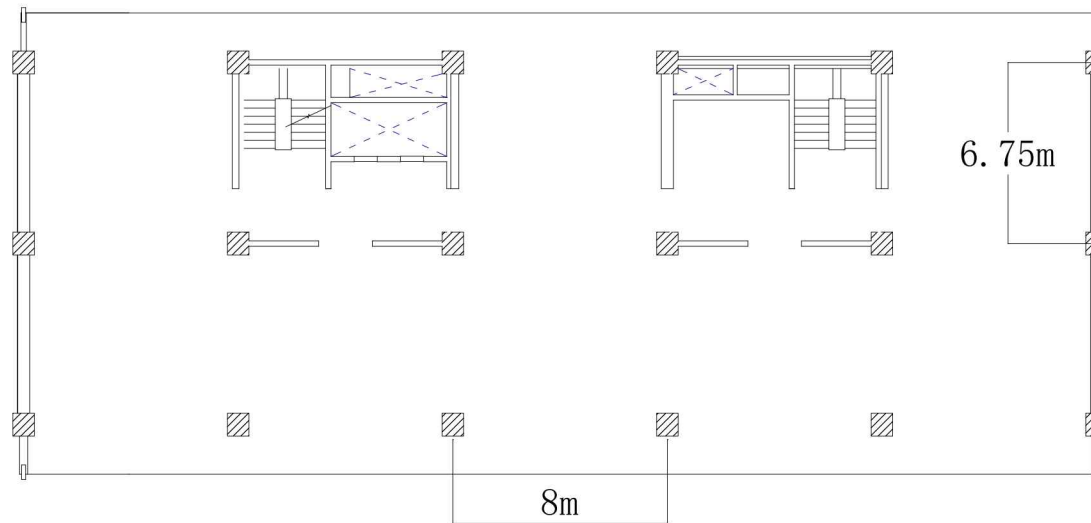
Purdue University

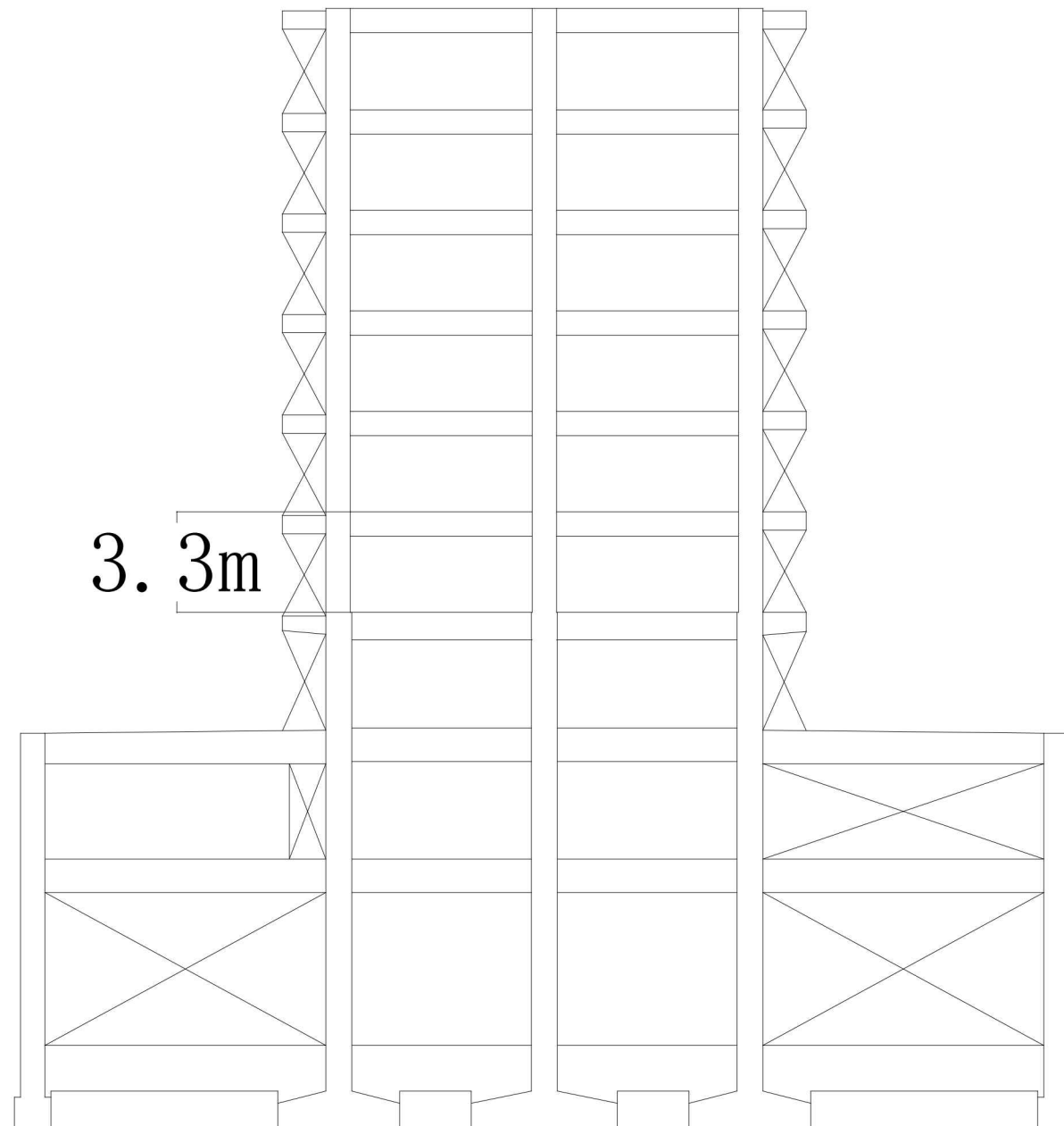


Plan View (stories: 1-2)



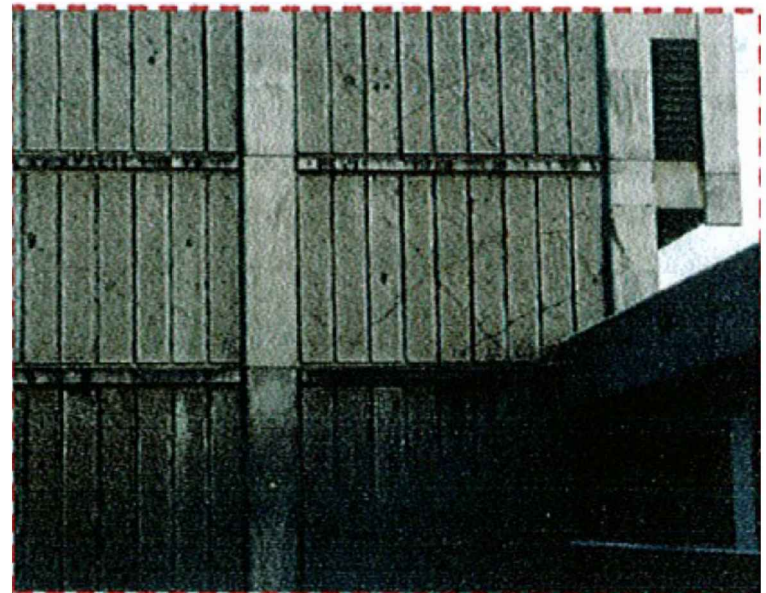
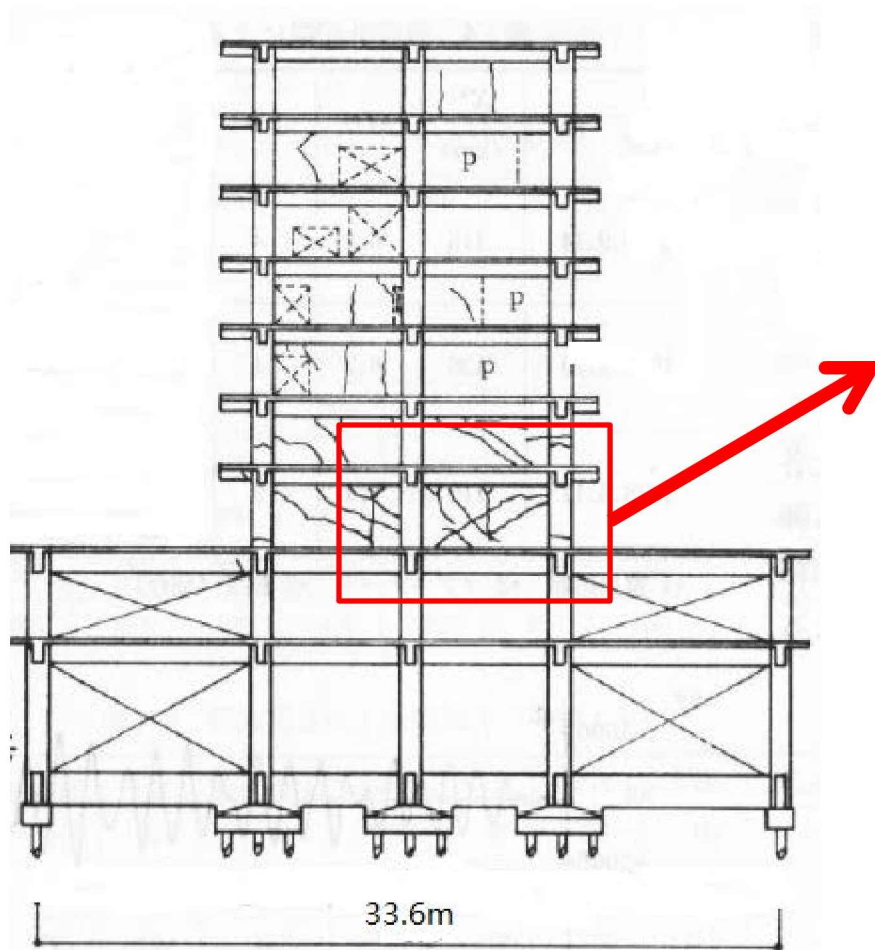
Plan View (stories: 3-9)





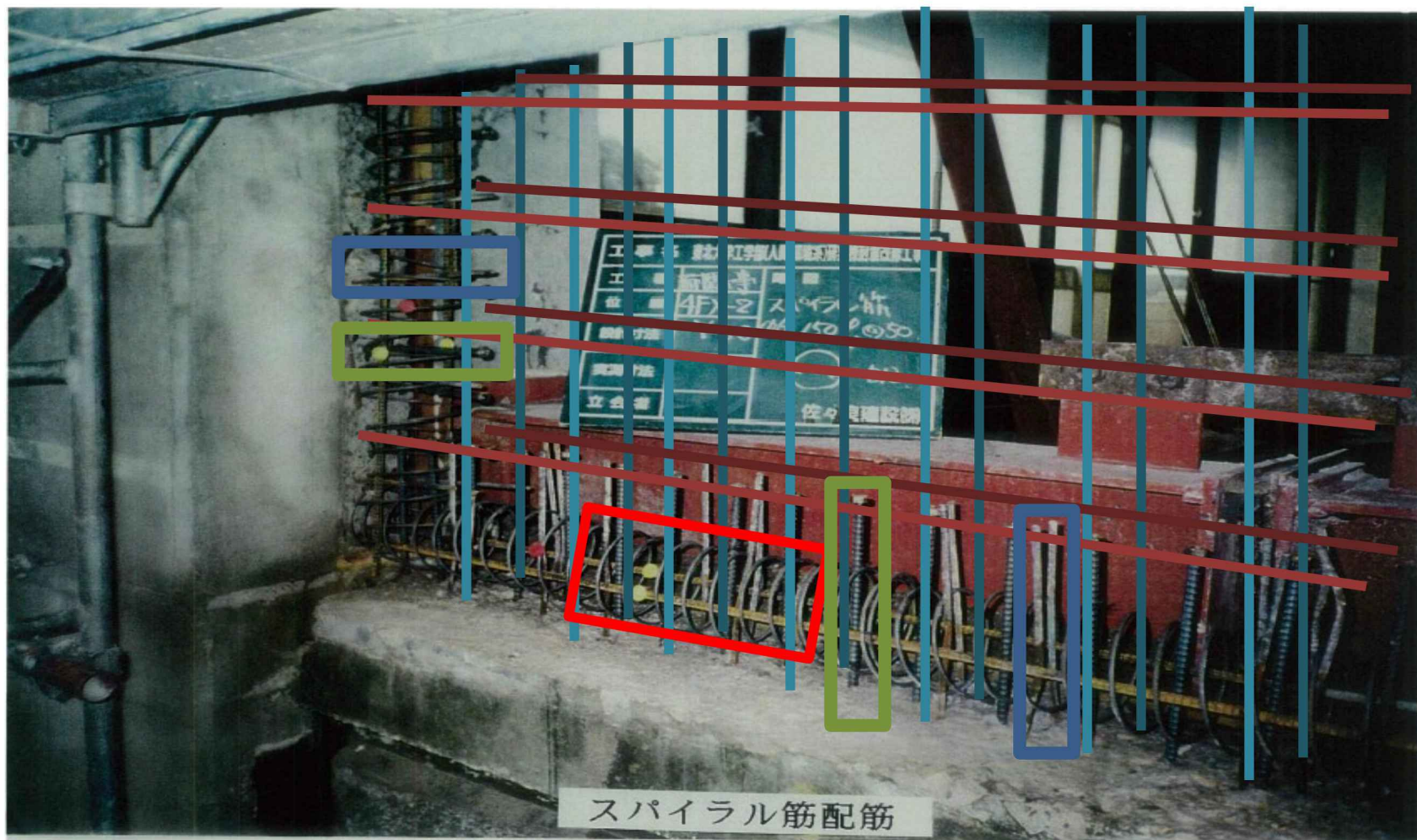
Earthquakes and Strengthening

Miyagi Earthquake 1978

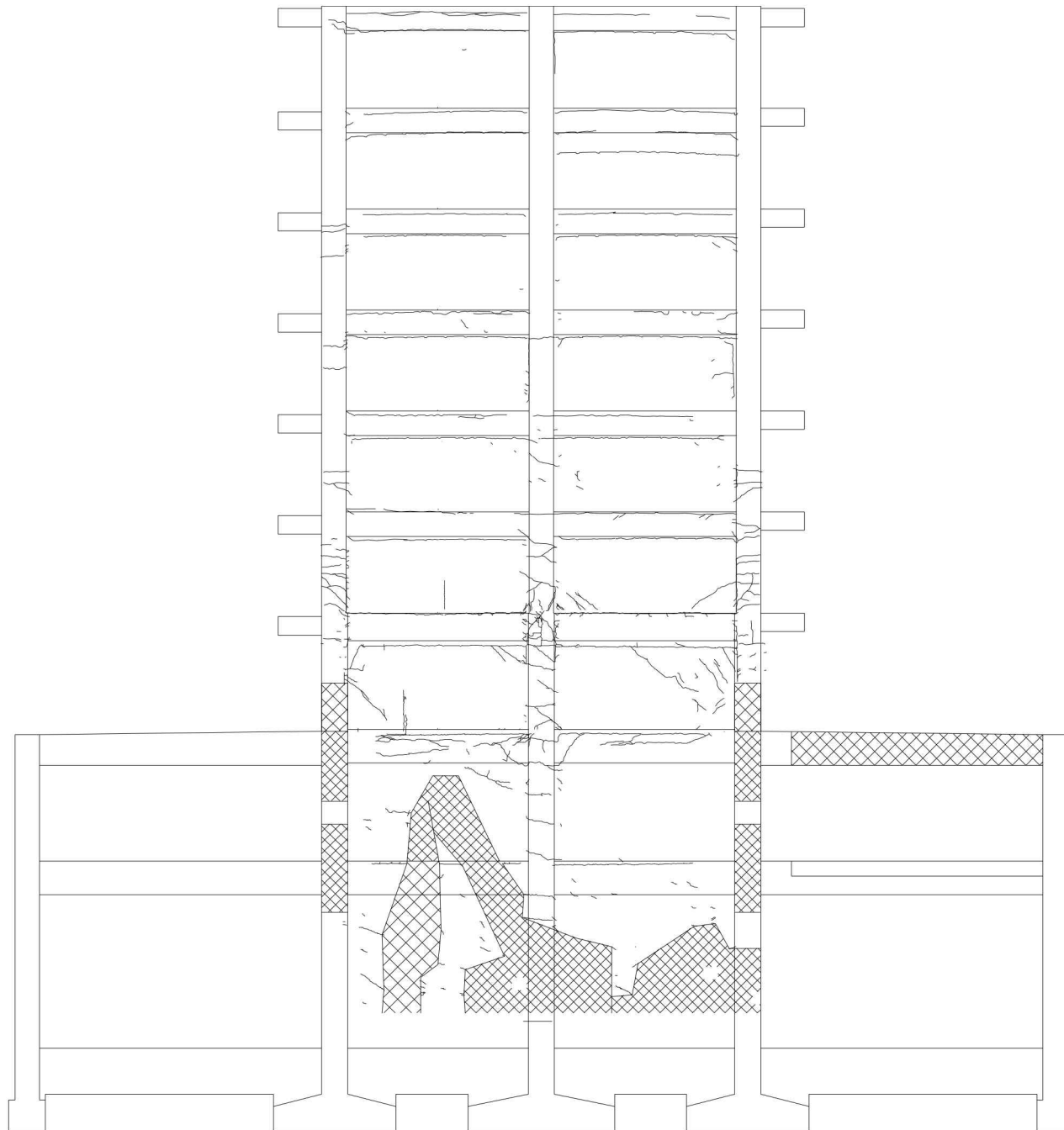


Shiga et al. (1981)

Strengthening in 2001

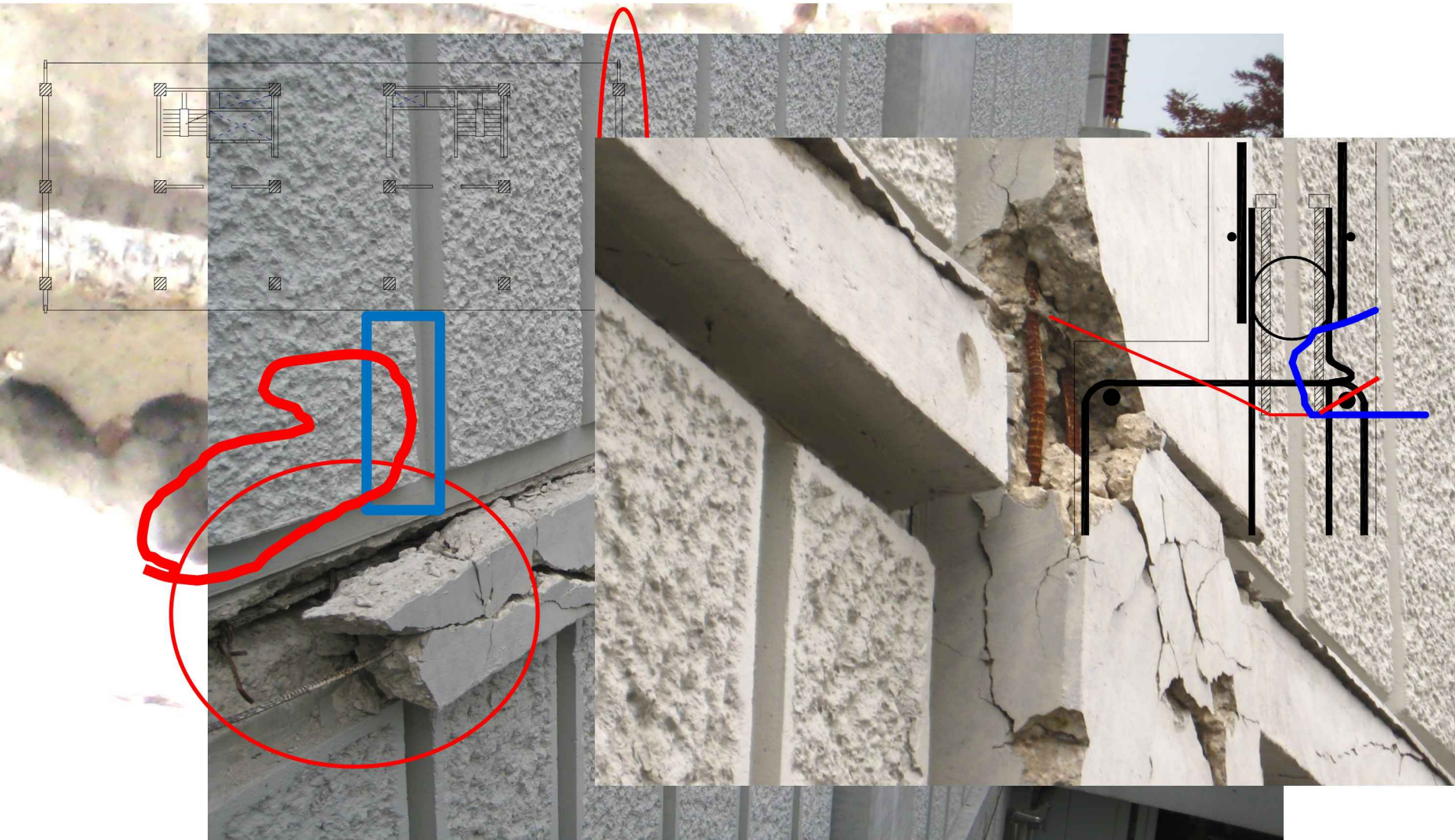


Tohoku Earthquake 2011

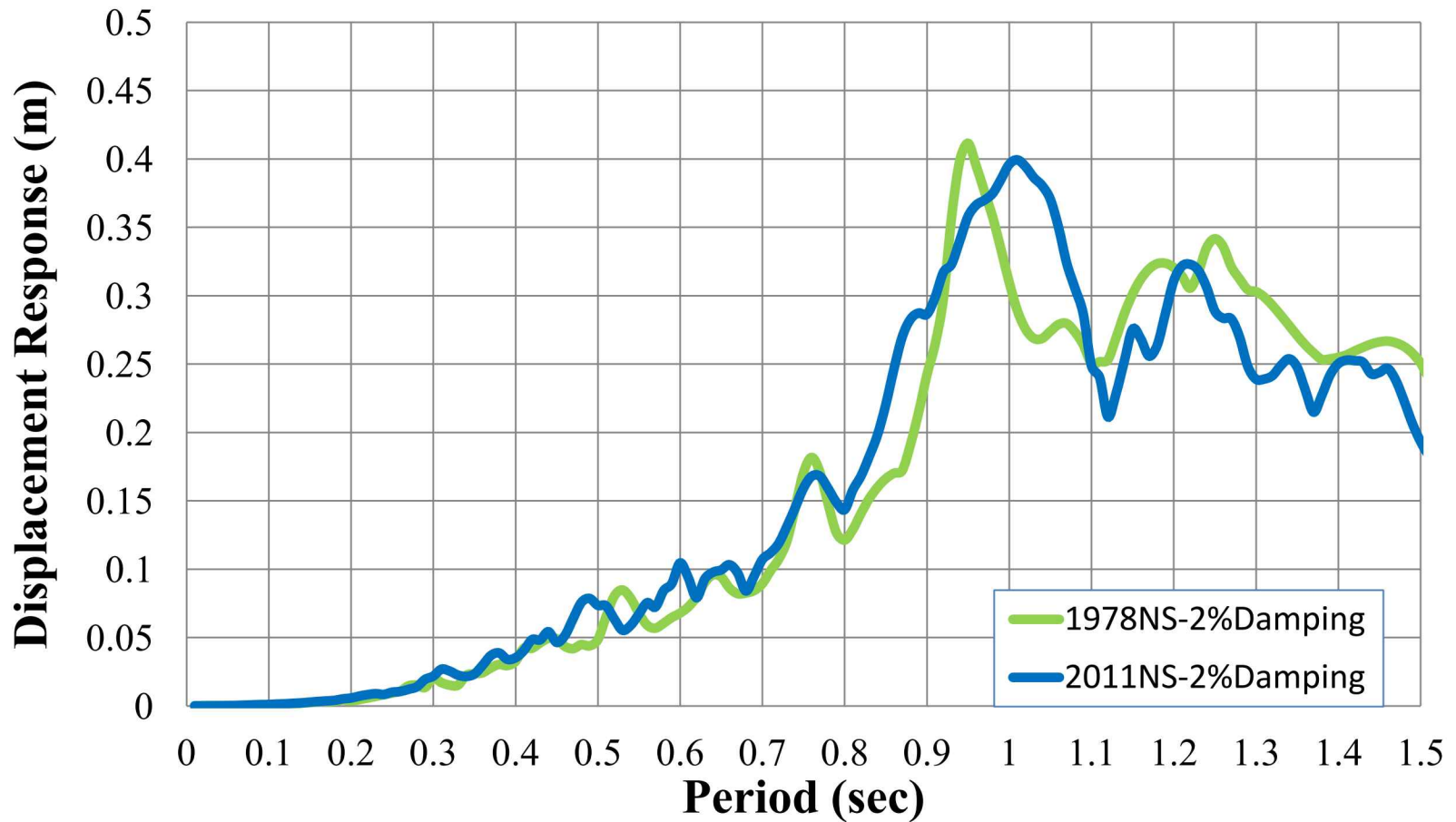




Discontinuity (bottom of third story)



Tohoku Earthquake 2011



Hypothesis

Discontinuity

(longitudinal web reinforcement)

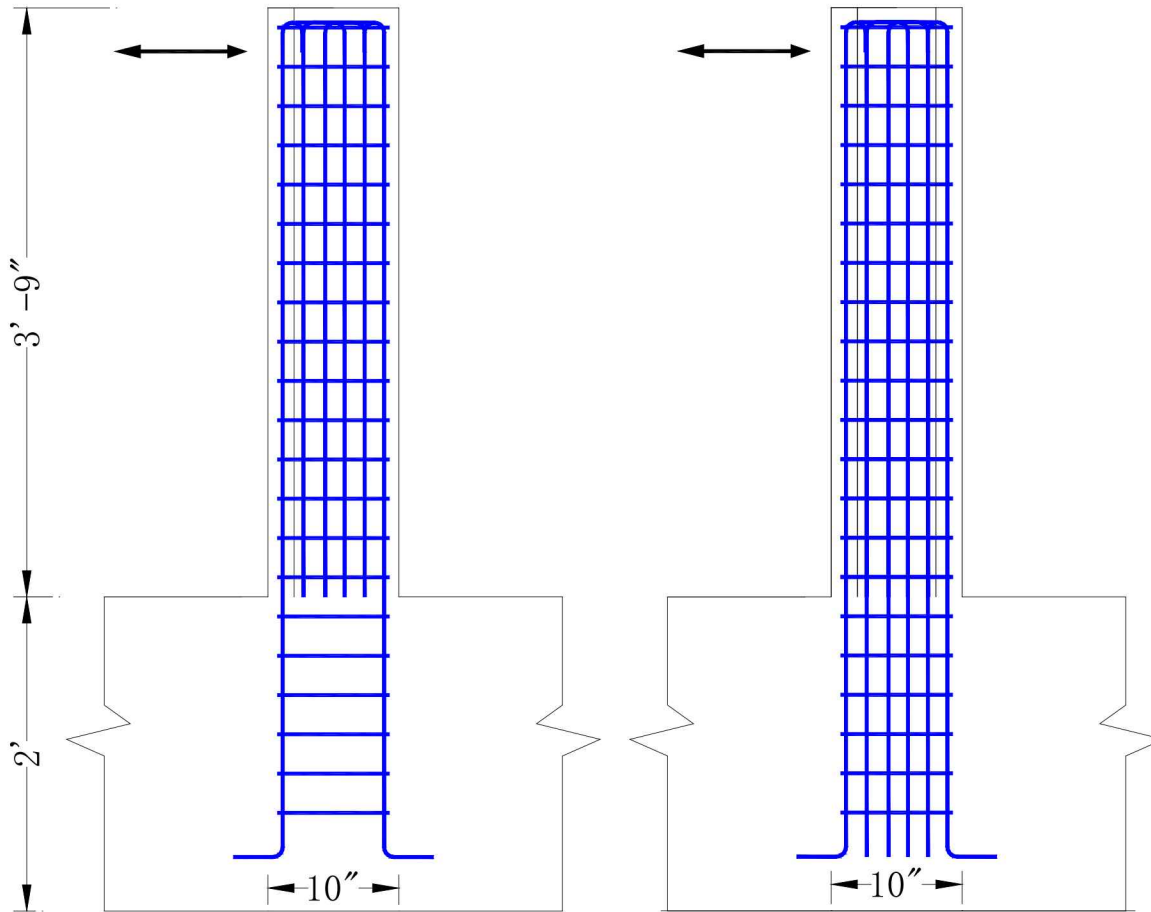


Strain Concentration

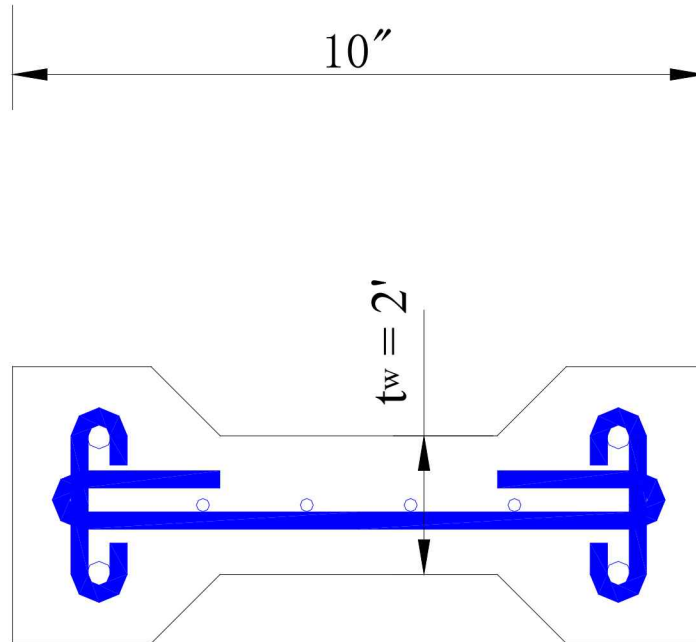


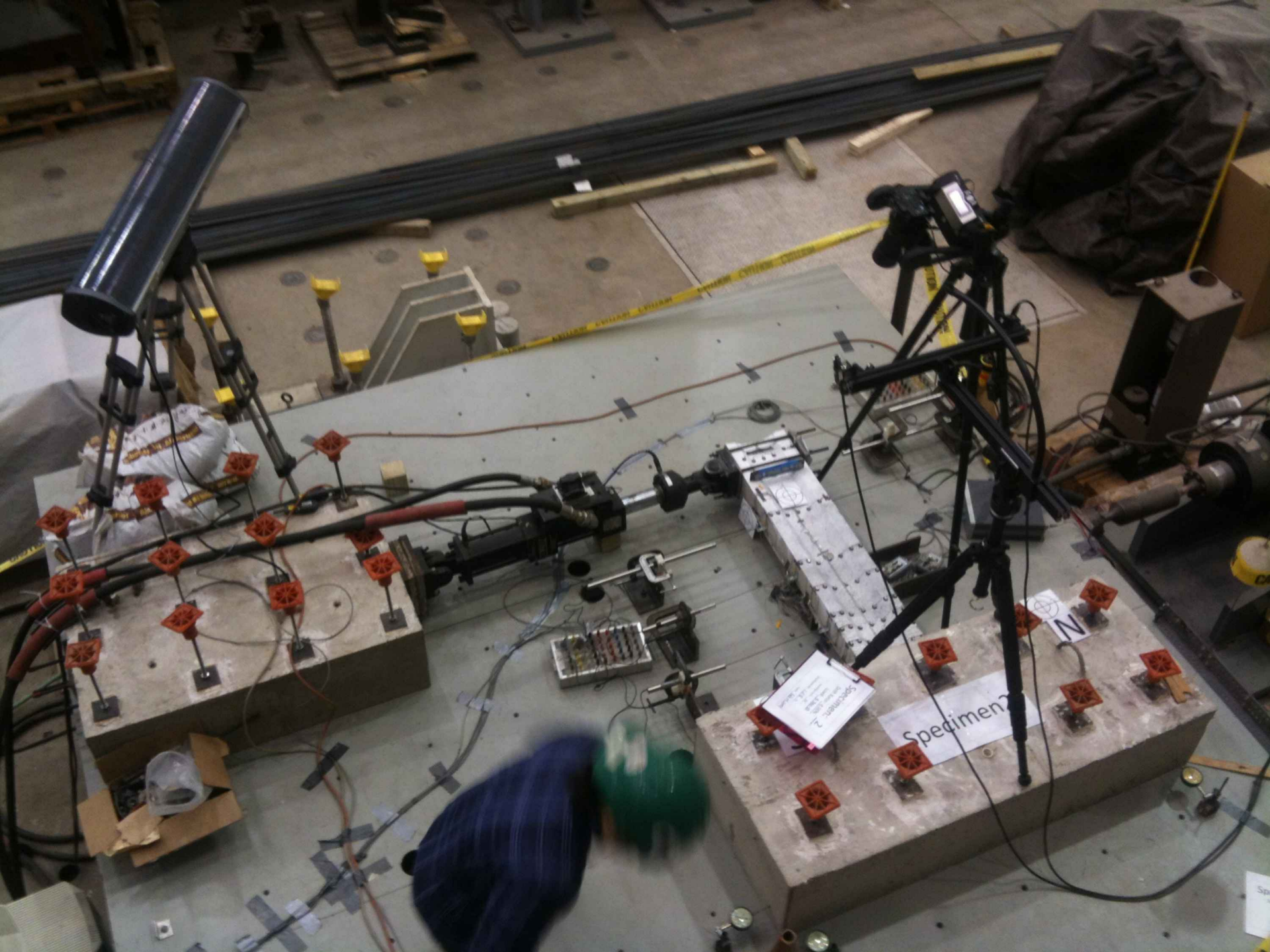
Decrease in drift capacity

Experimental Program



Experimental Program





Specimen 1

Specimen 2

Specimen 3

Specimen 4

Specimen 5

Specimen 6

Specimen 7

Specimen 8

Specimen 9

Specimen 10

Specimen 11

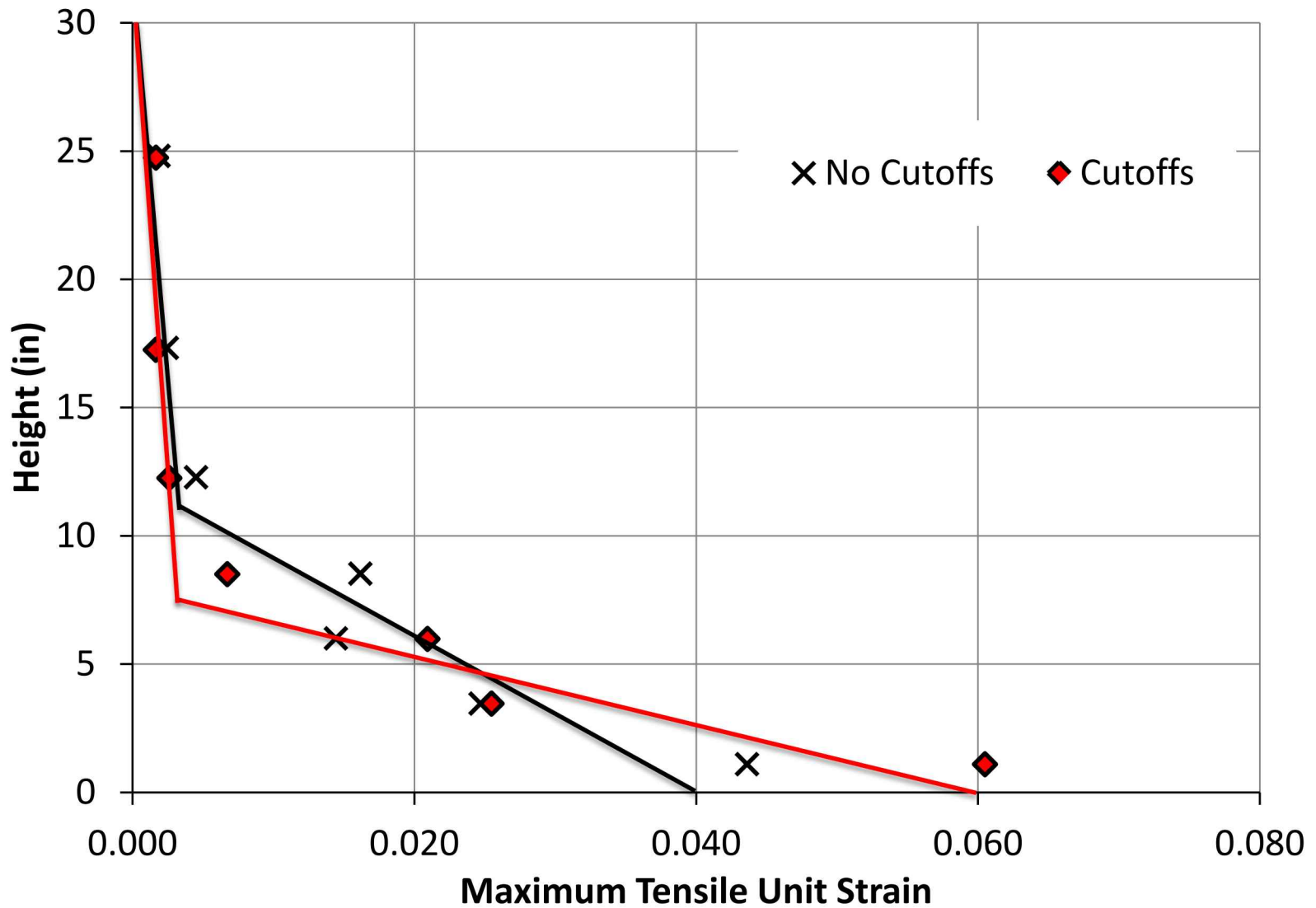
Specimen 12

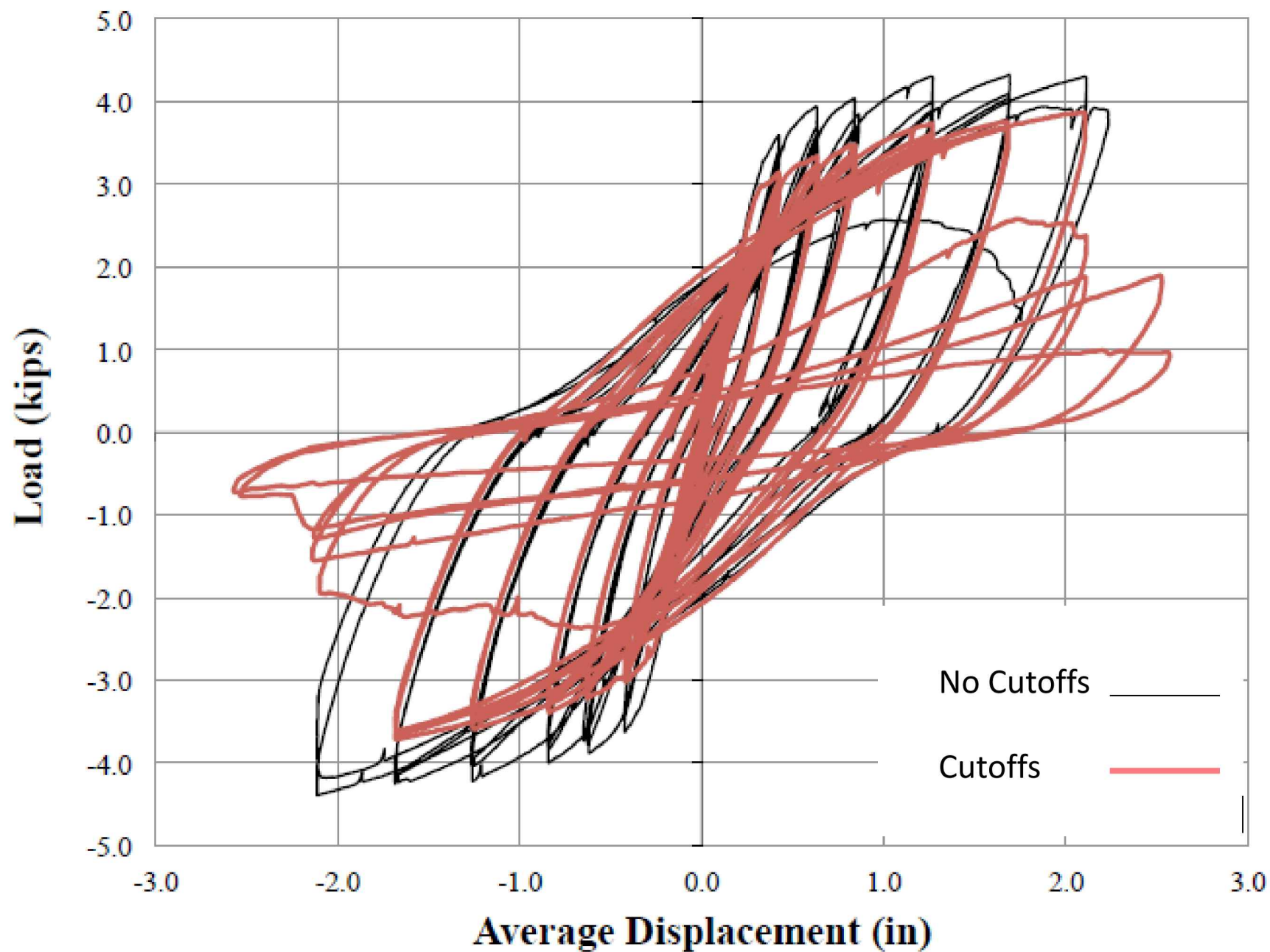
Specimen 13

Specimen 14



Tensile Strain Distribution at a Drift Ratio of 3%





Hypothesis

Discontinuity

(longitudinal web reinforcement)



Strain Concentration



Decrease in ~~drift capacity~~ toughness