Collapse of Older RC Frames during Earthquakes

- Ongoing Project and Joint Strength Estimation

A Collaborative Study: UBC / NCREE / PEER

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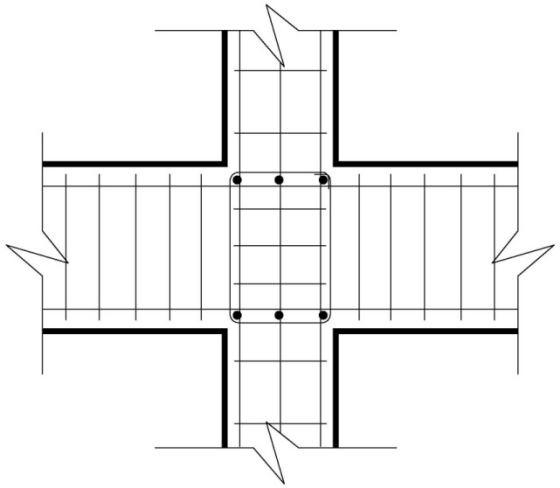
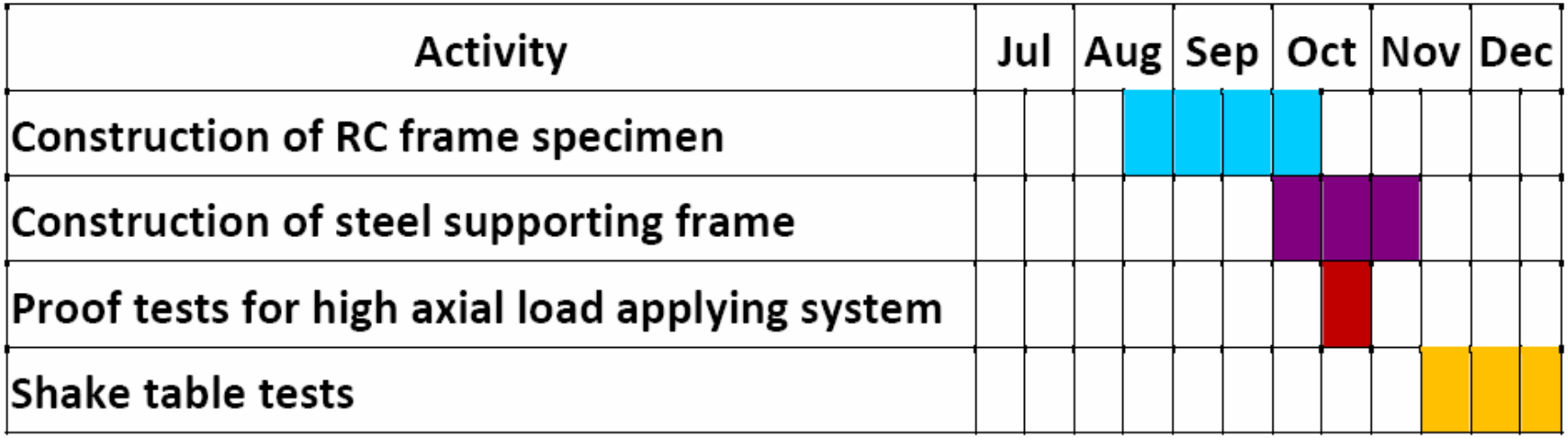


Ongoing Project

- Scheduling
- Proof Tests
- Constant Axial Load Applying System
- Lead Weight Fixture

Scheduling


Activity
Jul
Aug
Sep
Oct
Nov
Dec
Construction of RC frame specimen
Construction of steel supporting frame
Proof tests for high axial load applying system
Shake table tests

Proof Tests

(1) Cross-sectional area of column: 20cmx40cm
(2) 100cm clear column height
(3) Flexure, and flexure-shear failures

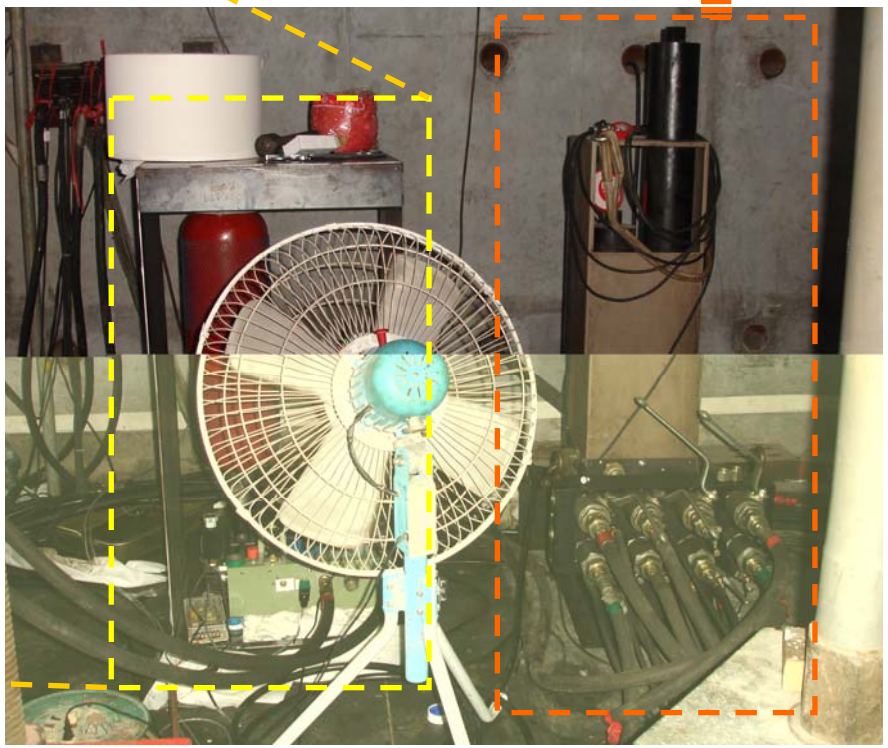
embedded PVC sleeves for bolting lead packets

4 embedded bolts for connecting axial load applying system to the column

Purposes of single column tests:
(1) Performance verification of high axial load applying system
(2) Performance verification of lead weight fixture mechanism

Constant Axial Load Applying System

MTS Pumping System
(e.g., 200kgf/cm^2)



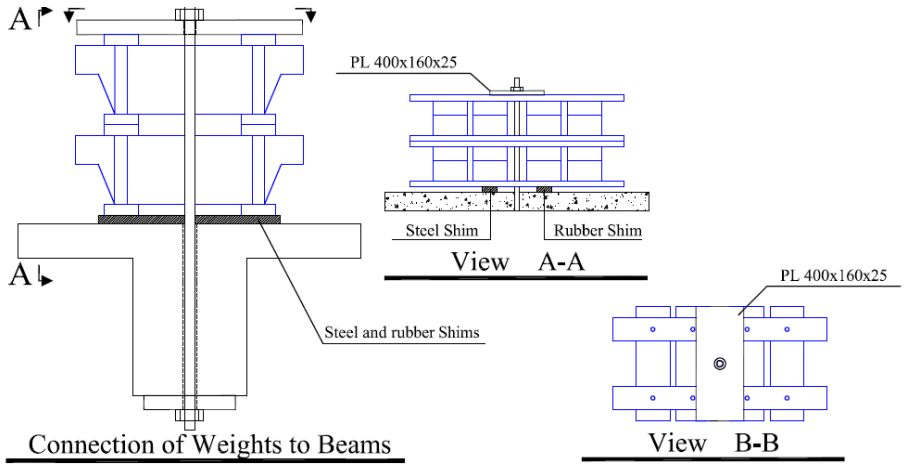
Pressure reducing valve

Pressure reducing and relieving valve
(fine tuning to keep a constant pressure at 150kg/cm^2 level to minimize the influence from column lengthening/shortening)

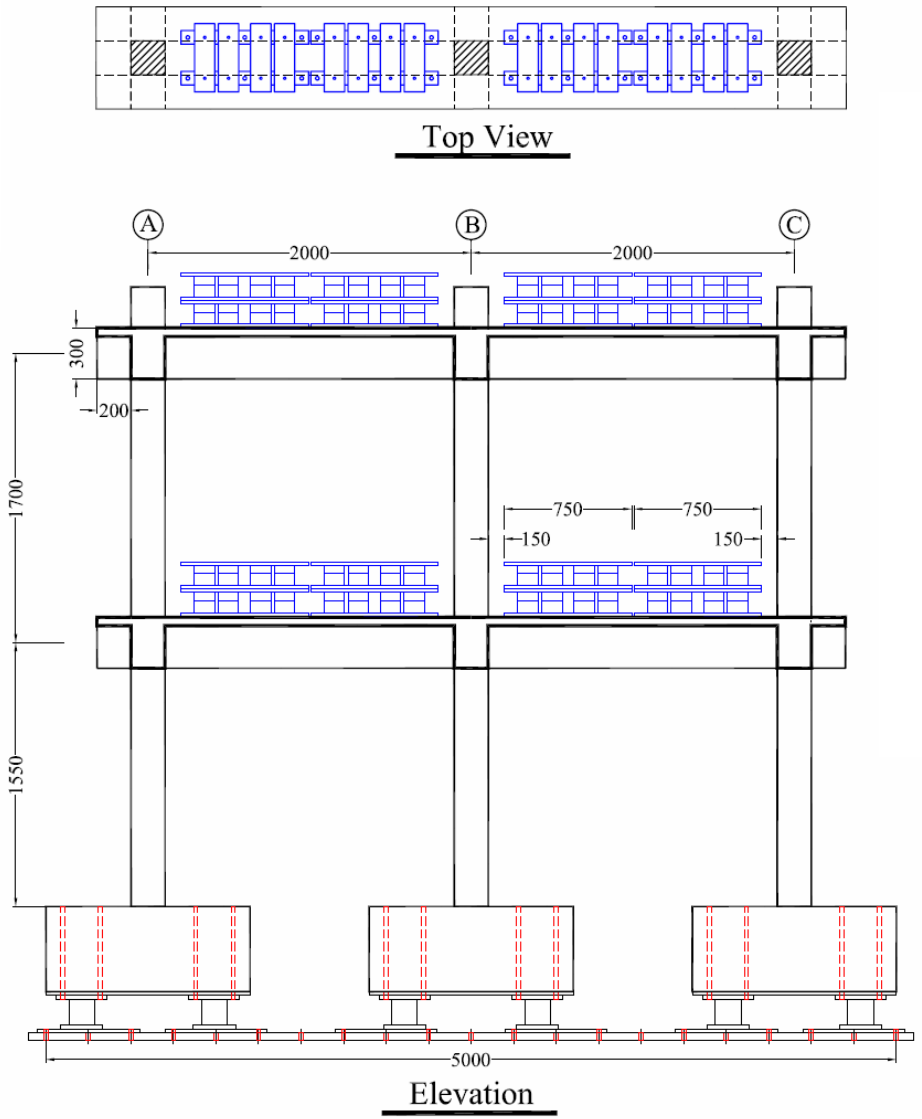
Performance requirements:

- ✓ No more than 10% pressure loss in cylinder under a vertical setback of 25mm
- ✓ Synchronizing valves to ensure simultaneous axial load applications

Lead Weight Fixture



prestressing rod + steel shim + rubber shim

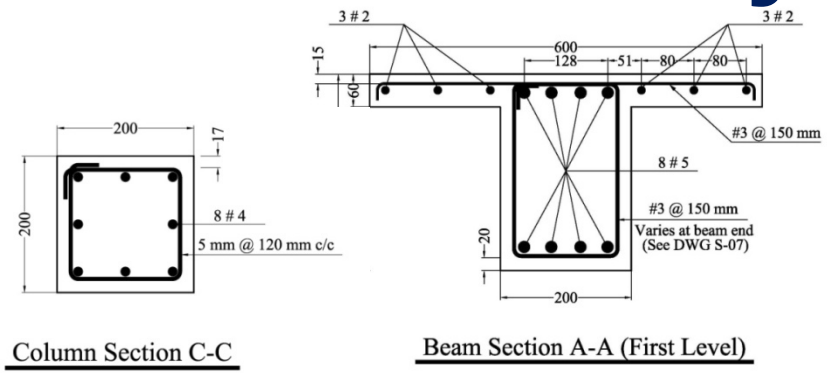


Joint Strength Estimation

- Demand Analysis
- Strength Analysis
- Strength-to-Demand Ratio
- Discussion

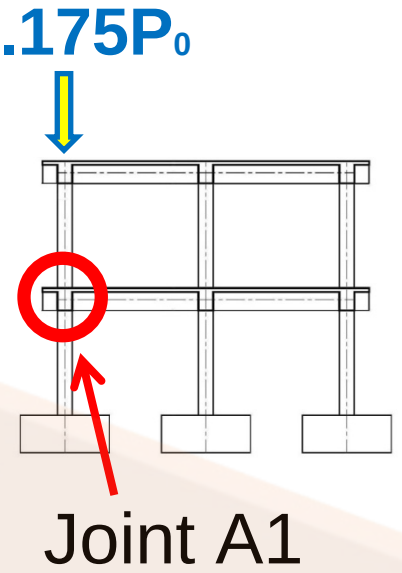

Demand Analysis

Demand Analysis



Beam

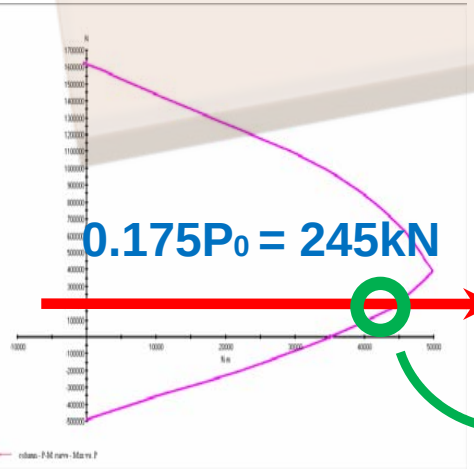
Analysis



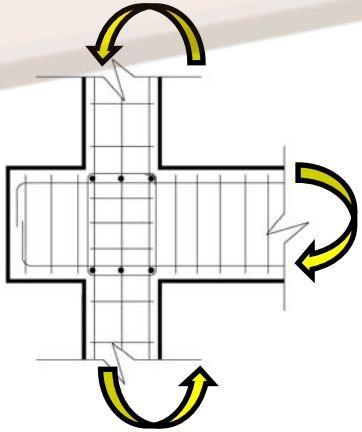
$M_{nb} = 135kN\text{-}m$

P-M curve

Analysis



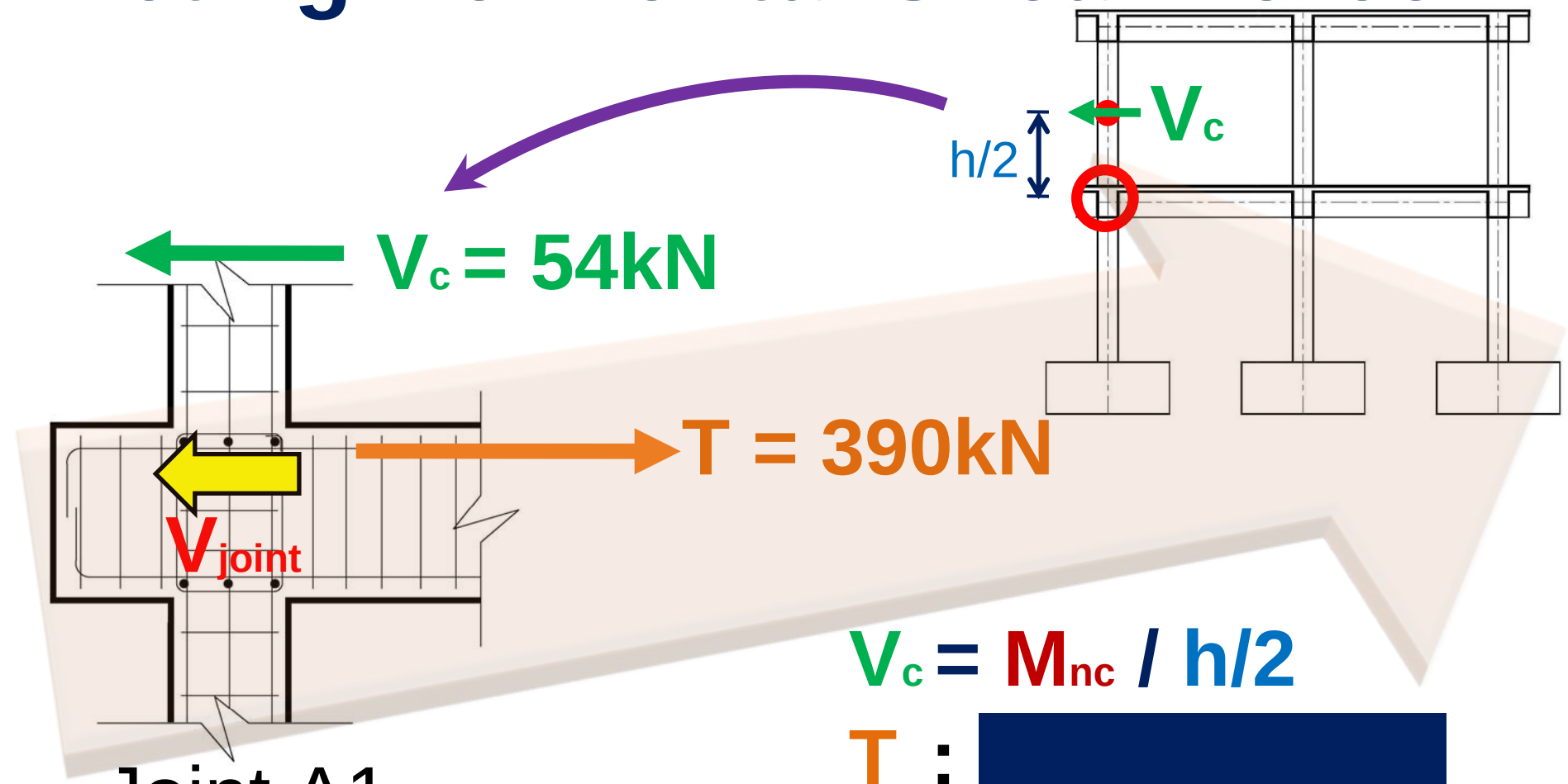
$M_{nc} = 46kN\text{-}m$



$M_b = 0.68M_{nb}$

$M_{nc} = 46kN\text{-}m$

Acting Horizontal Shear Force



Joint A1

$V_c = M_{nc} / h/2$

T :

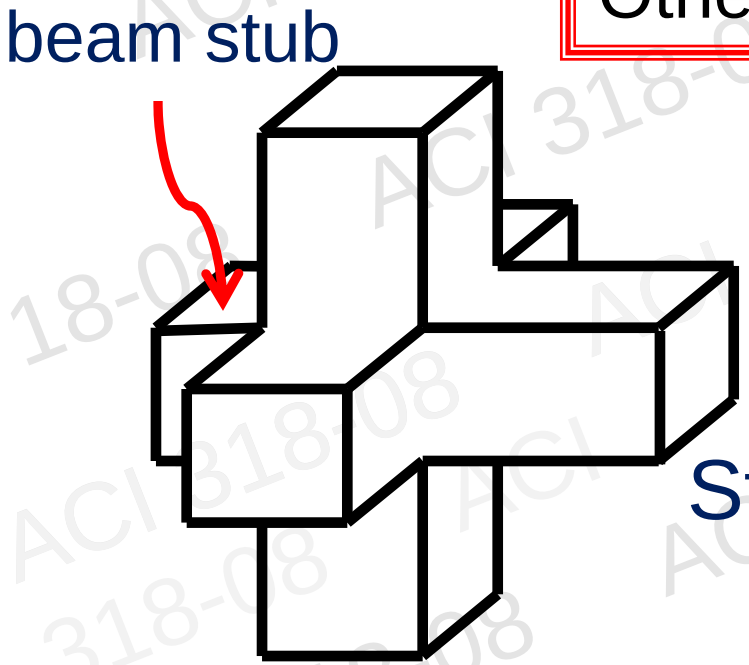
$V_{joint} = T - V_c = 3$

Strength Analysis

Strength Analysis

ACI 318-08 Seismic Provisions

Four faces confined	$V_n = 1.67\sqrt{f'_c}A_j$
Three faces confined	$V_n = 1.25\sqrt{f'_c}A_j$
Others	$V_n = 1.00\sqrt{f'_c}A_j$



Joint A1

We choose :

$$V_n = 1.67\sqrt{f'_c}A_j = 350\text{kN}$$

Strength-to-Demand Ratio (β)

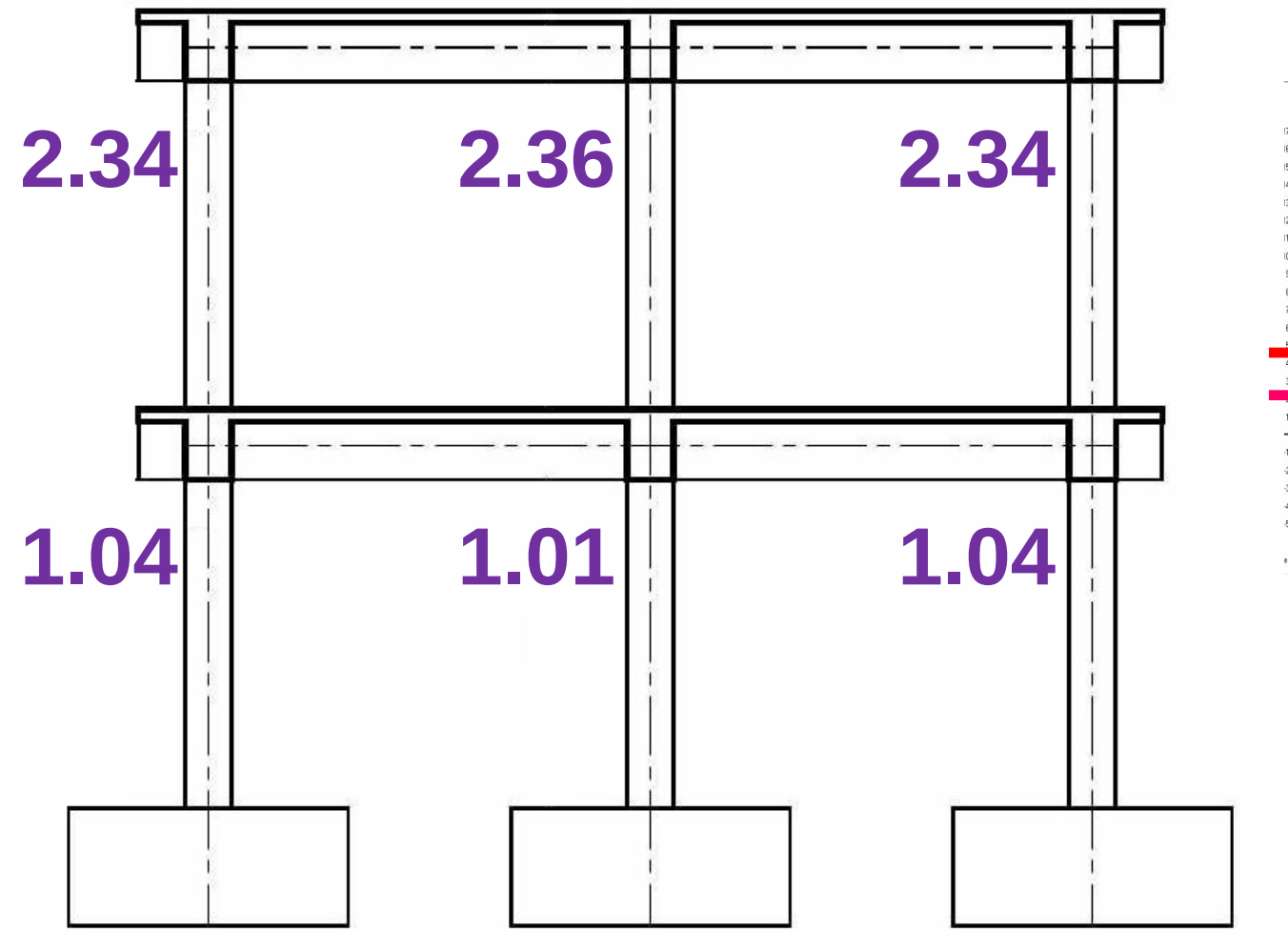
$$\beta = 1.04$$

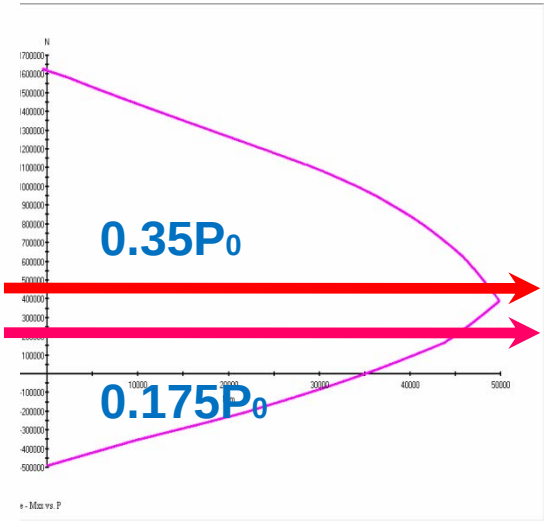
Strength-to-Demand Ratio

High Axial Load

$0.35P_0 = 491kN$

$0.175P_0 = 245kN$ $0.175P_0 = 245kN$

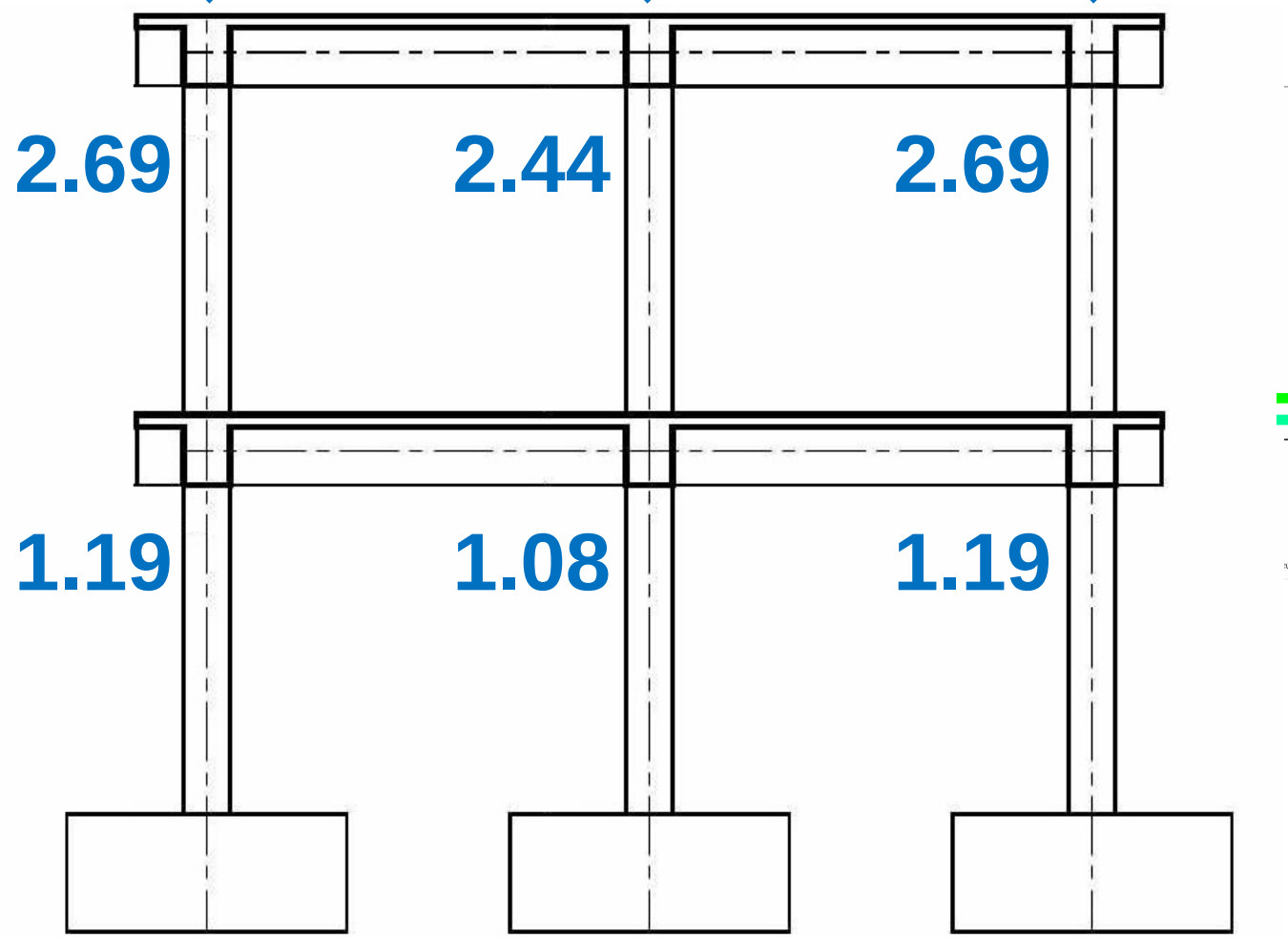


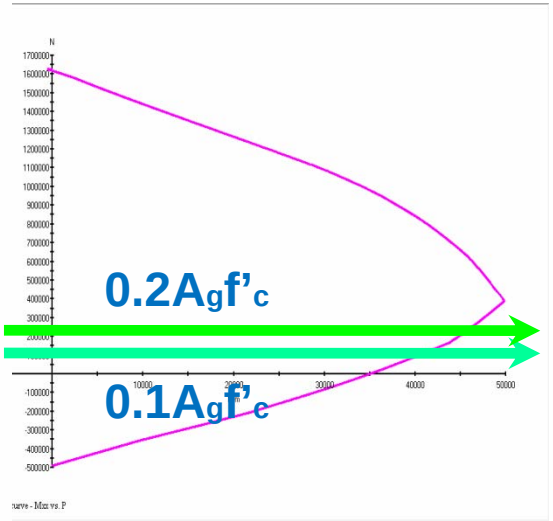


Low Axial Load

$0.2A_gf'_c = 221kN$

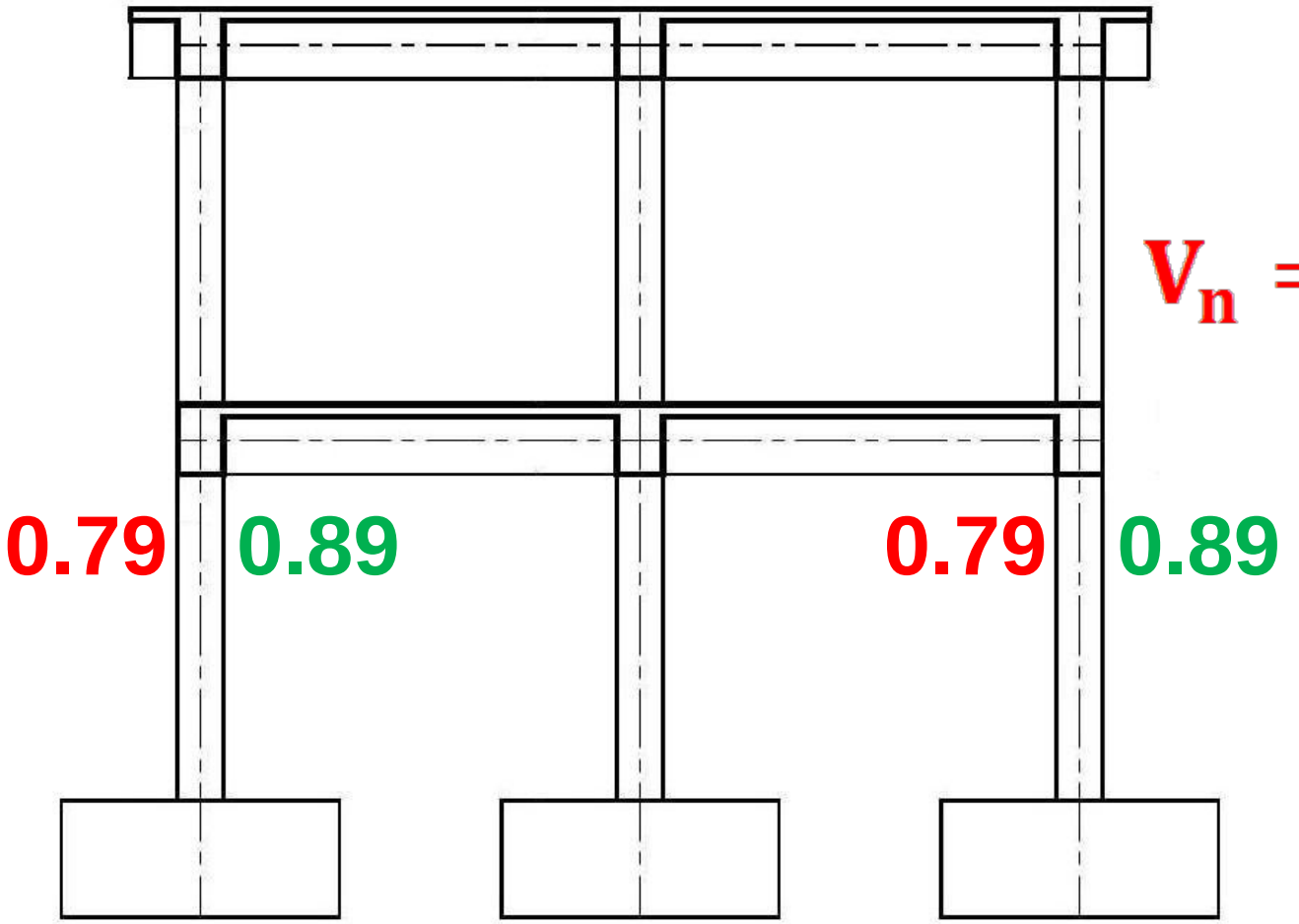
$0.1A_gf'_c = 110kN$ $0.1A_gf'_c = 110kN$





W/O beam stub

- High Axial Load
- Low Axial Load



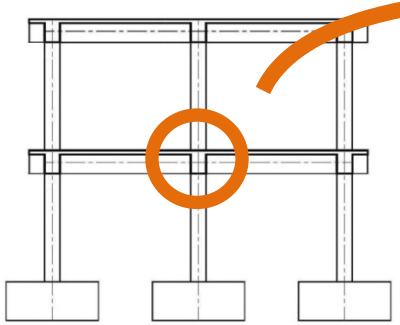
$$V_n = 1.25\sqrt{f'_c}A_j$$

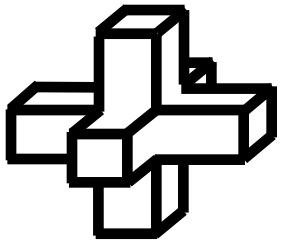
Discussion

Compare with the specimens tested by :

Kitayama, Kojima, Otani and Aoyama (1989; in Japan)

TAIWAN (2008)

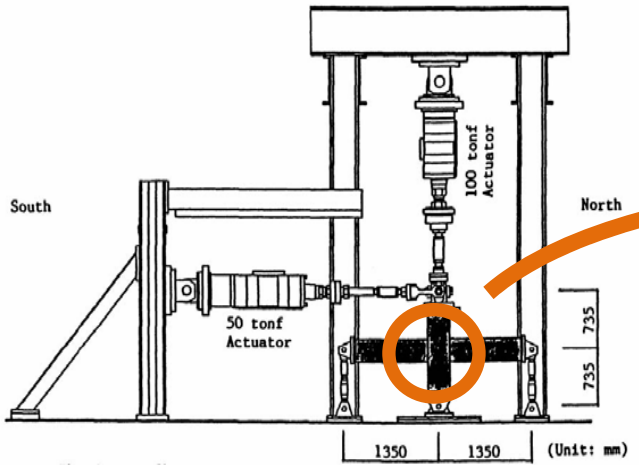


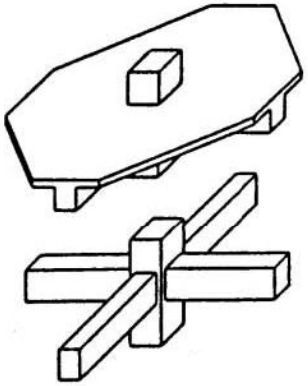


Joint B1

Column Failed

JAPAN (1989)





Interior joint

Beam Failed

Compare with the specimens tested by :

Kitayama, Kojima, Otani and Aoyama (1989; in Japan)

*For **Interior Joint***

	BEAM	COLUMN	h_c / d_b	JOINT SHEAR STRESS
TAIWAN	200×300 (mm)	200×200 (mm)	**23.6**	**0.27 ~ 0.31 f'c**
JAPAN	200×300 (mm)	300×300 (mm)	**23.6**	**0.35 ~ 0.40 f'c**

Specimens A1, A2, A3, A4

tested by Kitayama, Kojima, Otani and Aoyama (1989; in Japanese)

- Beam:
  200x300 mm
- Column:
  300x300 mm
- Slab:
  70 mm

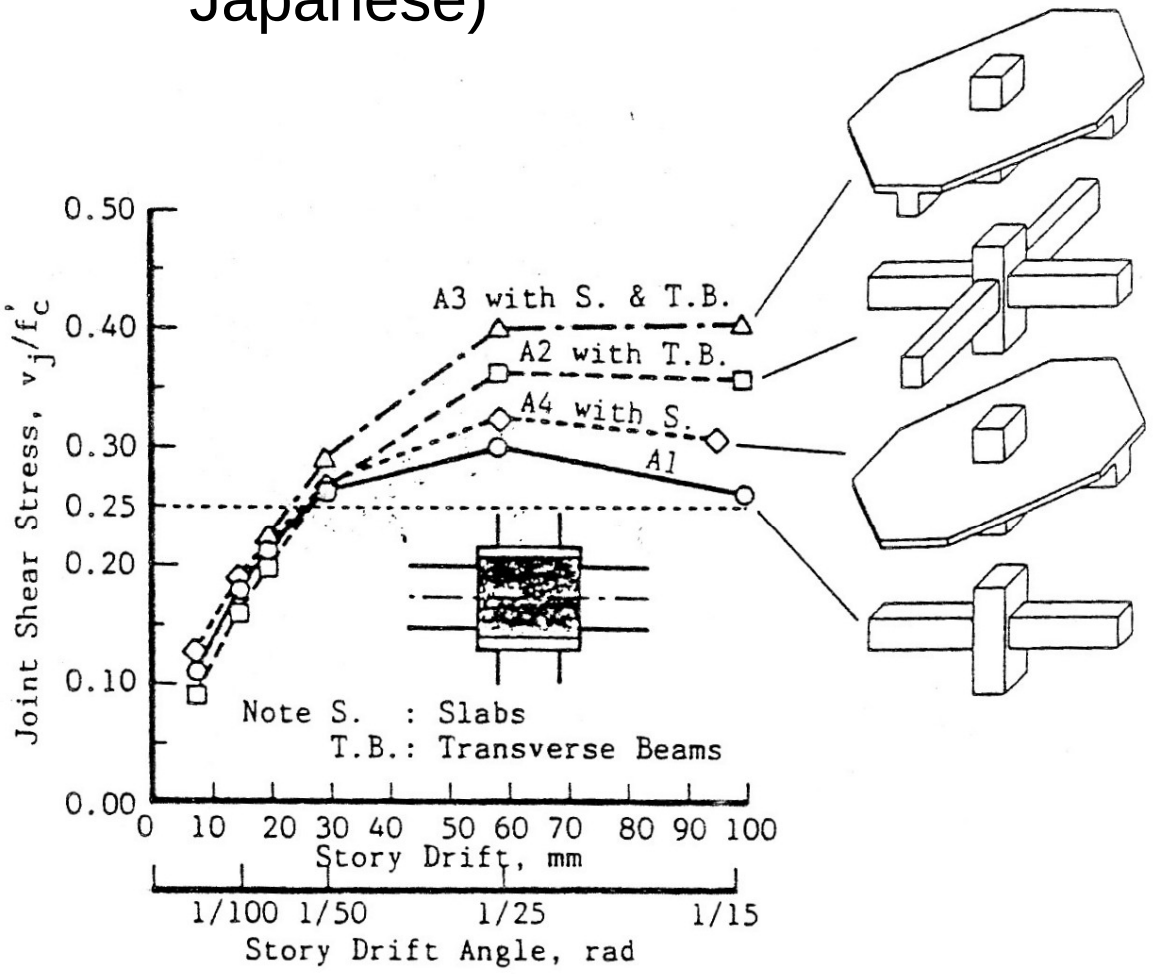


Fig. 15--Story drift -- joint shear stress relations

Thank you !!