Seismic Retrofit of Ductile Concrete Moment Frames with Innovative Pin-Supported Walls

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Background

Moment Frame

Shearwall

Kobe city hall after 1995 Kobe EQ

RC frame after 2008 Wenchuan EQ

Shearwall damage in 2010 Chili EQ

Pin-Supported Wall-Frame System

(EERI, 2010)
Pin-Supported Walls

- Weak story (Soft story)
- Strengthening
- Coordinator
- Hinge
Pin-Supported Walls

Redundant strength

\[ F_{\text{EQ},j} = V_j - F \]

Inadequate strength

\[ F_{\text{EQ},i} = V_i + F \]
G3 Building in Tokyo Tech

Before – 2008.10
During – 2009.12
After – 2010.3

Post-tensioned wall (1~11F)
Connector (1~11F)
SRC frame
Steel damper (2~9F)
Bottom hinge
Transverse shearwall (1~9F)
Post-Tensioned Wall and Connector

- Steel rib-22
- Steel web-12
- Post-tensioned tendon 30-ф12.7 (SWPR7B)
- Longi. rebar D29
- Lateral rebar 13@200
- Rocking wall
- Existing column
- Shear key
- Horizontal truss
- Existing beams

\[ P_{\text{con}} = 0.68P_y \]
\[ \sigma_{cp} \approx 7 \text{ MPa} \]
Steel Damper

Weight: 2500 kN

\[ \sum \frac{F_{dy}}{W_{wall}} = 7.5 \quad \sum \frac{F_{dy}}{W_{wall}} = 4.6 \]
Steel Damper

Existing column
Anchor bolt
Rocking wall
Stud
Web
Rib

Web: PL-6, SLY225
Flange: PL-19, SN400B
Rib: PL-6, SS400 at 250mm spacing

Web height $H = 312$mm
Total length $L = 750$~$1500$mm

Plan View

Two sets of fasteners to make dampers replaceable
Bottom Hinge

Steel tendon  PT wall  SRC column

Steel brace  Concrete footing

Steel beam  Cast-iron hinge
Numerical Evaluation

- Nonlinear Time History Analysis
- Fiber-sectioned beam elements in ABAQUS
- 22 Ground Motions (scaled to PGV = 50 cm/s)
Numerical Evaluation

Nominal shear strength of bottom hinge

Ordinary Cracking  Pre-Tensioned Cracking

Height (m)

Moment (kNm)

Shear force (kN)
X  PGA: 67.3 cm/s² and PGV: 14.4 cm/s
Y  PGA: 52.8 cm/s² and PGV: 12.7 cm/s
Diagonal cracks on transverse shear walls during 2011 Tohoku EQ
Diagonal rust on steel damper

Protective coating peeled off at bottom hinge
Thanks for your attentions!