Group 3

Evaluation of seismic resistance of buildings in Peru

Group Leaders

Dr. Carlos Zavala	PI - SATREPS Peruvian side
Dr. Taiki Saito	Professor, Toyohashi University of Technology

G3 Research Subjects

Category	Achievement
Seismic Design of buildings in Peru (for new buildings)	Seismic test database of masonry elements → design formula
	Material testing
	Design method of non-ductile wall
Seismic Evaluation of buildings in Peru (for existing buildings)	Proposing evaluation method (based on JP)
	Computer Simulation software of masonry using DEM
	Remote monitoring with IT sensors
Seismic Retrofitting (for existing buildings)	Propose CF sheets retrofitting for non-ductile wall

Collection of Data of Masonry Structure

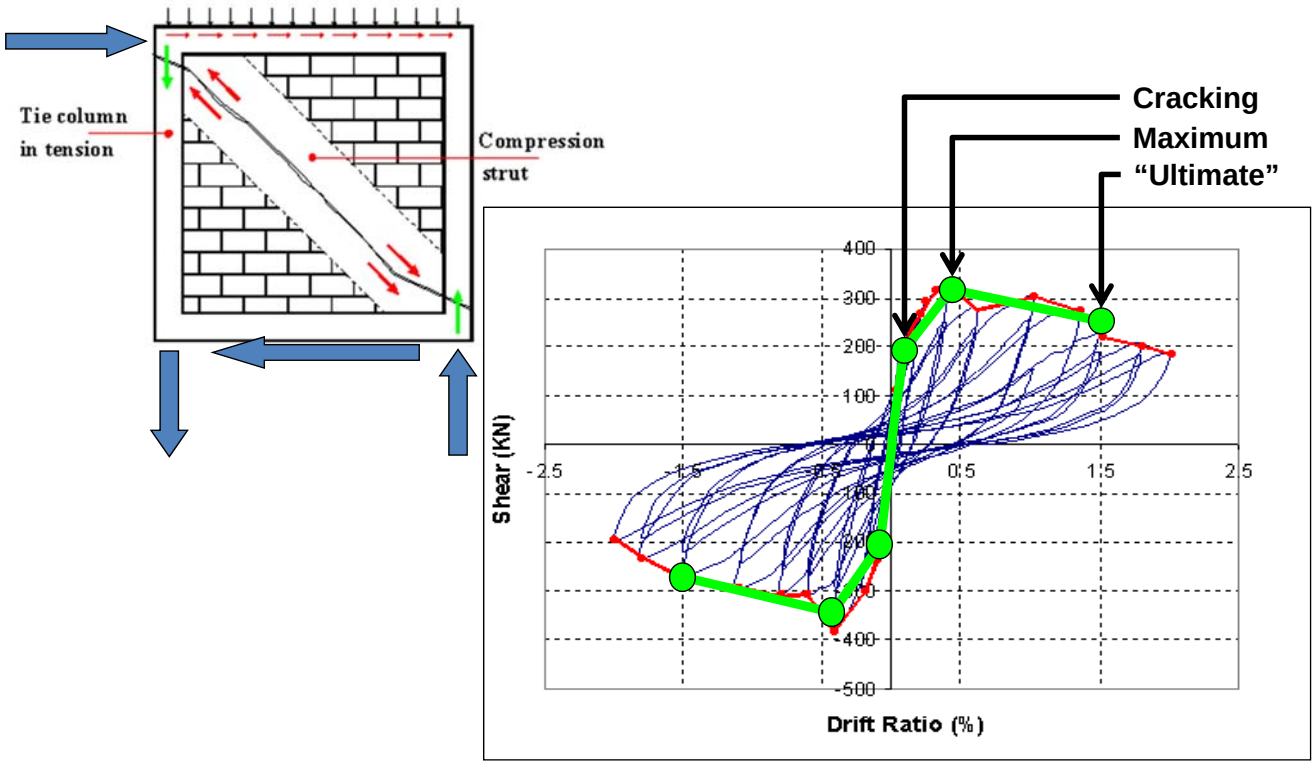
(as of March 13, 2012)

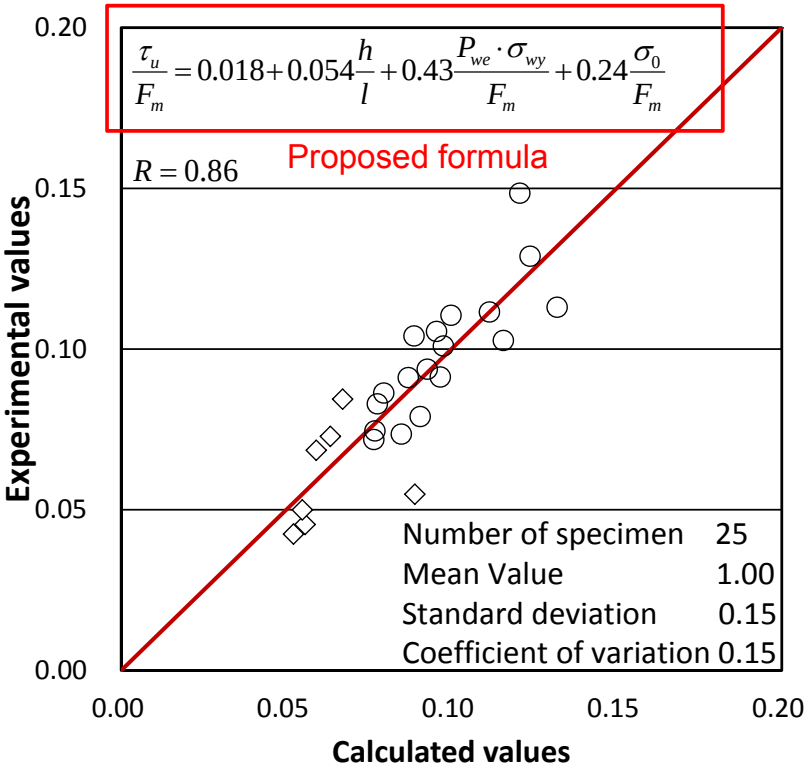
Reference	Total Number of Papers	Empirical Study	Others	Remarks
Architectural Institute of Japan (AIJ)	367	241	57:material 69: others	1979 - 2010
Japan Concrete Institute (JCI)	20	12	8: material, analysis, others	2003 - 2008
World Conference on Earthquake Engineering (WCEE)	243	89	154: design, analysis, others	1980(7WCEE) - 2008(14WCEE)
Earthquake Spectra (Earthquake Engineering Research Institute: EERI)	158	12	146: design, analysis, others	1984 - 2011

Masonry : Unreinforced Masonry, Reinforced Masonry and Confined Masonry

Elwood 2009

In-plane shear response



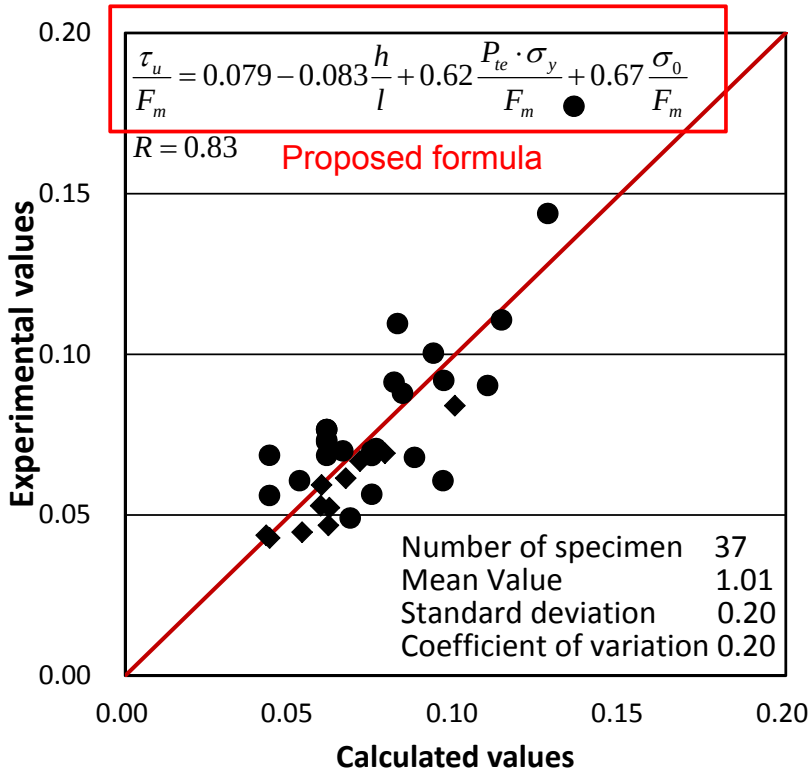


RM Walls (Fully Grouted Concrete Blocks)

BRI
○ Shear Failure
KIKUCHI
◇ Shear Failure

Maximum Shear Stress τ_u/F_m

Evaluation of Shear Strength Using *Obtained Regression Equation*



RM Walls (Fully Grouted Concrete Blocks)

BRI
● Flexural Failure
KIKUCHI
◆ Flexural Failure

Maximum Shear Stress τ_u/F_m

Evaluation of Flexural Strength Using *Obtained Regression Equation*

Seismic Capacity Evaluation of Masonry Buildings

Seismic Structural Index I_s

$$I_S = \phi \times E_0 \times S_D \times T$$

$$\phi = \frac{n+1}{n+i}$$

n: number of stories of the building

i: number of the story for evaluation

E_0: basic seismic index of structure

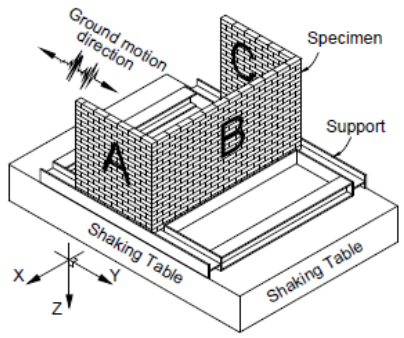
=***C*** (strength index) x ***F*** (ductility index)

S_D: irregularity index

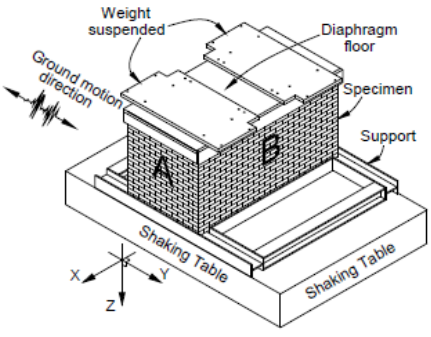
T: time index

Japan Building Disaster Prevention Association: Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings, 2001.10

Analysis of out-of-plane failure

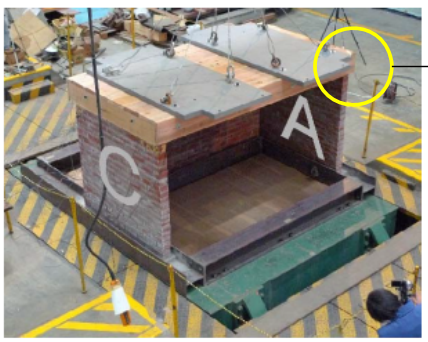


(a) Scheme of the test set up

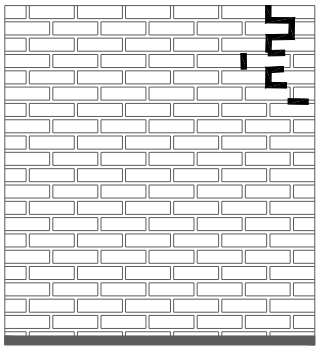


(a) Scheme of the test set up

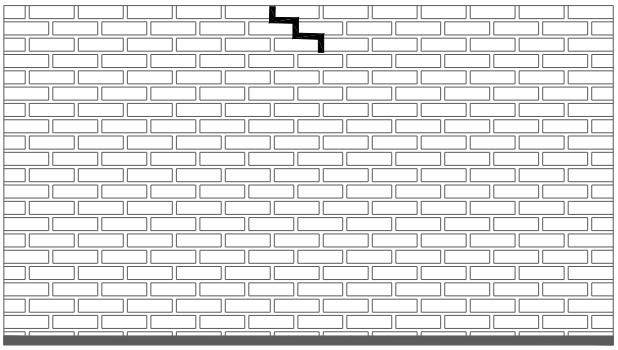
(b) Specimen of the shaking table



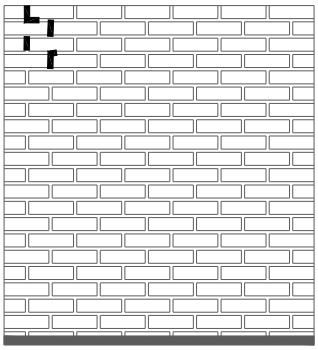
(b) Specimen of the shaking table



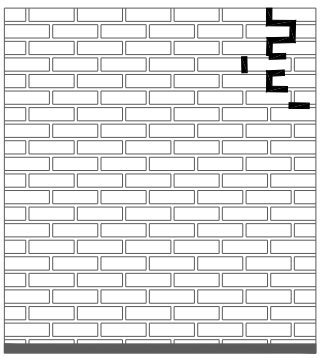
Wall A



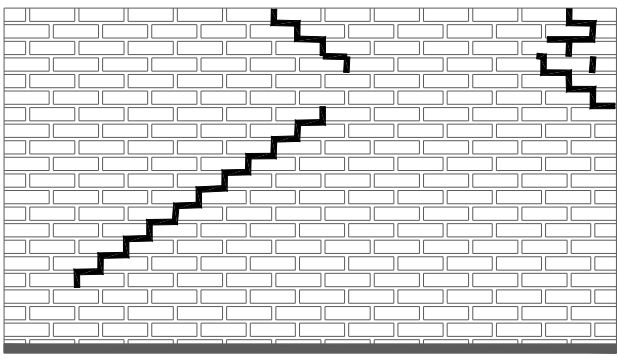
Wall B



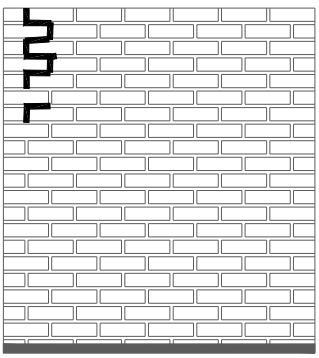
Wall C



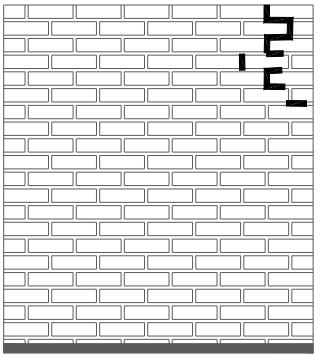
Wall A



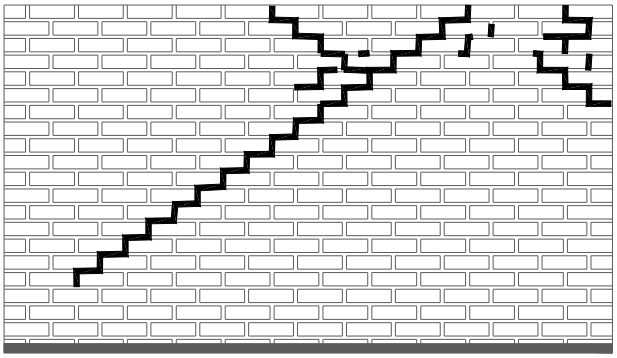
Wall B



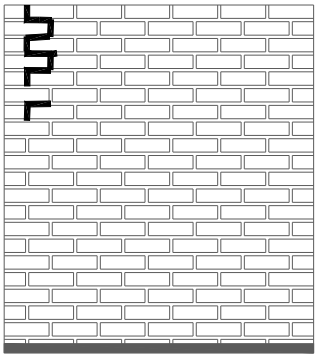
Wall C



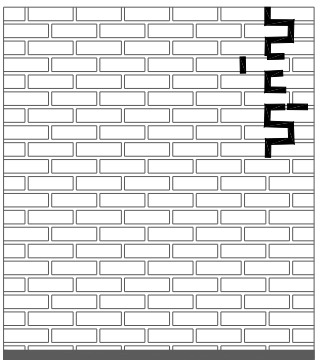
Wall A



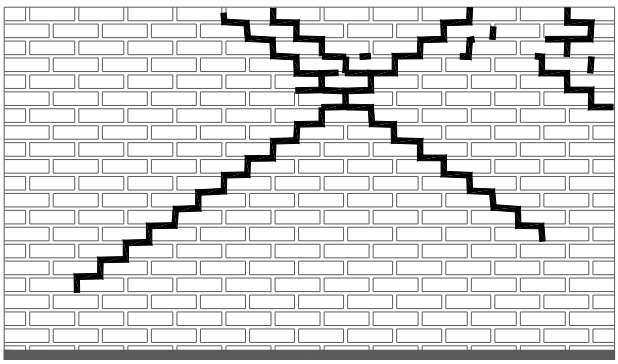
Wall B



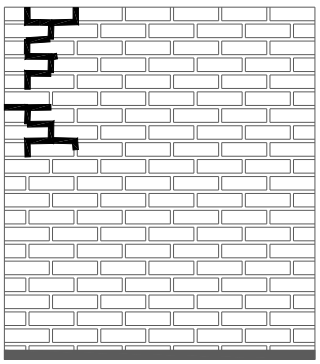
Wall C



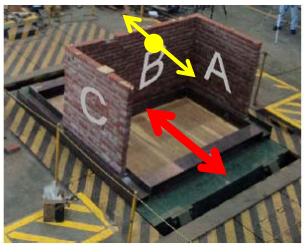
Wall A

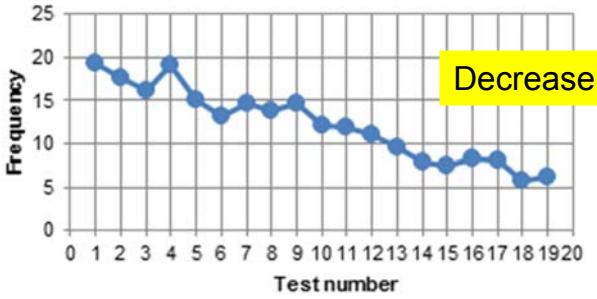


Wall B

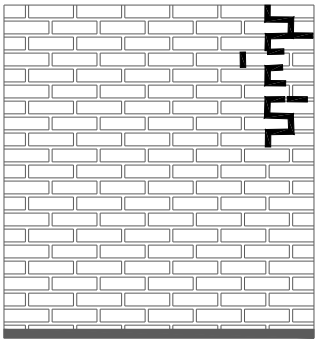


Wall C

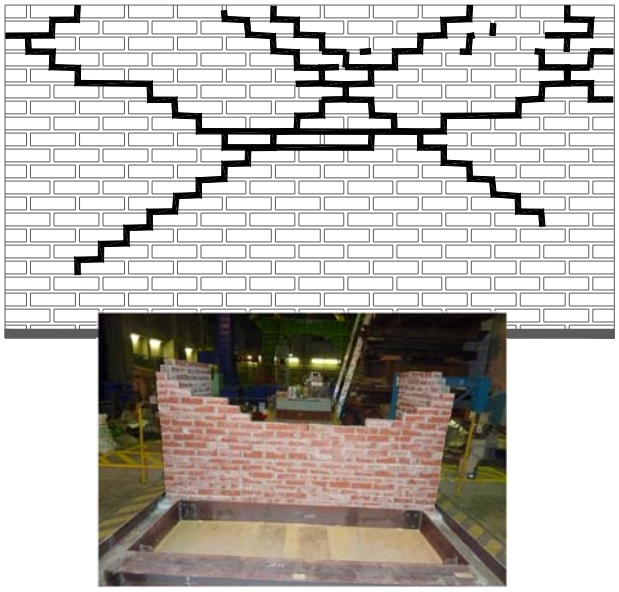


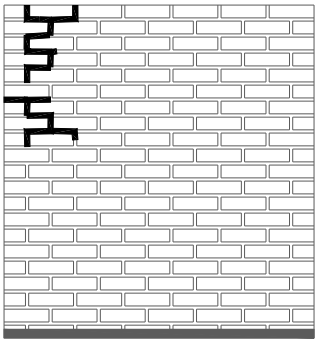


Decrease of frequency



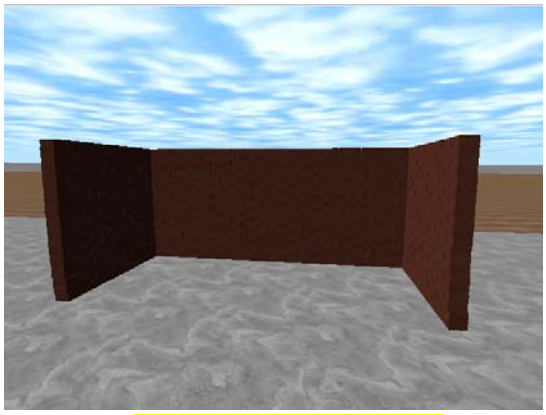
Wall A

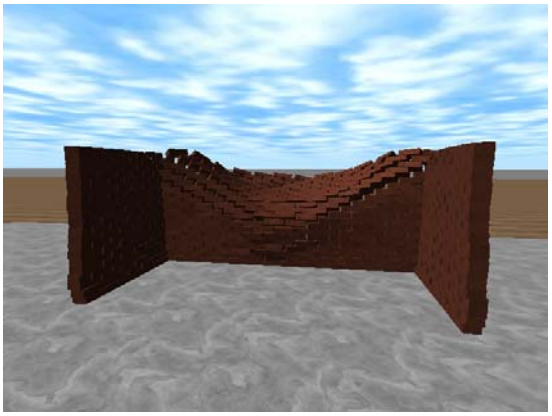




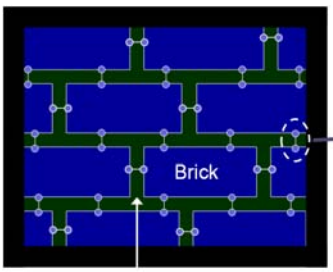
Wall C

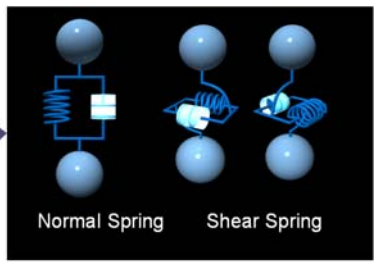
Simulation of out-of-plane failure





STERA_Briq

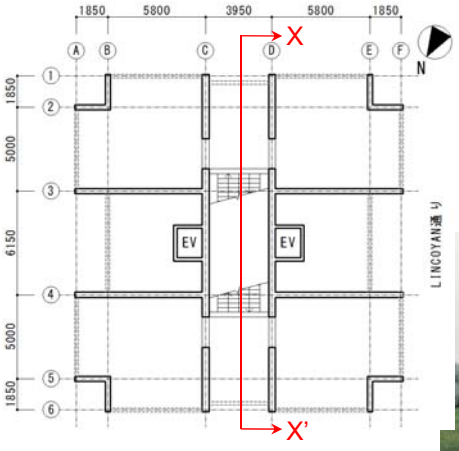




Discrete element model for brick

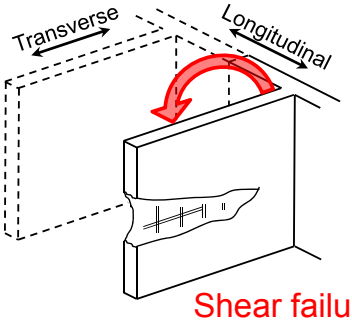
2010 Chile earthquake

17-story building



2010 Chile Earthquake

Japan-Peru-Chile joint investigation team



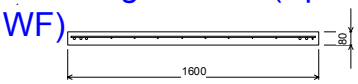
Wall structure suffered flexural failure.

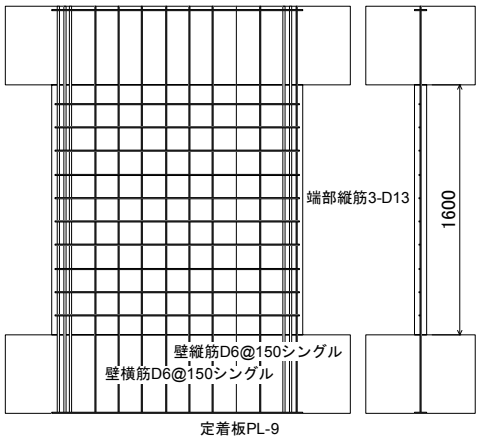
Shear failure of wall … studied well
Flexural failure of wall … need more study

Seismic retrofitting using CF sheets

Lower story wall in 12-story building assumed, about 2/3 scale
Three specimens were prepared
Non retrofitting wall is designed to be flexural failure

- Existing RC wall (Specimen WF)

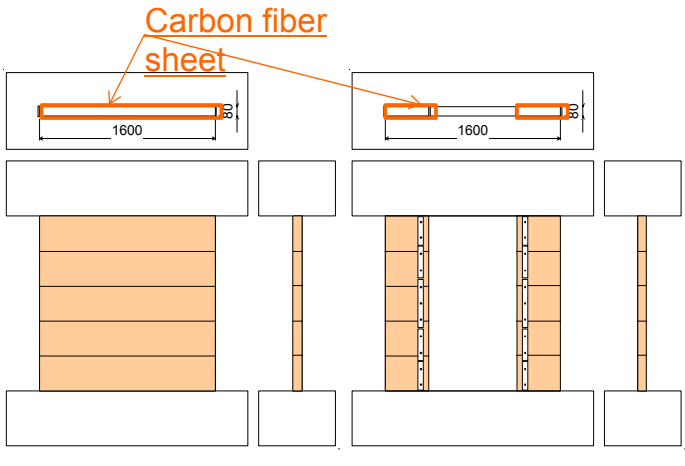




length of wall : 1600mm
height of wall : 1600mm
thickness of wall : 80mm

longitudinal bar at the end of wall : 3-D13
wall reinforcing bar : D6@150single

- Retrofitted RC wall (Specimen RWF1)



Wrapping CF sheet over Full-length of wall

- Retrofitted RC wall (Specimen RWF2)

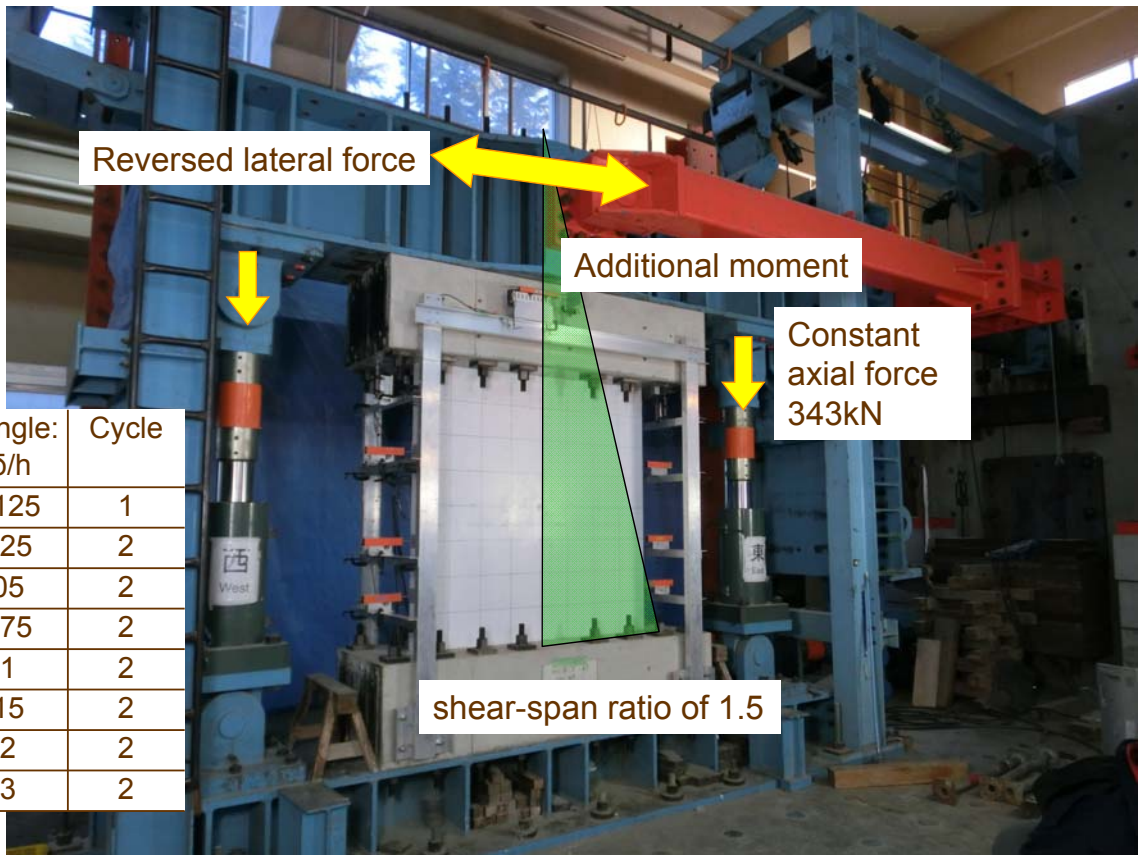
Wrapping CF sheet at the end of wall with steel plate and bolt

Specimens

Process of retrofitting

Wrap sheet

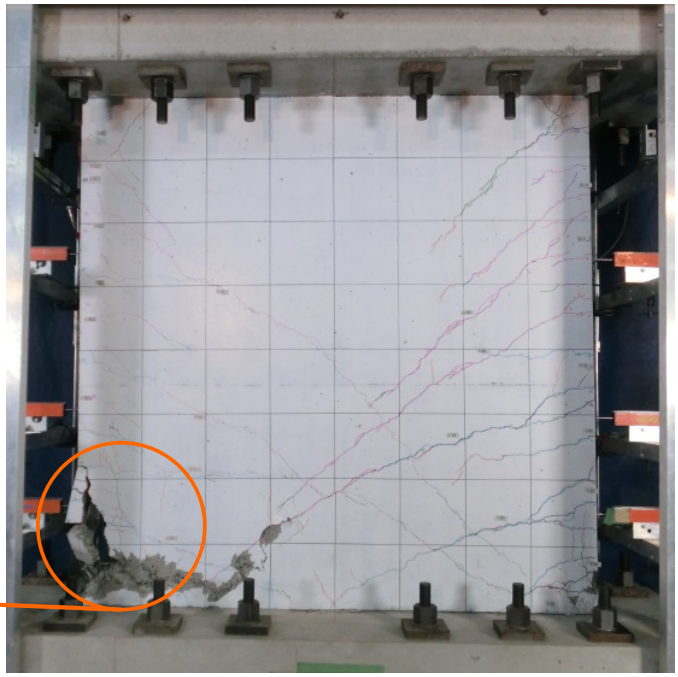
Loading procedure



Drift angle: R=δ/h	Cycle
0.00125	1
0.0025	2
0.005	2
0.0075	2
0.01	2
0.015	2
0.02	2
0.03	2

No retrofitting (flexural failure)

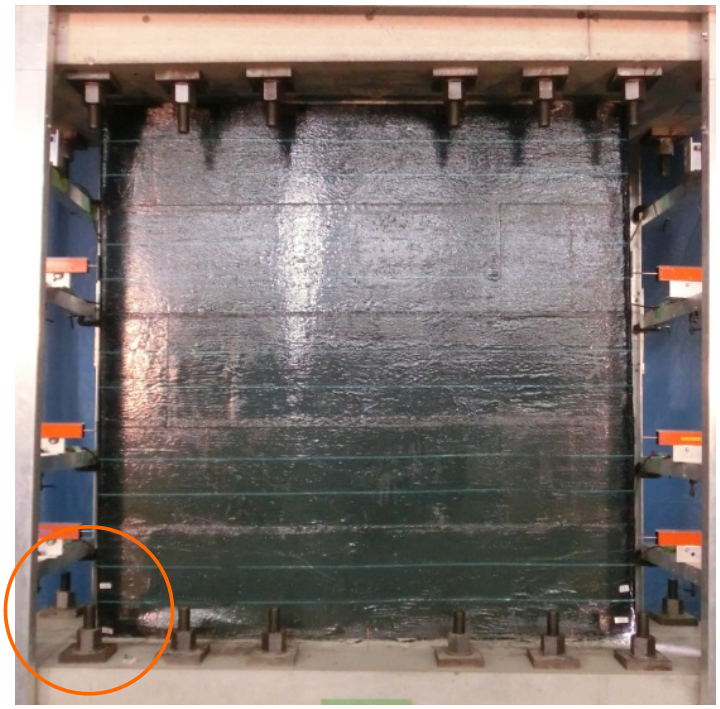
R=1.5%rad



Full retrofitting

Specimen RWF1

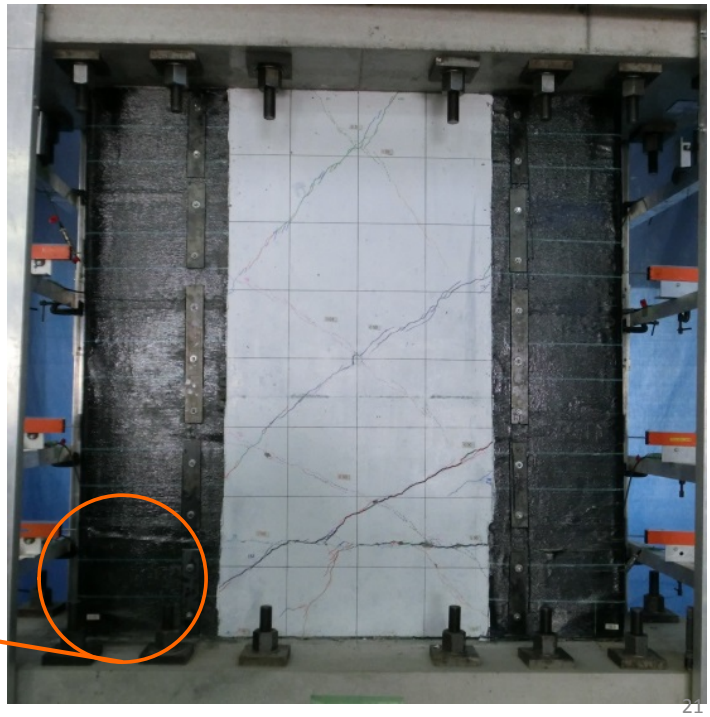
R=2.0%rad



Partial retrofitting

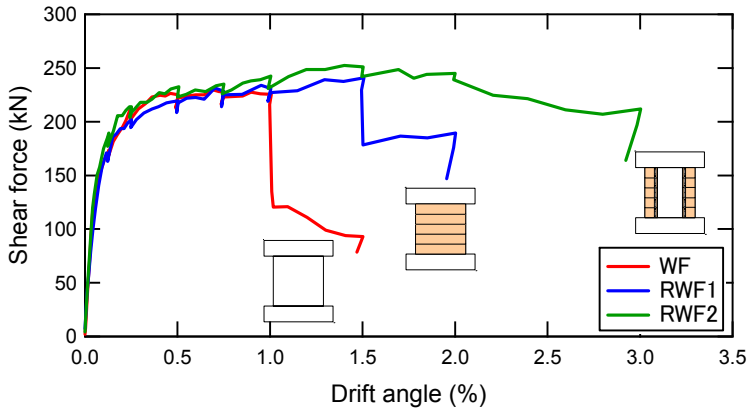
Specimen RWF2

R=2.0%rad



Shear force – drift angle relationship

Envelope curve



It is confirmed that ductility improve due to wrapping carbon fiber sheet.

Effect of constraining concrete of specimen RWF2 is larger than specimen RW