EXPERIMENTAL STUDY ON DAMAGE REDUCTION SESIMIC RETROFIT TECHNIQUE FOR RC FRAME USING ULTRA HIGH STRENGTH FIBER CONCRETE

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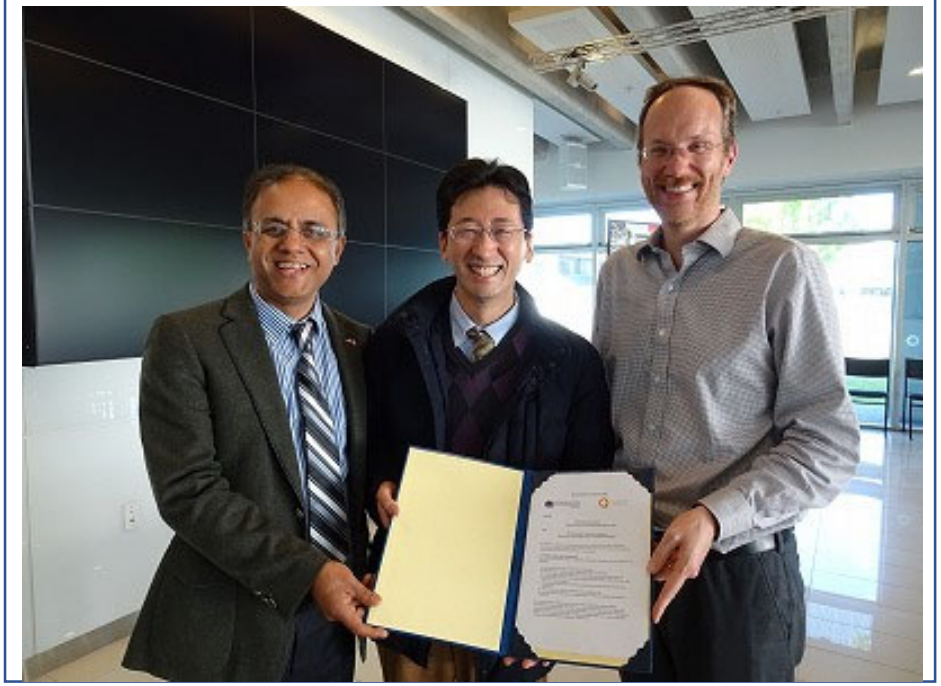
QuakeCoRE (NZ) and BRI(JAPAN)

Since 2016

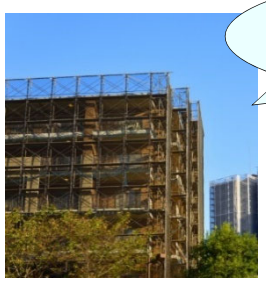


Since 2018

Affiliate Organisation

Background

■ Conventional Seismic Retrofit Tech



Noise・
vibration・dust

Activity is interrupted due to retrofit works

■ Required Tech.

・short construction period
・small noise and vibration

→ without post-installed anchors

■ Recent Earthquake Damage for R/C structures

Demolished R/C condo. satisfied current code due to Non-structural walls damage

AIJ Tohoku Branch : The 2011 Tohoku EQ damage investigation report, 2013.5

■ Required Seismic Retrofit Effects

・damage reduction
・max response reduction

Purpose

■ **Target : existing medium-rise R/C buildings satisfied current code**

■ **Development of retrofit technique**

1.Reduce maximum EQ response and damage level of members

2.Easy construction work

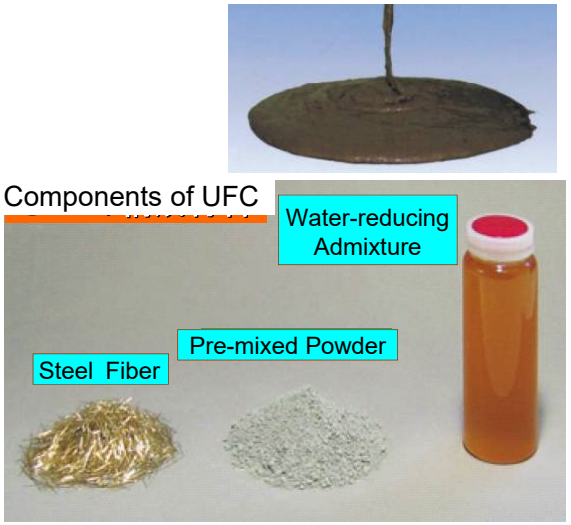
Utilize Precast Ultra high strength Fiber Concrete （UFC） wall panel

Structural test was done considering followings;

①Improve horizontal deformability of frame

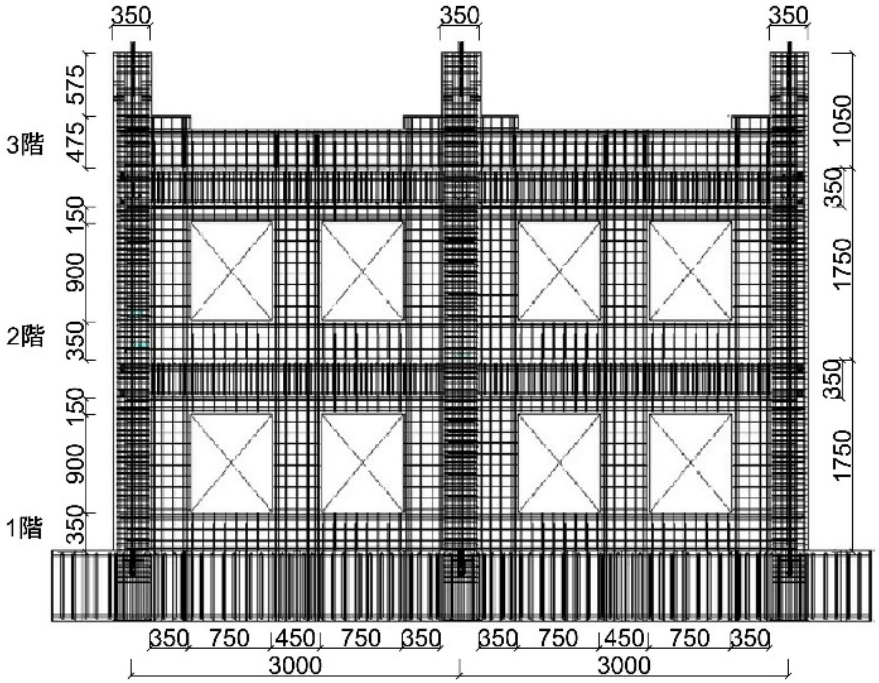
②Reduce damage of non-structural RC walls

③Control collapse mechanism



Specimen : reinfo. arrangement

Typical government office：2 story+2span
Non-structural RC walls



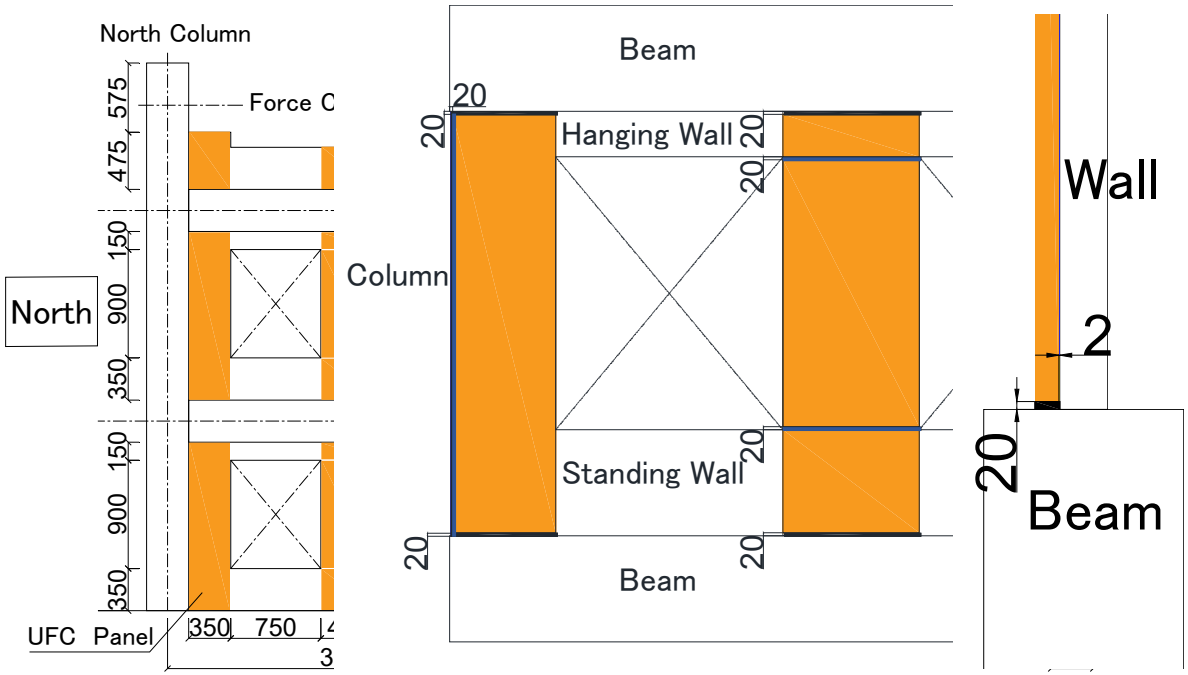
Scale			1/2
RC wall Thickness			60mm
Concrete Compressive strength			30Mpa in design
Column with wing wall	Column	Cross-section	350mm × 350mm
		Main bar	16-D16(SD345)
		Shear reinfo.	2-D10(SD295A)@50, pw=0.811%
	Wing wall	Edge bar	2-D13(SD295) single layer
		Vertical	D6(SD295)@100 single layer, pv=0.533%
		Horizontal	D6(SD295)@100 single layer, ph=0.533%
Beam with walls	Beam	Cross-section	250mm × 350mm
		Main bar	T5-D16(SD345), B3-D16(SD345)
		Shear reinfo.	2-D10(SD295A)@50, pw=1.14
	Hanging Standing wall	Edge bar	2-D13(SD295) single layer
		Vertical	D6(SD295)@100 single layer, pv=0.533%
		Horizontal	D6(SD295)@100 single layer, ph=0.533%
Wall with rectangular section		Edge bar	2-D10(SD390) single layer
		Vertical	D6(SD295)@100 single layer, pv=0.533%
		Horizontal	D6(SD295)@100 single layer, ph=0.533%
UFC Panel		Thickness	30mm
		Compressive strength	200Mpa in design
Axial force ratio			Outside 0.075, Inside 0.15

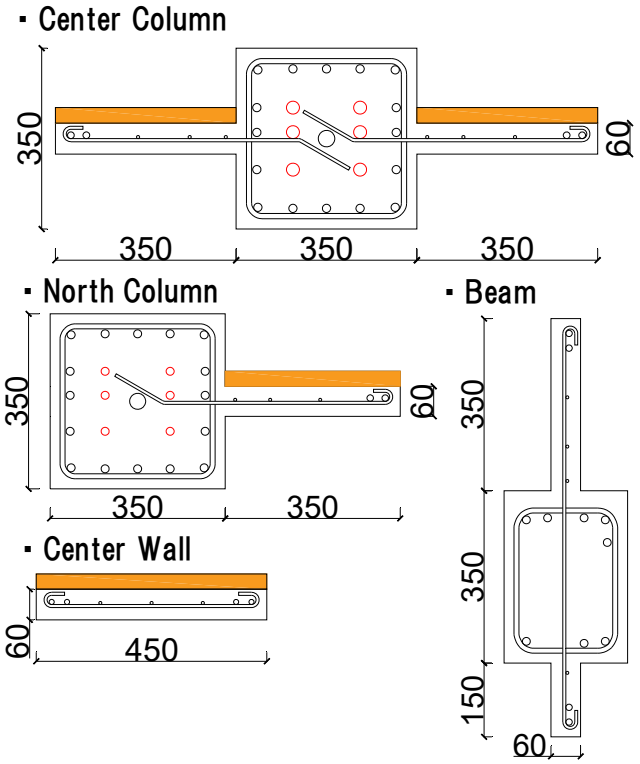
Outline of Seismic Retrofit

UFC panels are pasted on the non-structural wall face from one side using the epoxy resin adhesive

The gaps between beam and UFC panel : high strength non-shrinkage mortar

The other gaps: epoxy resin





Used Materials

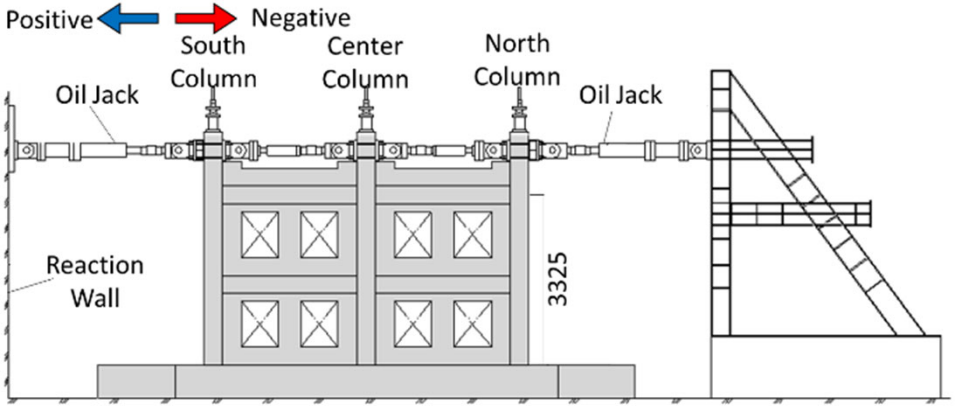
Steel, Concrete, Epoxy resin adhesive , UFC, High strength non-shrinkage mortar

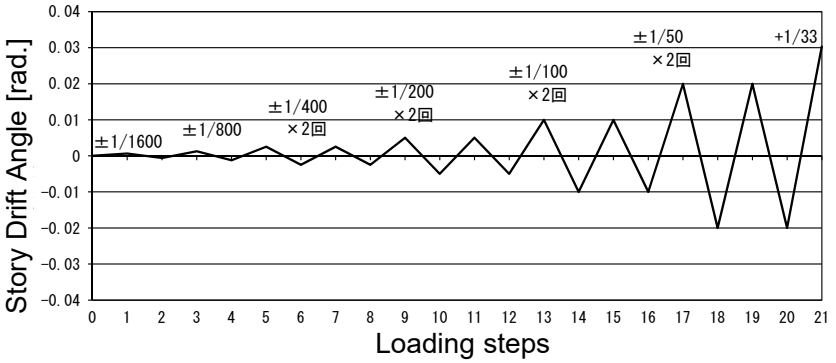
Reinforcing bars Components	Diameter	Grade	Yield strength (N/mm^2)	Young's Modulus (kN/mm^2)
Main bar for beam & column	D16	SD345	391	191
Edge bar for wing, standing and hanging walls	D13	SD295A	338	182
Edge bar for center walls	D10	SD390	402	187
Shear reinforcement	D10	SD295A	350	180
Bar of walls	D6	SD295A	346	185

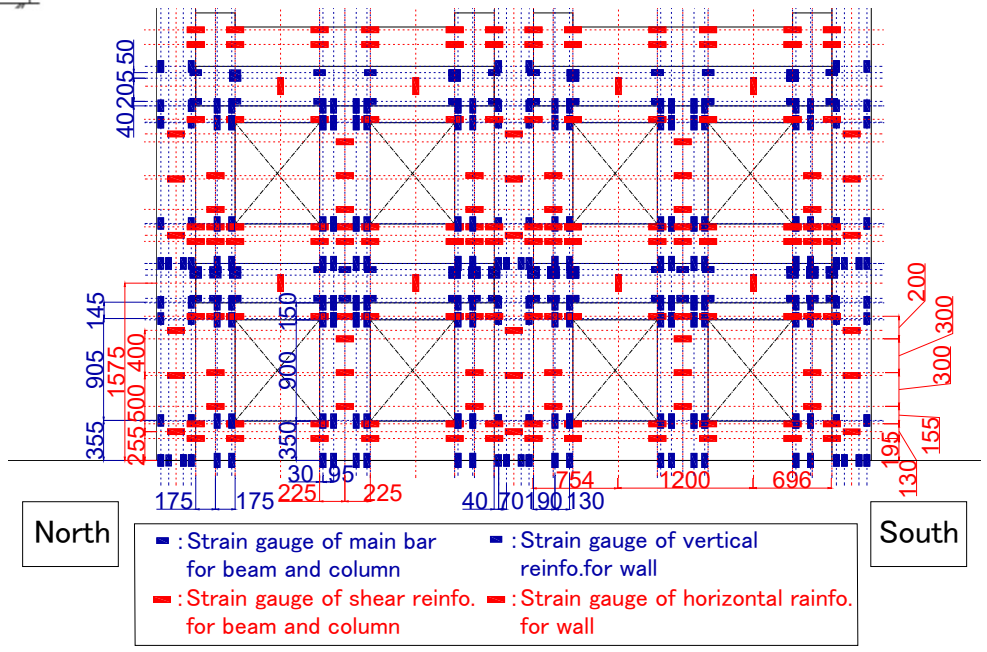
Concrete Story	Compressive strength (N/mm^2)
Top story	38.2
2nd story	36.8
1st story	39.8

UFC	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)	Young's Modulus (kN/mm^2)	Non-shrinkage mortar	Compressive strength (N/mm^2)	Tensile strength (N/mm^2)	Young's Modulus (kN/mm^2)
	220	38.3	54.0		106	8.86	30.7

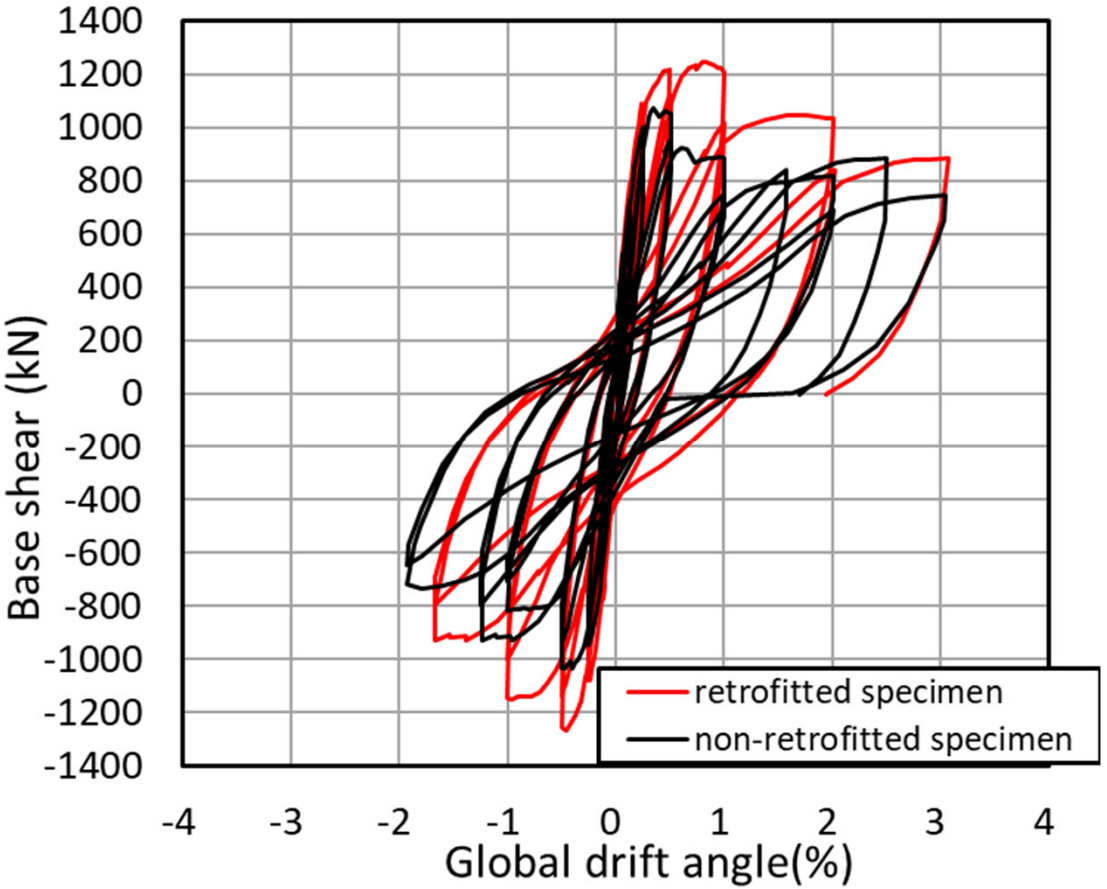
Loading and Measurement Plan







Test Results : Seismic Retrofit Effects1

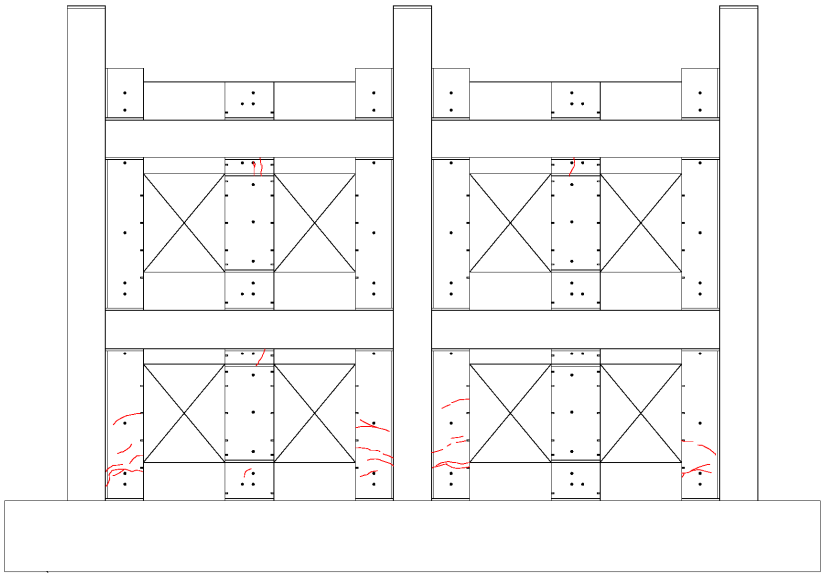


■Observed Effects1：

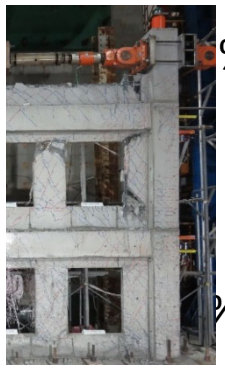
①improve maximum strength

②improve ductility（around R=1％）

Test Results：Seismic Retrofit Effects2

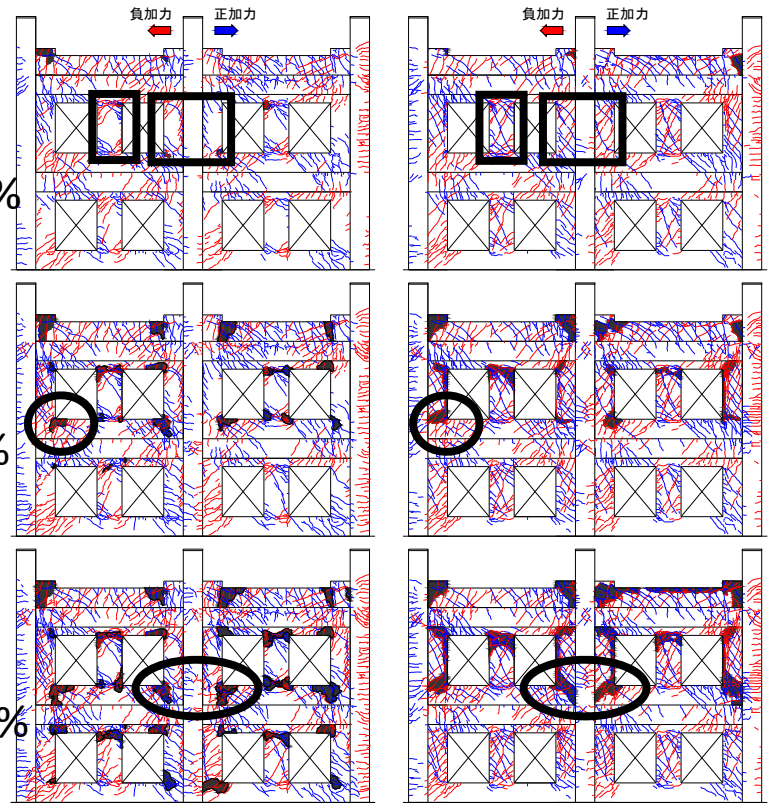


Damage of UFC panel



specimen

(a) Retrofitted　　(b) Non-Retrofitted

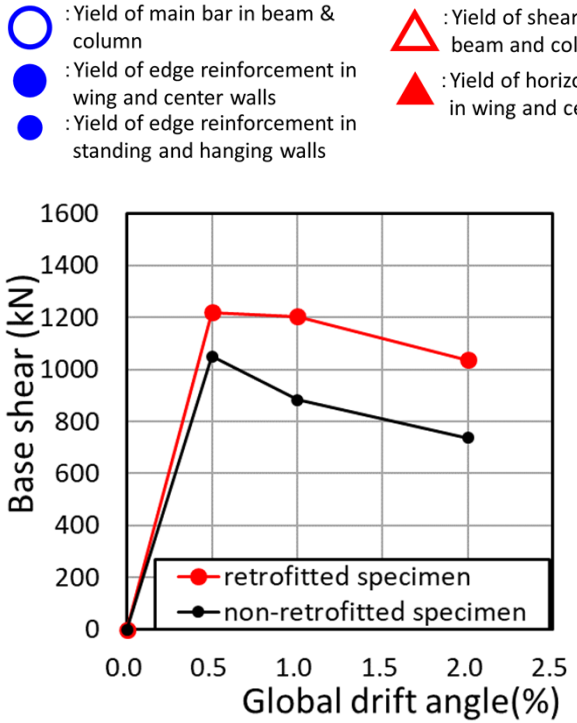


■ Observed Effects2：

1.Reduce non-structural R/C walls damage

2.Change damage distribution due to ultimate flexural strength with UFC(Collapse Mechanism Control 01)

Test Results : Seismic Retrofit Effects3



R=0.5%

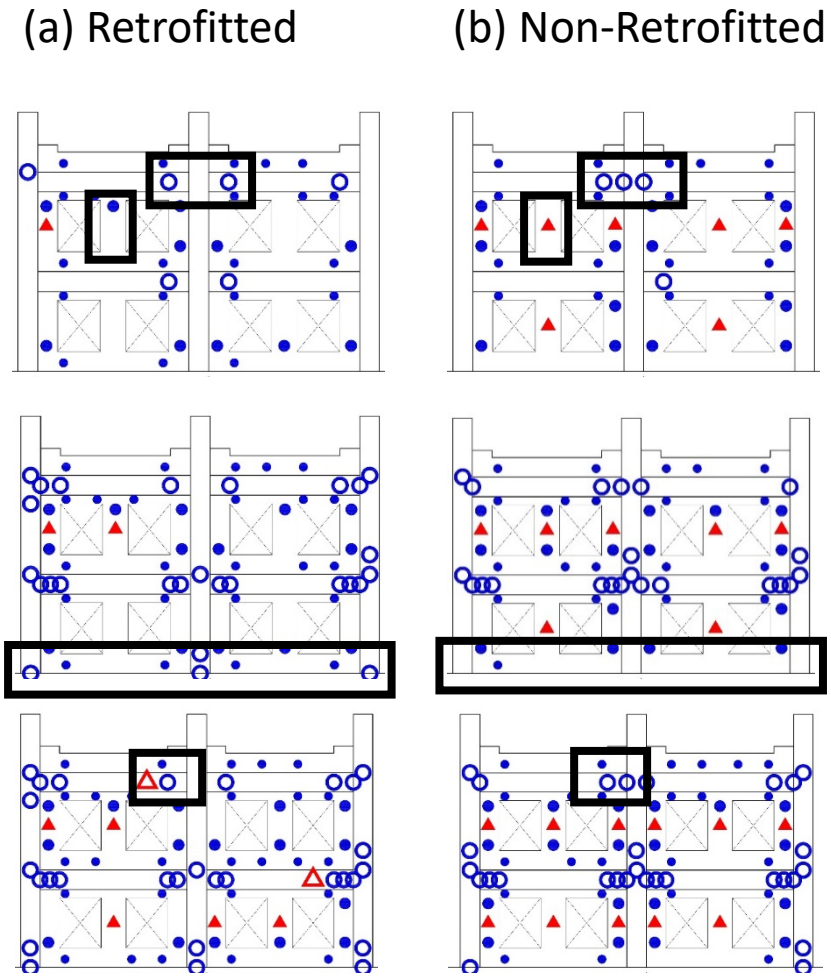
Change of yielding distribution by UFC rotational behavior

R=1.0%

Change of yielding position of main bars at 1st story column

R=2.0%

Change of yielding of shear reinfo. at 3rd story beam



■ Observed Effects3 :

①Change of yielding distribution （Collapse Mechanism Control 02）

Conclusions

Structural test for 2 story-2span R/C frame retrofitted by UFC panels was implemented and following knowledge were obtained.

Seismic Retrofit Effect1 : Improvement of deformability
Maximum strength was kept until R=1.0%, strength deterioration was controlled until R=2.0%.

Seismic Retrofit Effect2 : Reduction of non-structural wall damage
Damage reduction of retrofitted members at deformation level around maximum strength was observed.

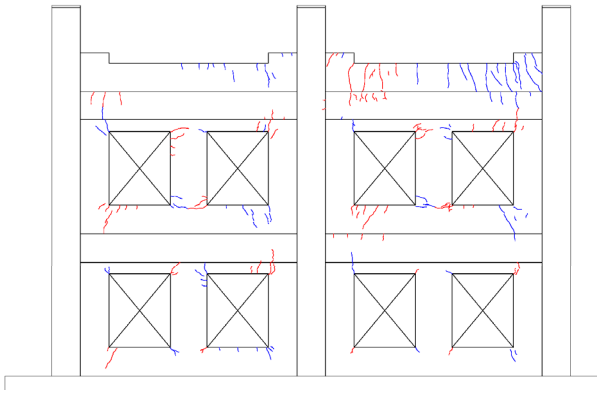
Seismic Retrofit Effect3 : Collapse mechanism control
Collapse mechanism was changed from story collapse to overall collapse by the seismic retrofit, story horizontal deformation distribution was improved.

Test Results　Non-retrofitted Specimen

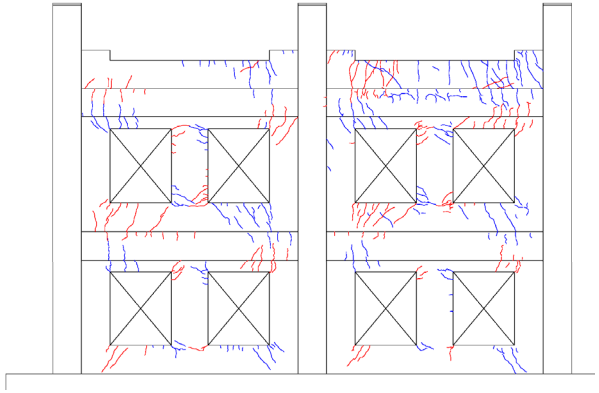
Test Results　Retrofitted Specimen

Crack states

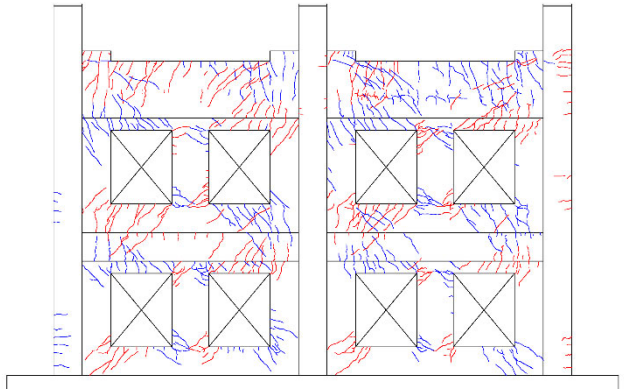
±1/1600 rad. 負加力 正加力



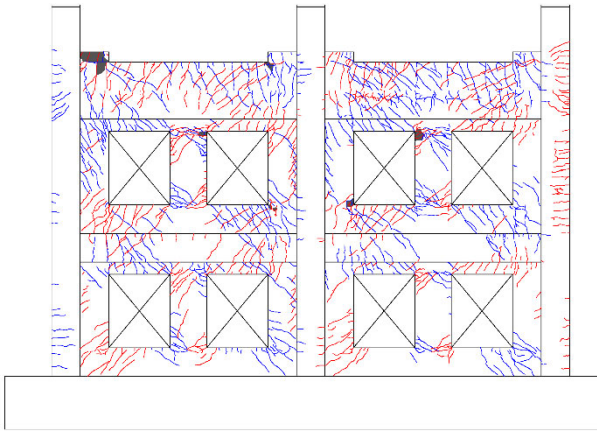
±1/800 rad. 負加力 正加力



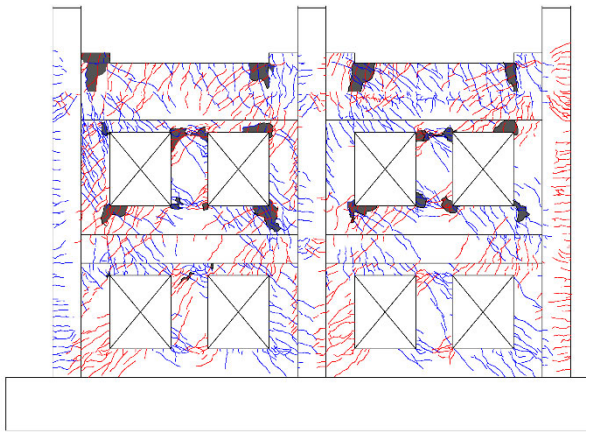
±1/400 (2) rad. 負加力 正加力



±1/200 (2) rad. 負加力 正加力



±1/100 (2) rad. 負加力 正加力



±1/50 (2) rad. 負加力 正加力