

Damage investigation of timber structures by
The 2007 Noto Peninsula Earthquake

Kaori Fujita

Department of Architecture, The University of Tokyo

Hiromi Sato

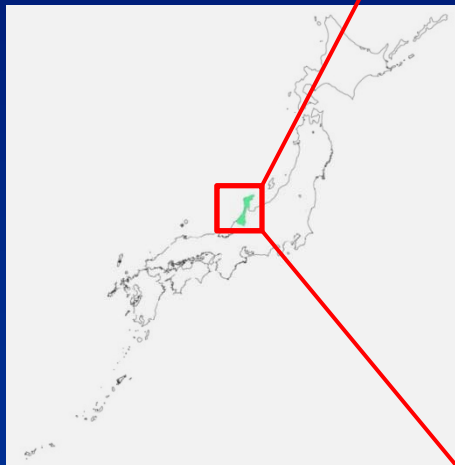
Faculty of Engineering, Tokushima University

Introduction

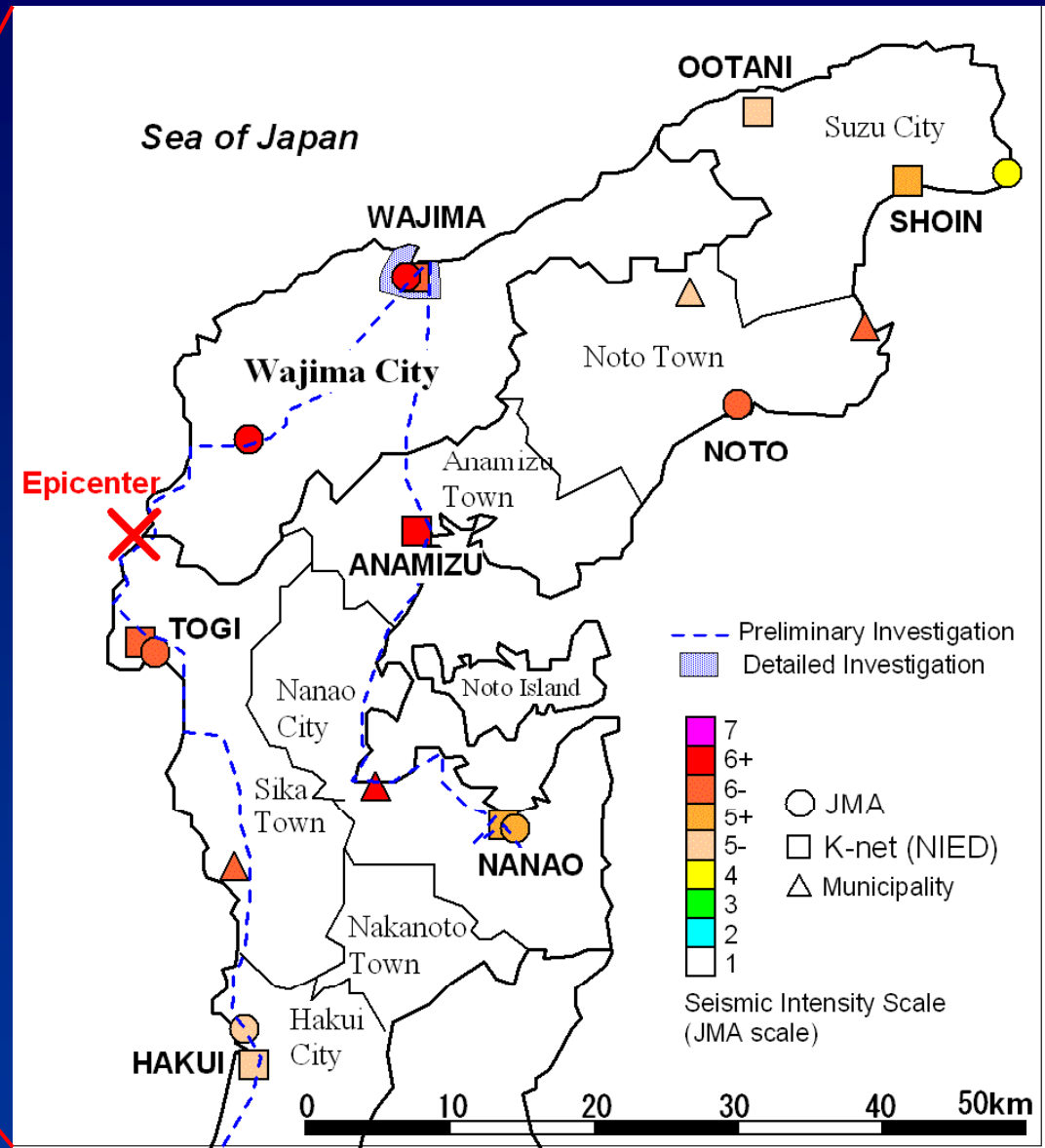
- Case study of Noto Peninsula earthquake 2007
 - Seismic performance of timber structures
 - Rehabilitation and seismic strengthening
- Devastated district
 - Regional city (70persons / km²)
 - Depopulation, aging society and traditional townhouses

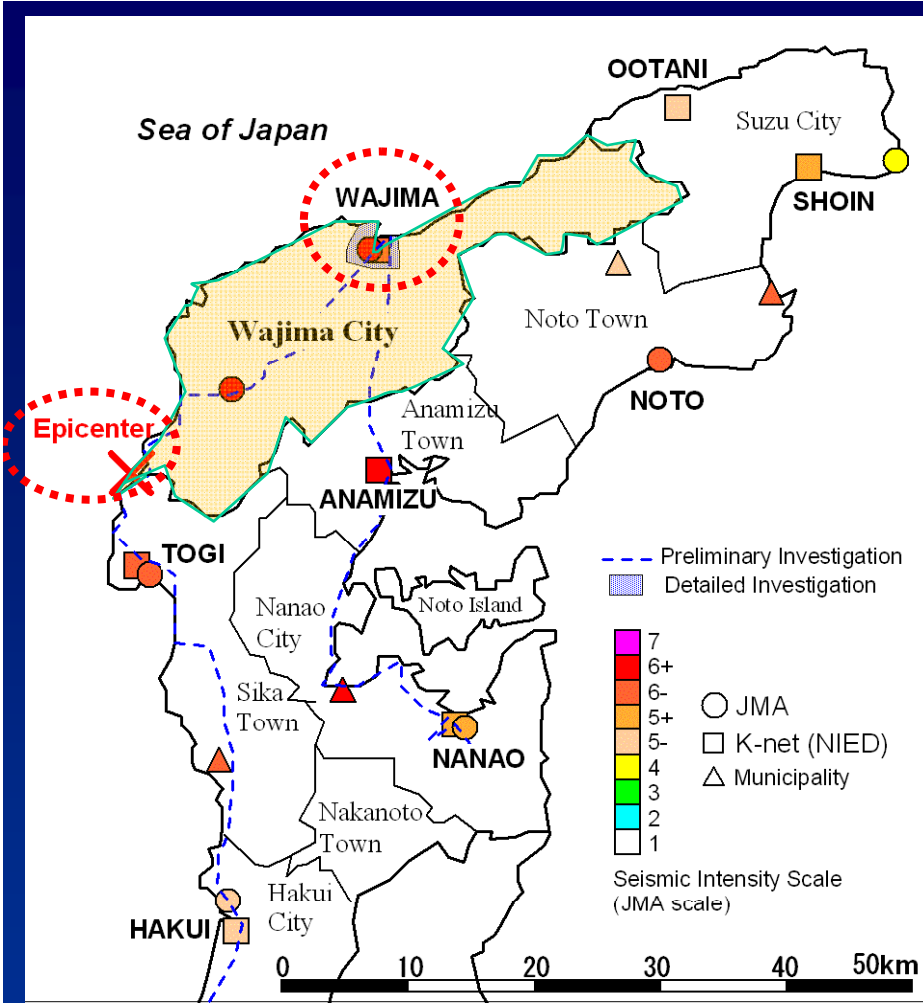


Outline of 2007 Noto Peninsula Earthquake



- 25th March, 2007
- Magnitude 6.9
- Off Noto Peninsula coast

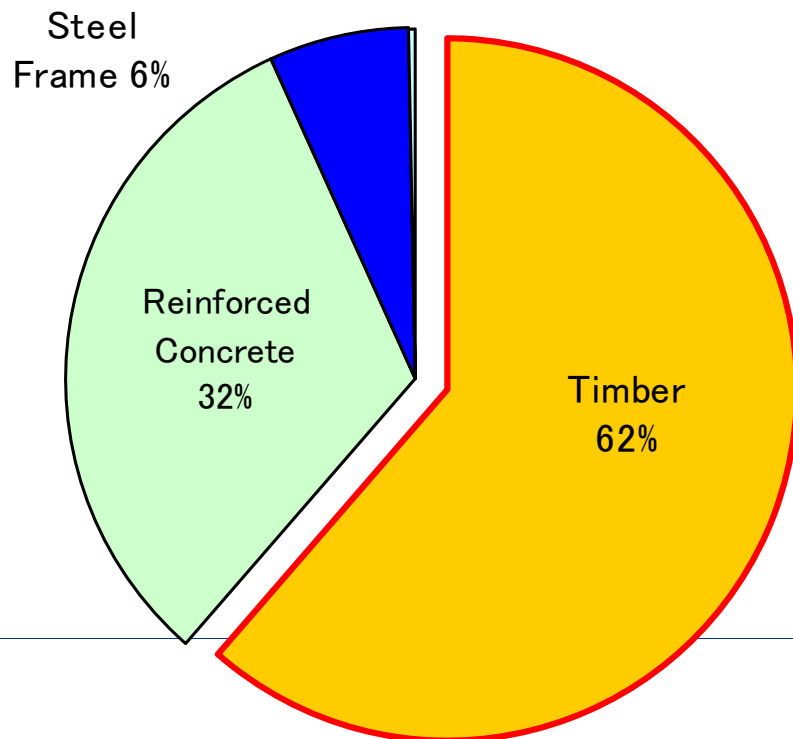




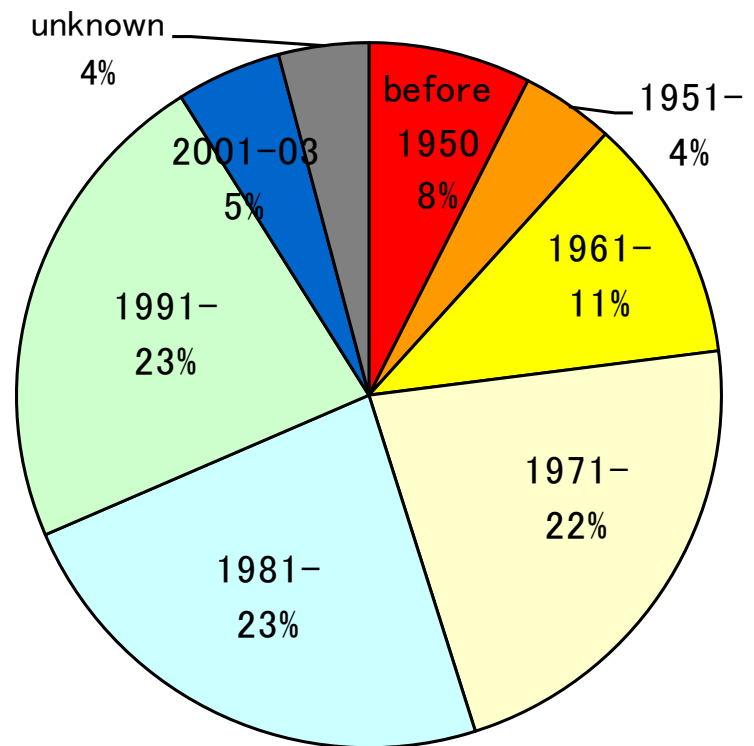
Over 2,000 houses were severely damaged
Most of the damage occurred in Wajima City

Construction year of existing timber houses in Japan

Structural Type of Existing houses in Japan (46,862,900 units)

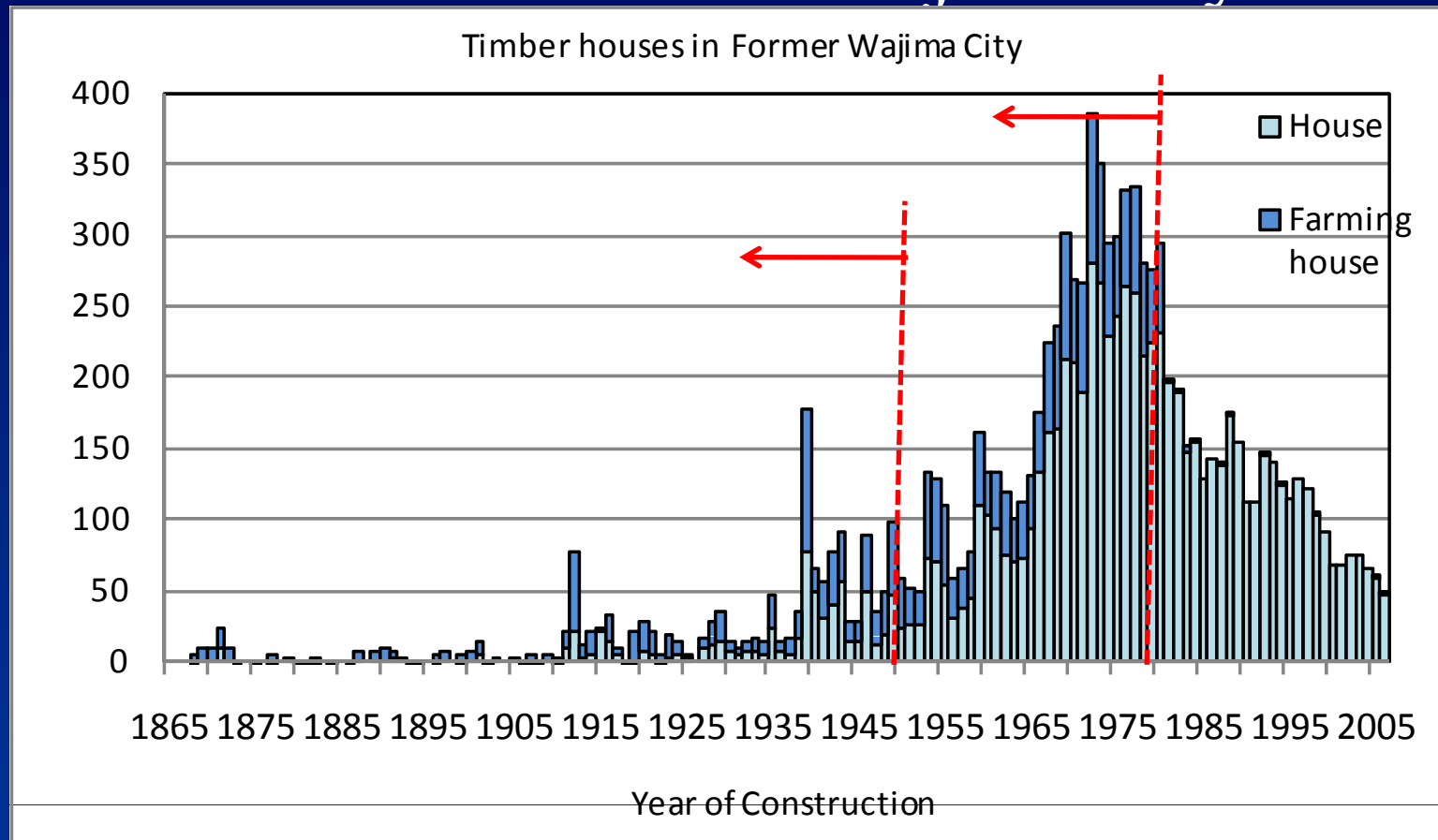


Construction Year of Existing Timber houses in Japan (28,759,000 units)



- Before 1950 : 8%
- Before 1980: 45%

Distribution of construction year of timber houses in Wajima city



- Before 1950: 15%
- Before 1980: 70%

Wajima City

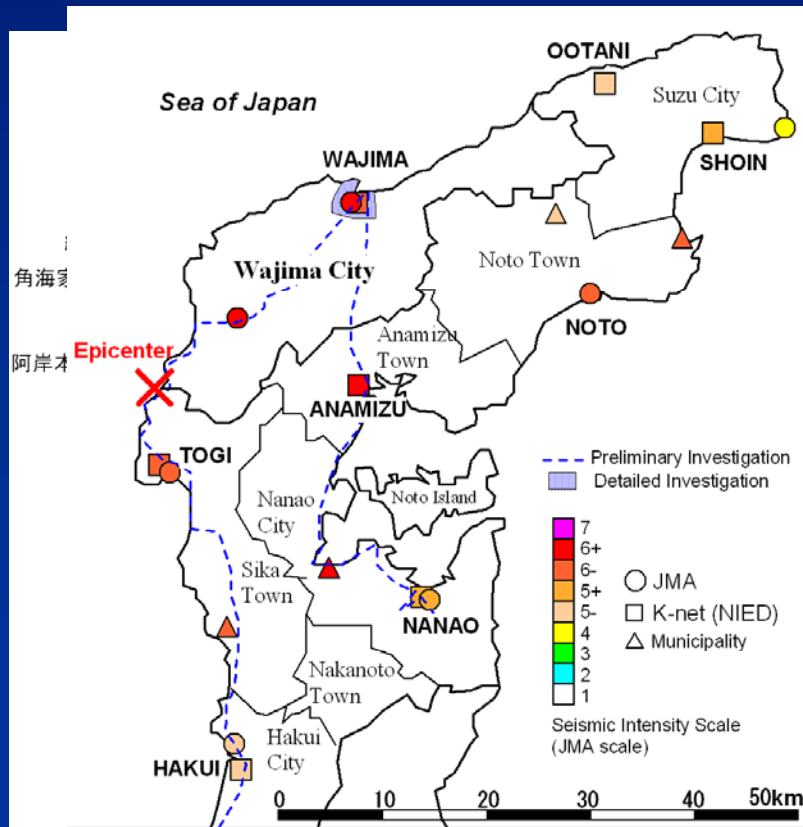
Population: 32,000

Houses: 7,020 units

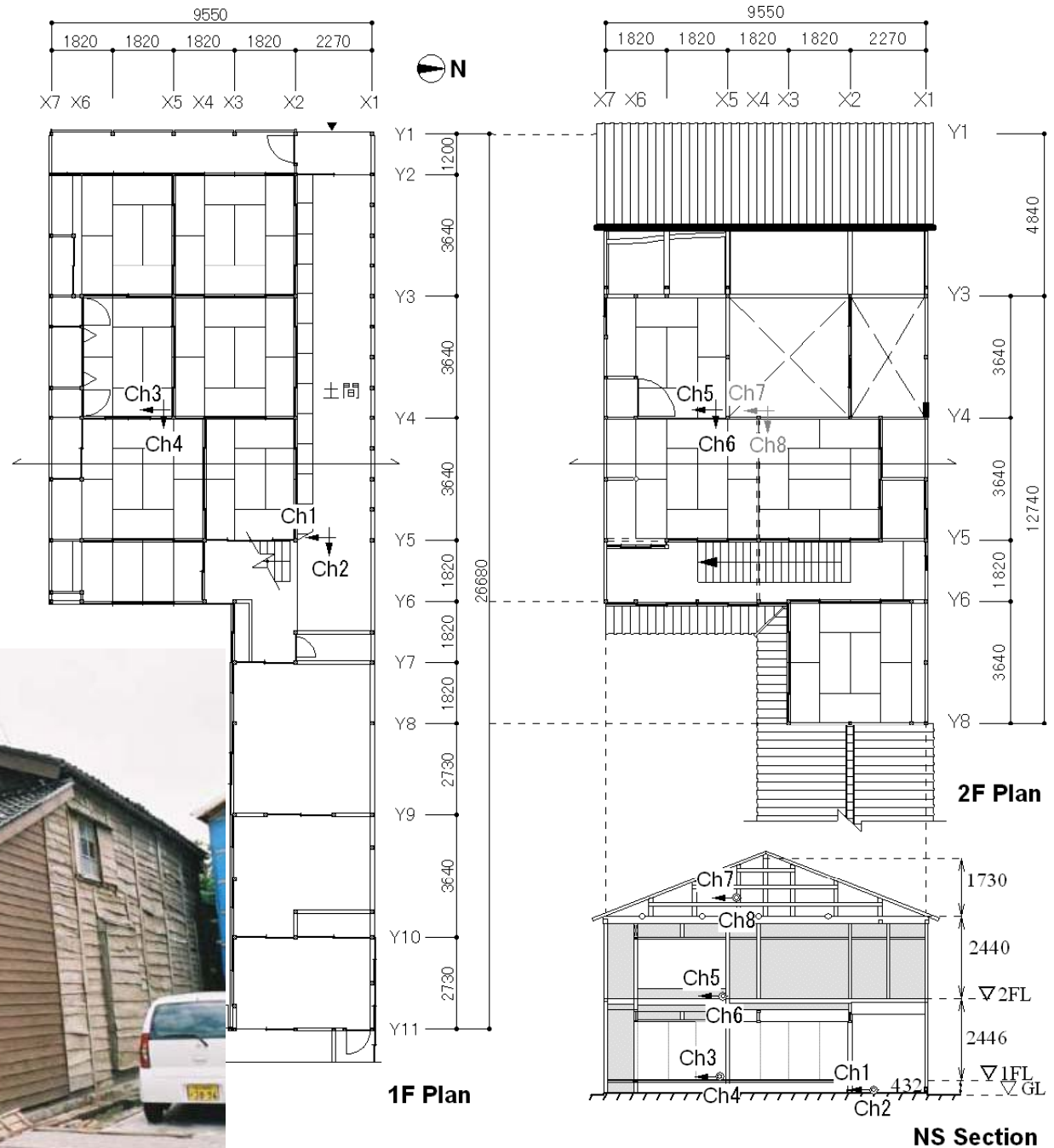
70persons/km²

Damaged townhouse

Hashiride, Wajima



Detail investigation on Traditional Townhouse



Seismic Diagnosis

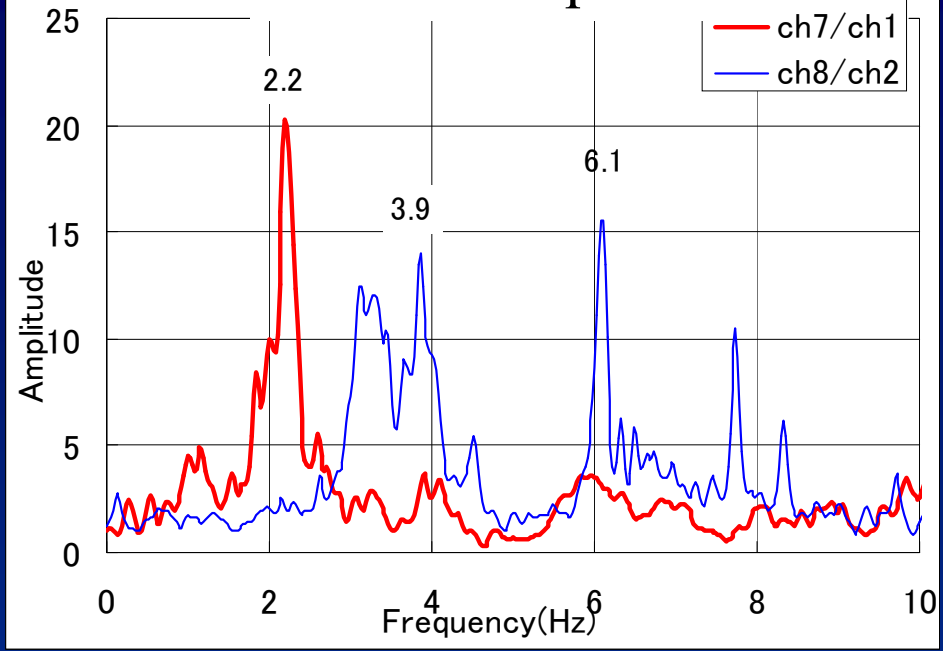


	direction	Horizontal load carrying capacity	Seismic Force	Seismic Index
		kN	kN	
1 st	X(NS)	29.2	103	0.28
	Y(EW)	69.4		0.67
2 nd	X(NS)	33.6	45.2	0.74
	Y(EW)	35.5		0.78

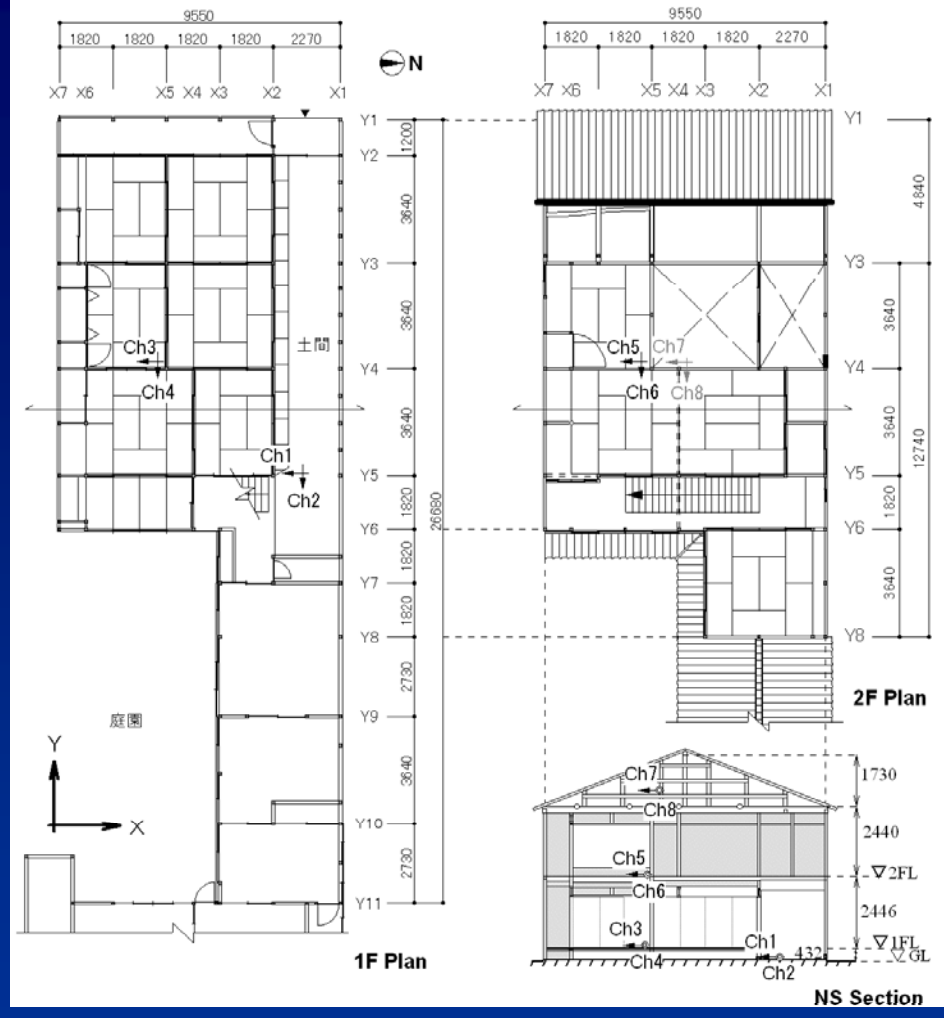
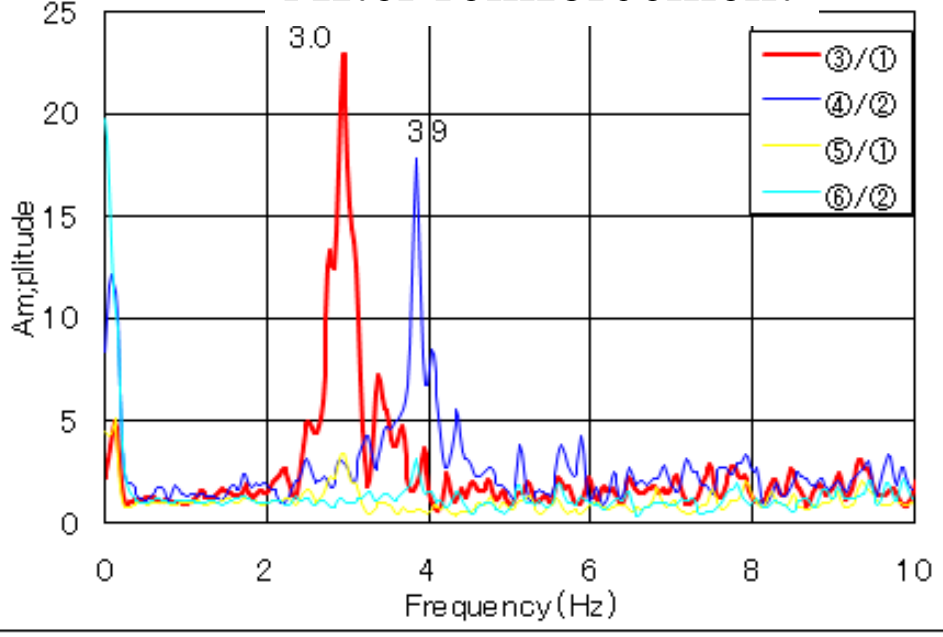
Seismic Index	
1.5 or more	Safe
1.0~1.5	Low possibility of collapse
0.7~1.0	Possibility of collapse
0.7 or less	High possibility of collapse



After earthquake



After reinforcement



After reinforcement
 Natural frequency
 2.2Hz → 3.0Hz



- Steel bracing (temporary emergency measures)

Technical problems and solutions

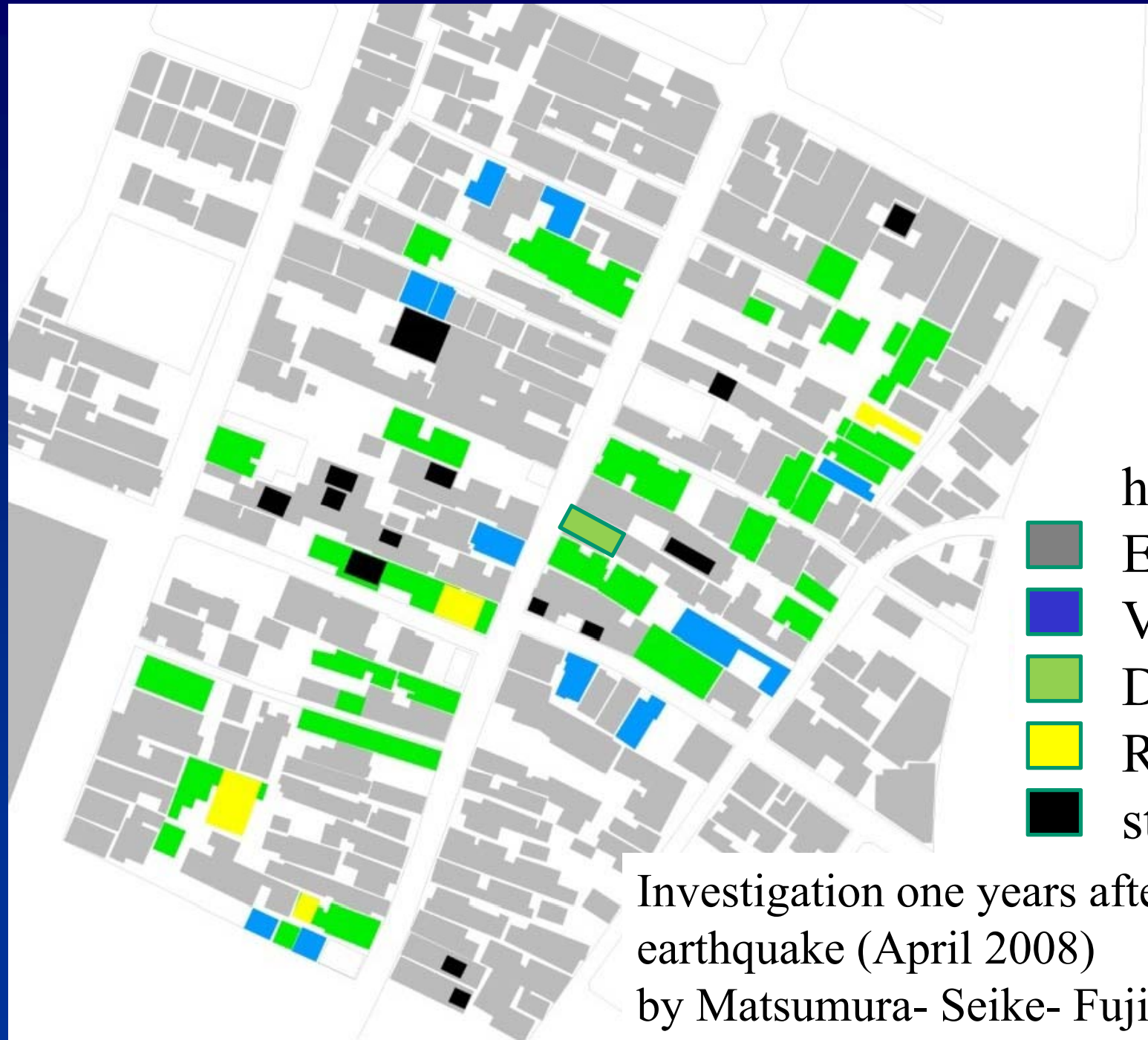


- Evaluation of structural performance of existing structures accurately
 - Basic structural data based on experiments
 - Seismic diagnosis of existing timber structures
- Efficient methodology and devices for structural reinforcement

Enforcement of structural reinforcement is not high
Over 10 million timber houses in need



- Vacant lots inside the city after the earthquake
- 7,000 housing units > 6,500 households



houses



Existing



Vacant



Demolished



Rebuilt



storehouse

Investigation one years after the earthquake (April 2008)

by Matsumura- Seike- Fujita Studio UT



- Townhouse damaged by the earthquake



demolished



- Town houses designed for dense urban district

Conclusion

- Seismic diagnosis/strengthening of existing houses
 - Number of houses are sufficient
 - Preservation of architectural heritage
 - Environmental sustainability
- Efficient methodology and devices for structural reinforcement
 - Technical, economical
 - Enforcement is the main problem
- How do we design the shrinking regional cities