17th U.S.-Japan-New Zealand Workshop
on the Improvement of Structural Engineering and Resilience
Queenstown, New Zealand

Statistical Analysis of Building Damage in Japan based on the 2016 Kumamoto Earthquake

November 14, 2018

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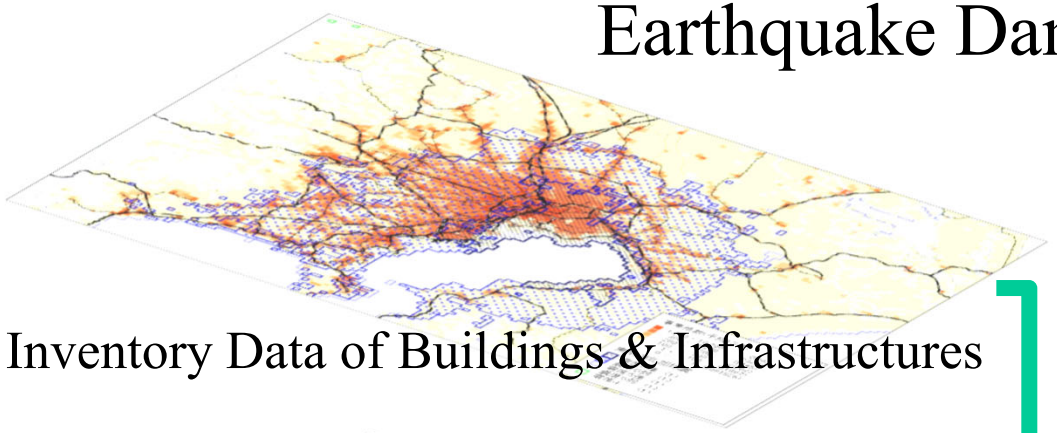
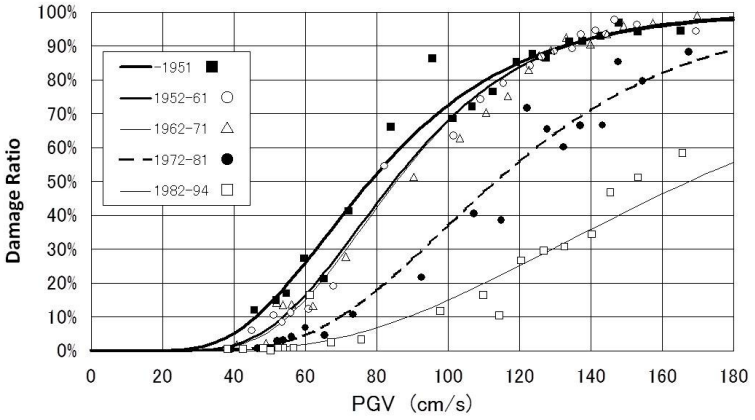
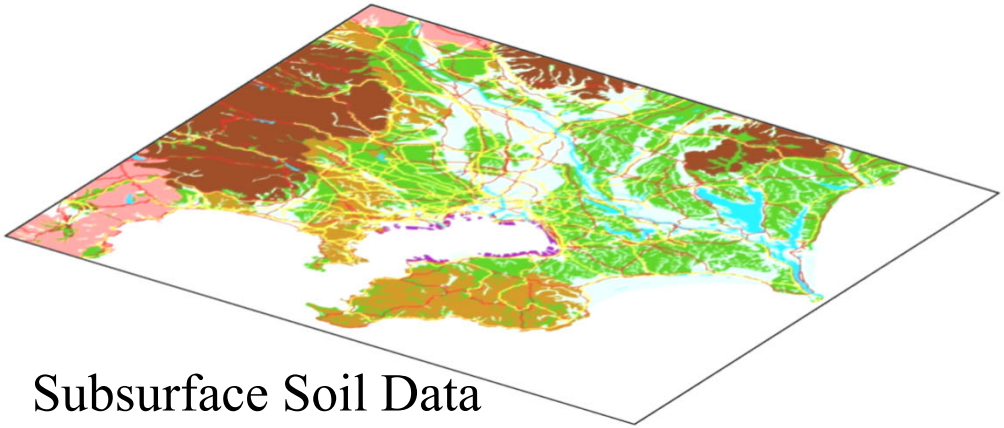
Earthquake Damage Assessment Flow



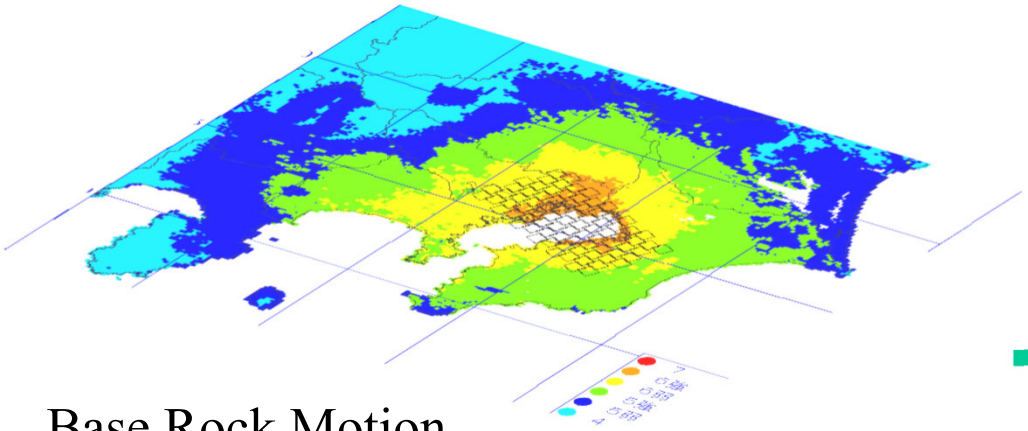
Inventory Data of Buildings & Infrastructures



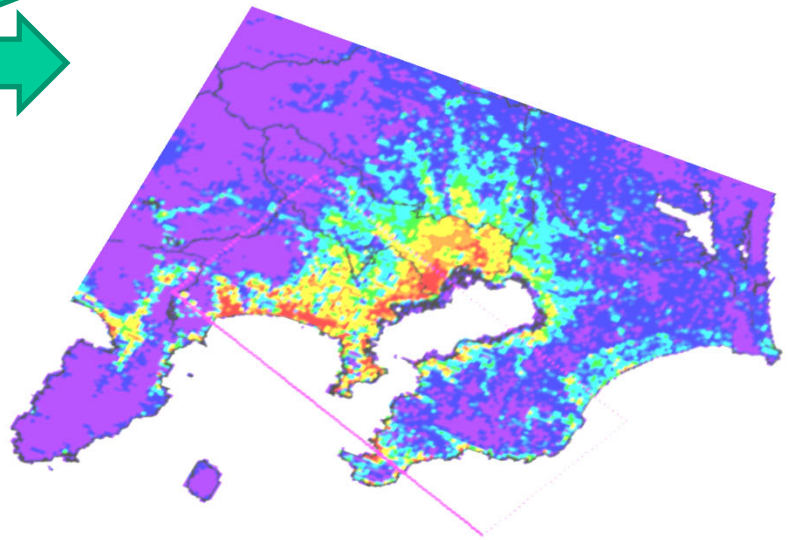
Fragility Curve



Subsurface Soil Data



Base Rock Motion



Damage Distribution

Building damage in Mashiki Town

April 16

Background

■ Empirical fragility curves developed from the 1995 Kobe earthquake have been widely used in Japan. But 23 years have passed since the event.

■ Significant building damages were caused in the April 2016 Kumamoto earthquake, and the Mashiki Town Government carried out the unified damage assessment for all the buildings in the town.

Objective of the Research

■ To analyze the building damage data in Mashiki Town compiled by the town government

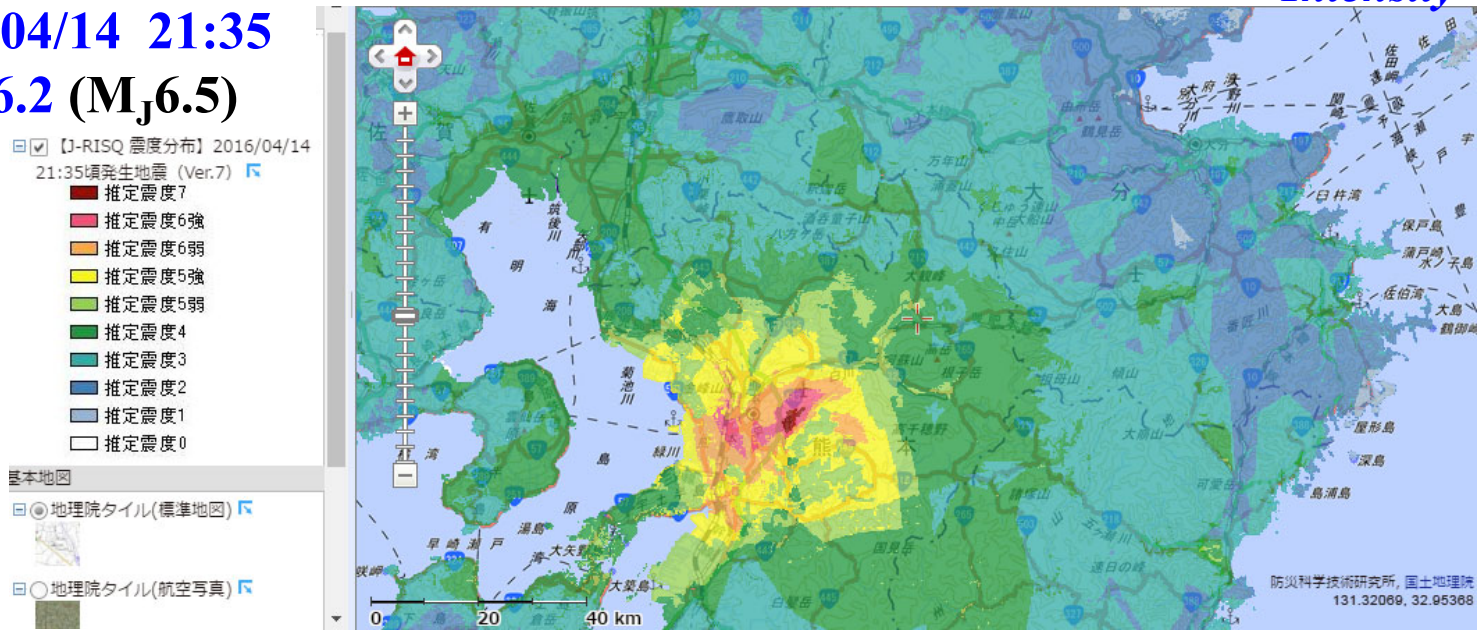
■ To develop fragility curves considering the structural material and construction period

Shake maps of the two Kumamoto events

JMA Instrumental Intensity

2016/04/14 21:35

M_w6.2 (M_J6.5)



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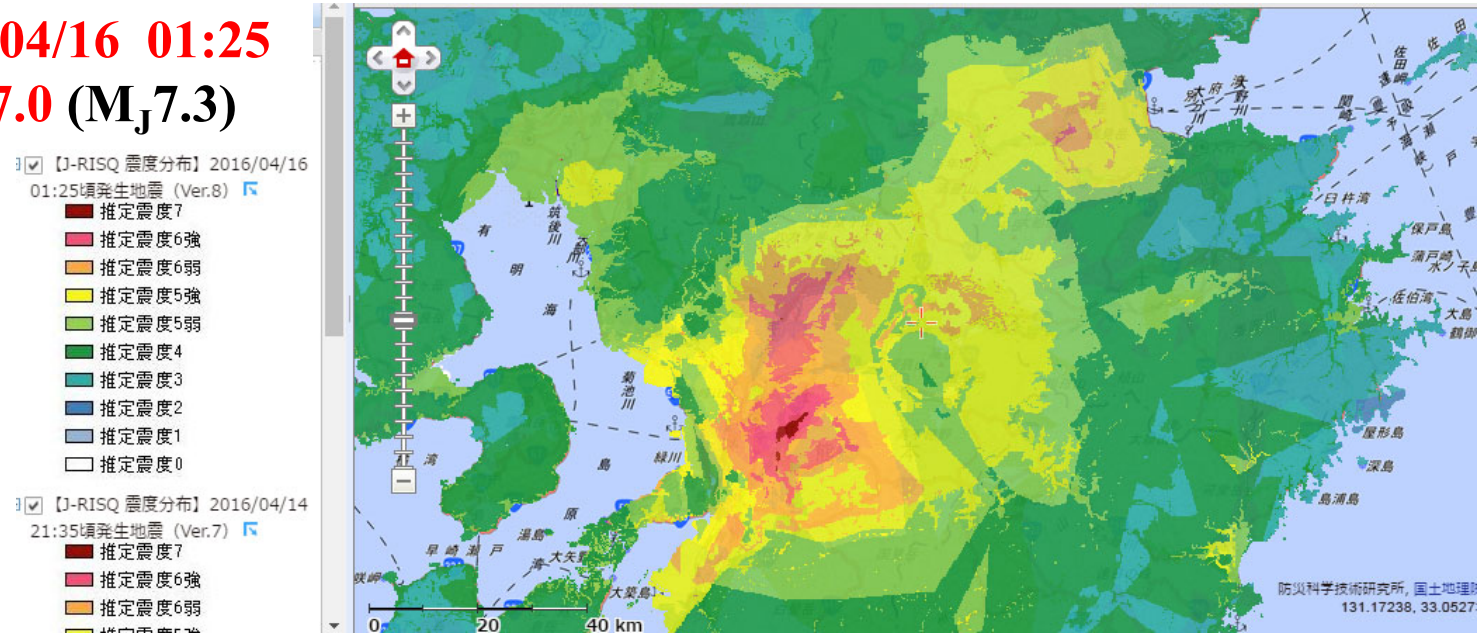
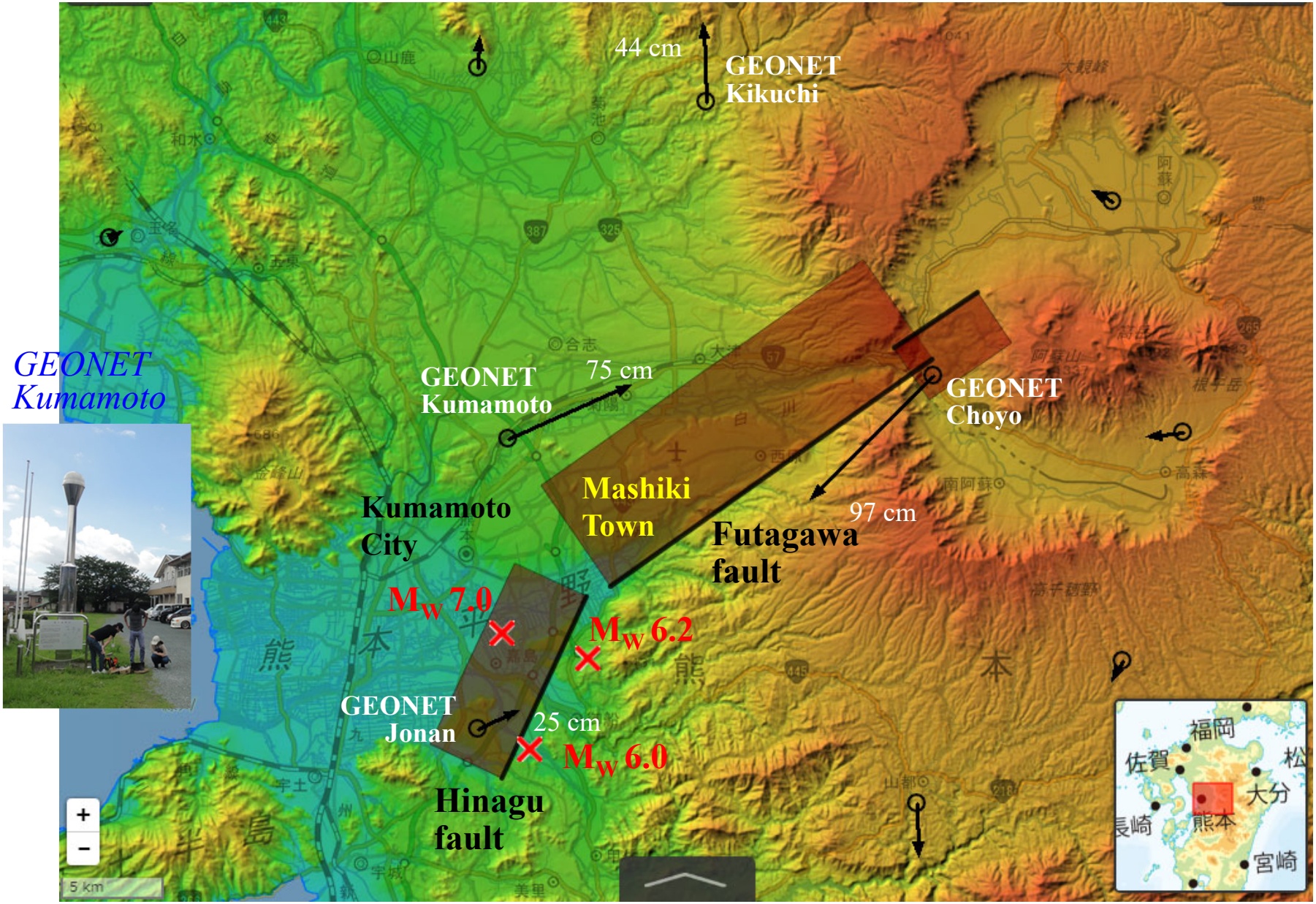
M_w7.0 (M_J7.3)

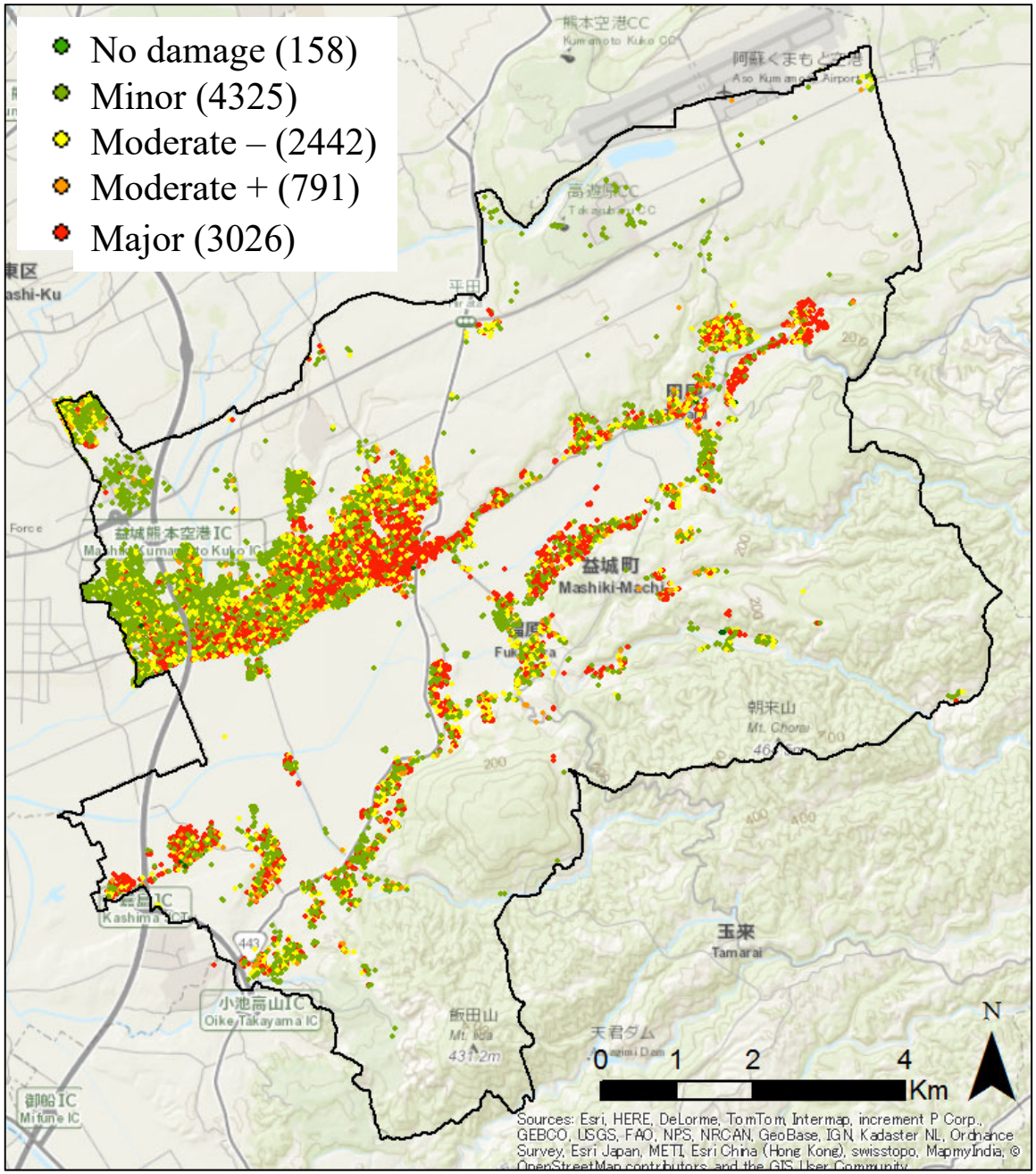


http://map03.ecom-plat.jp/map/map/?cid=20&gid=587&mid=2892

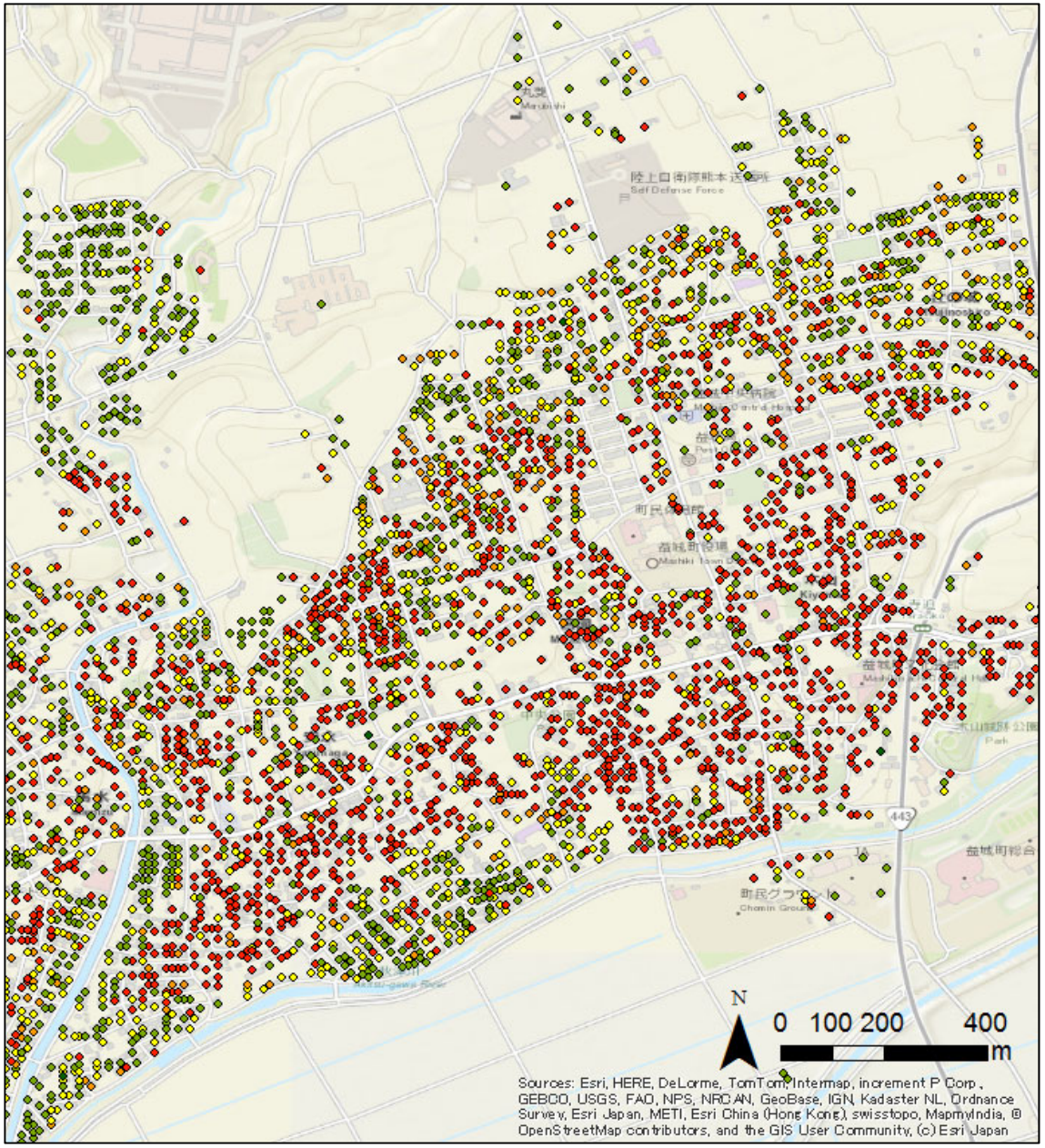
Causative faults and GNSS stations in the 2016 Kumamoto earthquake



Result of damage (loss) assessment by Mashiki Town Gov. (2017)

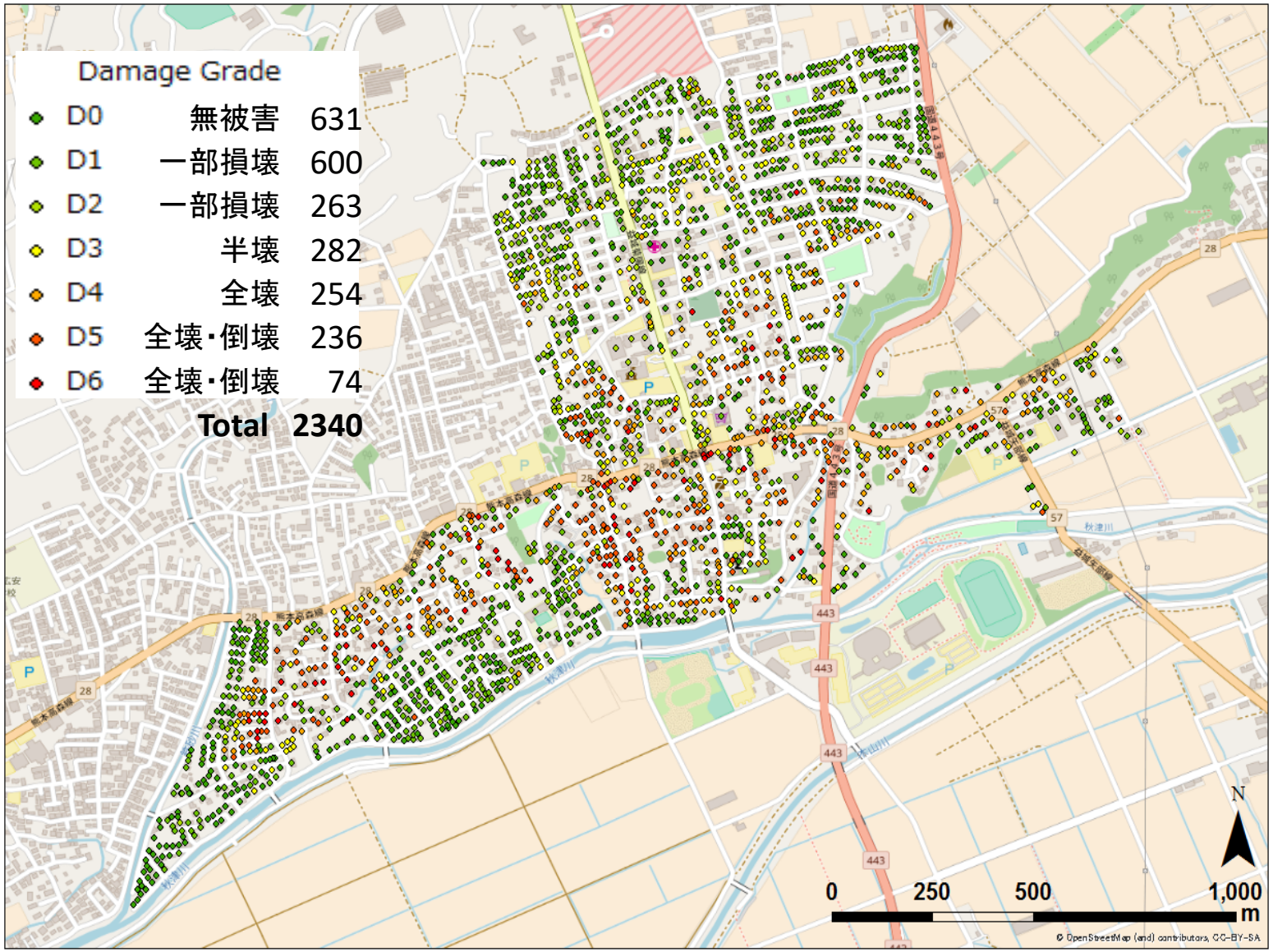


Building damage in the central Mashiki by the town government

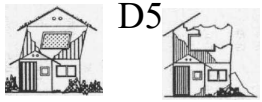


- No damage (158) 無被害
- Minor (4325) 一部損壊
- Moderate – (2442) 半壊
- Moderate + (791) 大規模半壊
- Major (3026) 全壊

Result of field survey by BRI and AIJ Kyushu branch based on Damage Grade of Okada & Takai (2000)



Earthquake loss evaluation class of buildings in Japan and schematic images of other damage classification methods

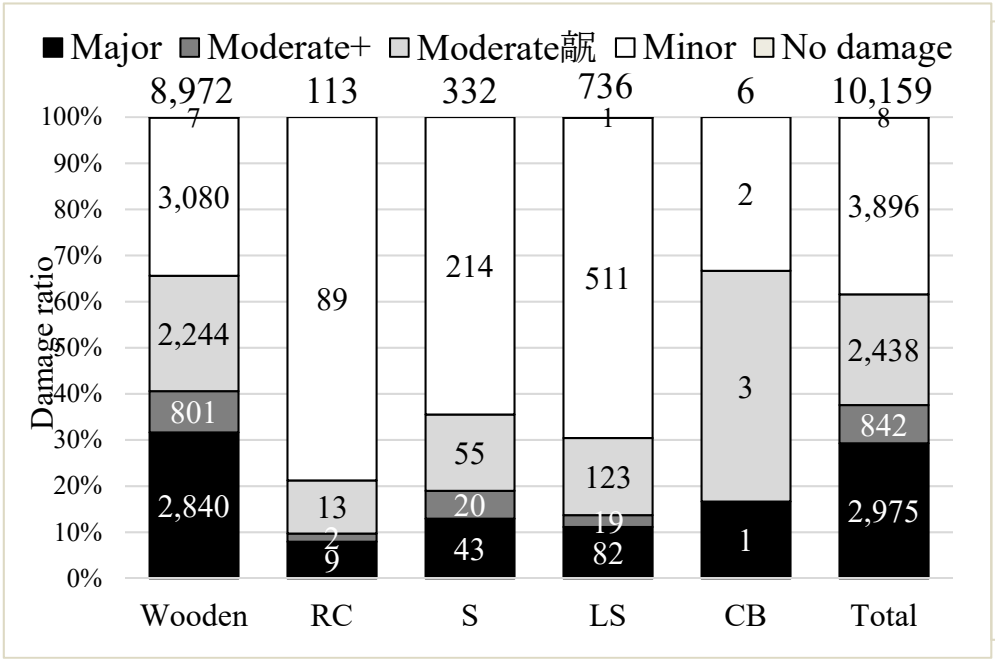
Current Damage (Loss) Class	Former Damage (Loss) Class	Loss Ratio (r), Damage Index	EMS-98	Okada & Takai (2000)
Major	Major	$r \geq 60\%$	G4 G5 	D4 D5 
		$50\% \leq r < 60\%$	G3 	D3 
Moderate +	Moderate	$40\% \leq r < 50\%$		
Moderate –		$20\% \leq r < 40\%$	G2 	D2 
Minor	Minor	$0\% < r < 20\%$	G1 	D1 
No	No	$r = 0\%$	(G0)	D0

Assuming the Loss Ratio (r) and the Damage Index (DI) are equal

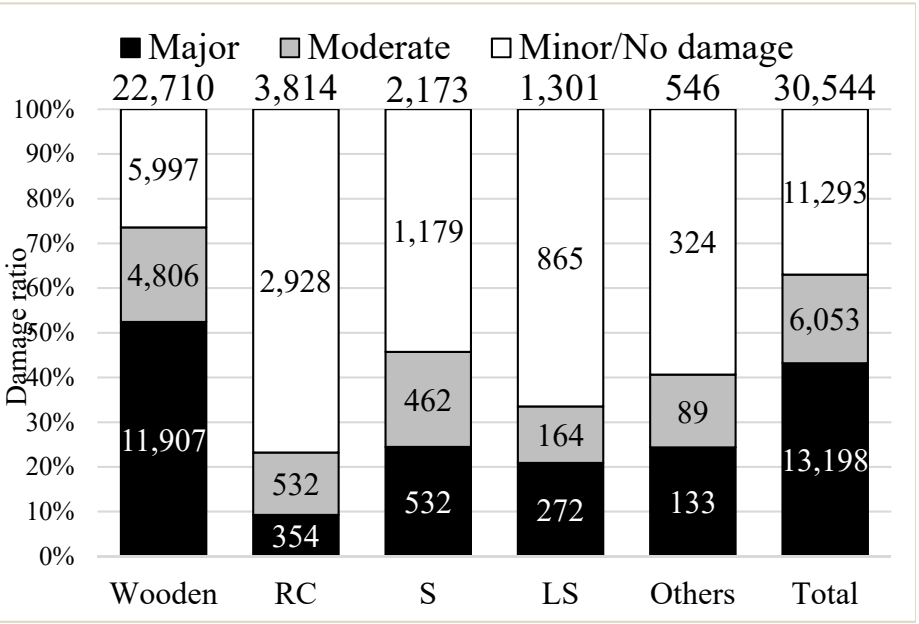
Comparison of damage classifications of buildings in the central Mashiki Town

	AIJ's survey							
Mashiki Town Gov.	**D0**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	Total
No damage	1	0	0	0	0	0	0	1
Minor	175	91	13	3	1	0	0	283
Moderate -	103	161	47	15	1	0	0	327
Moderate +	7	61	32	18	0	1	0	119
Major	18	83	80	146	147	149	31	654
Total	304	396	172	182	149	150	31	**1384**

Damage classification of buildings by local governments with respect to the structural type



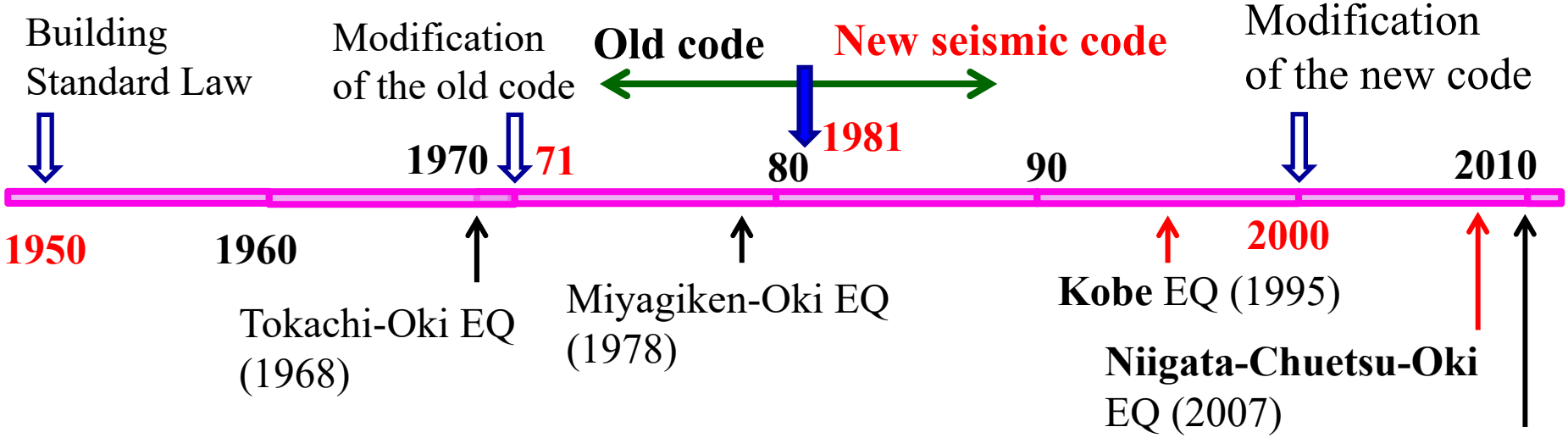
(a) Mashiki Town in 2016 Kumamoto EQ

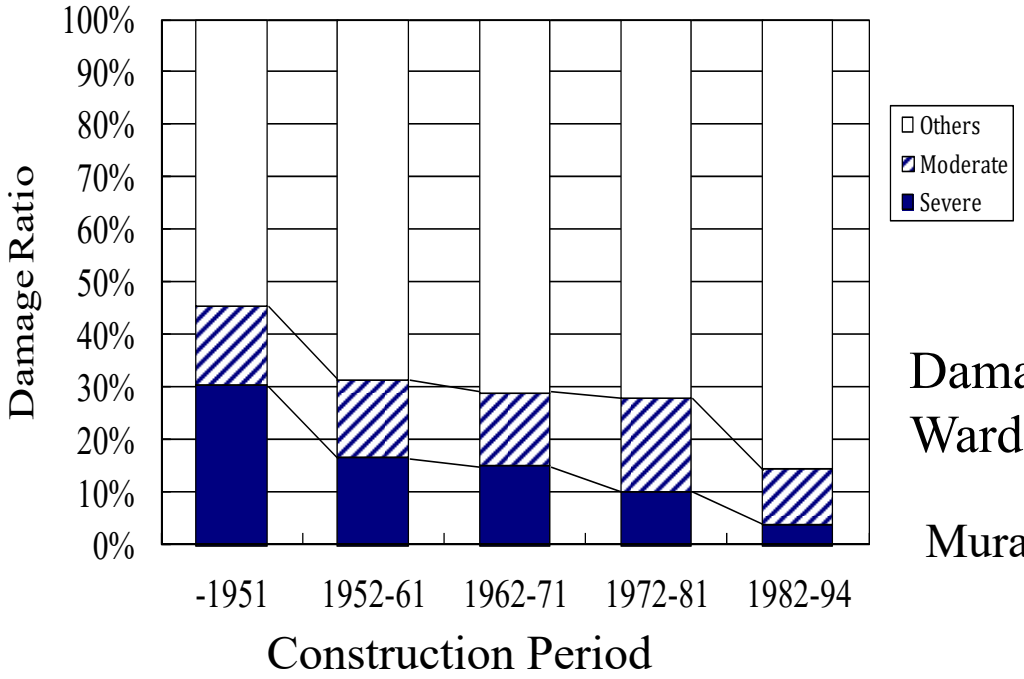


(b) Nada Ward in 1995 Kobe EQ

Murao & Yamazaki (1999)

Revision of building's seismic code in Japan

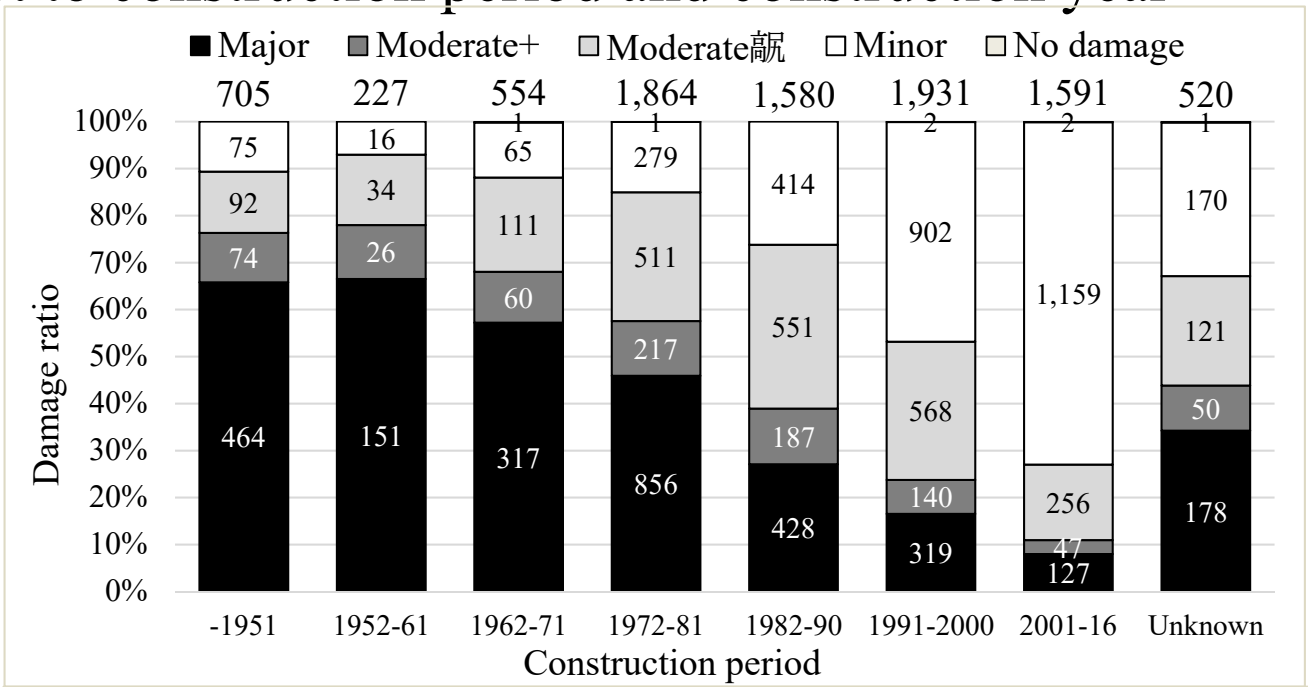


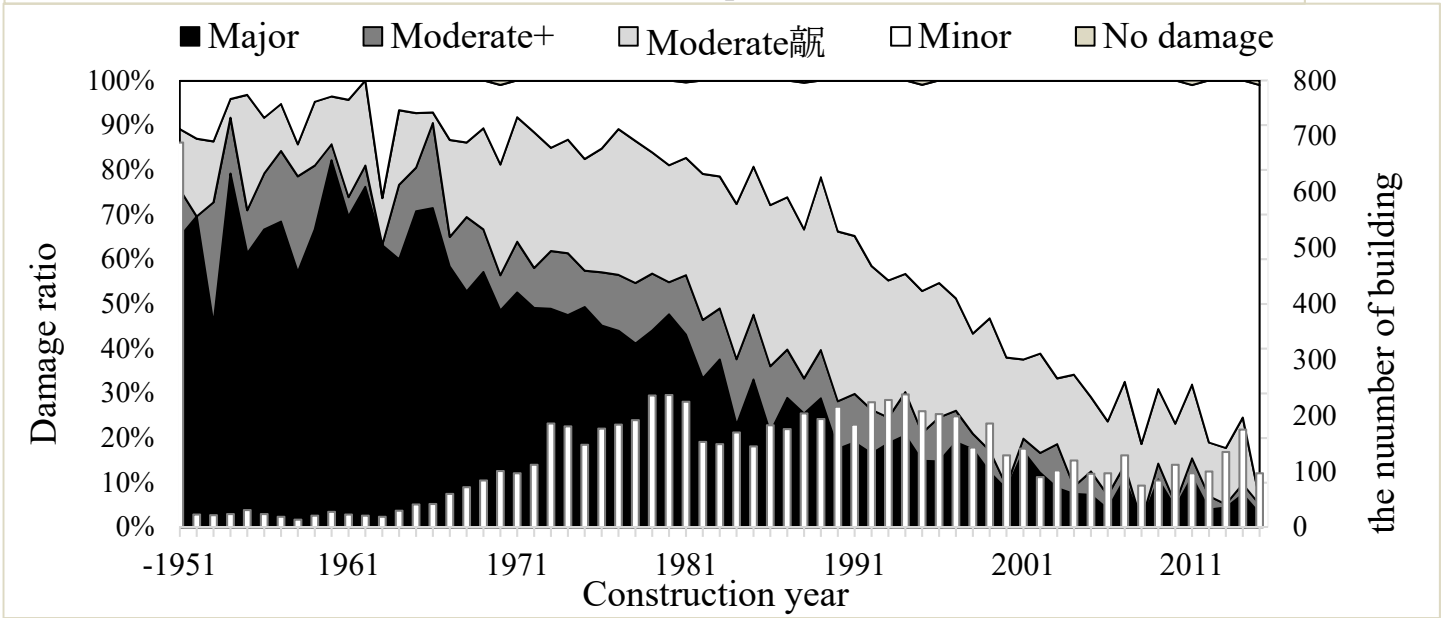


Damage ratio of RC buildings in Nada Ward classified by construction period

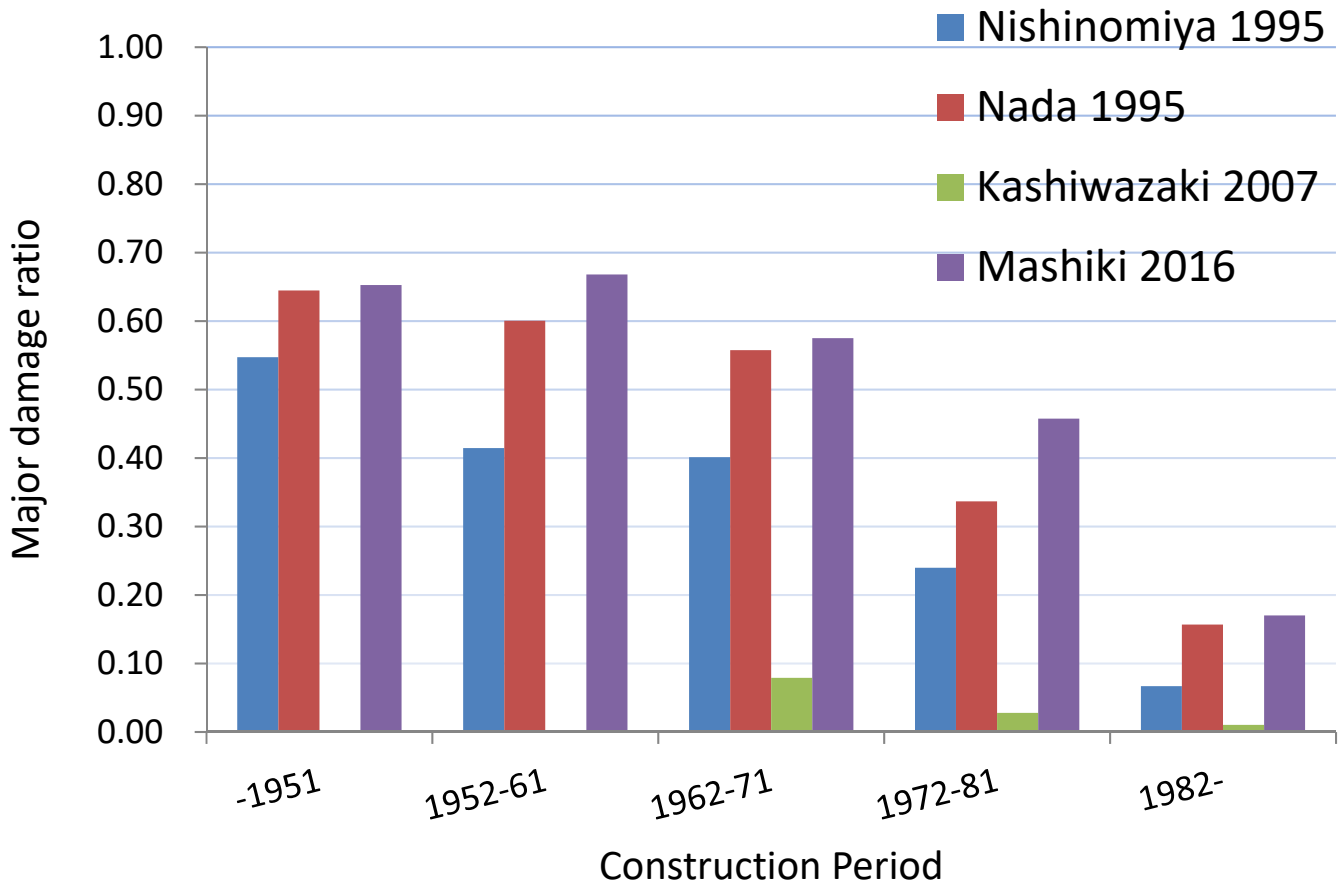
Murao & Yamazaki (1999)

Damage classification of wooden buildings in Mashiki Town with respect to construction period and construction year

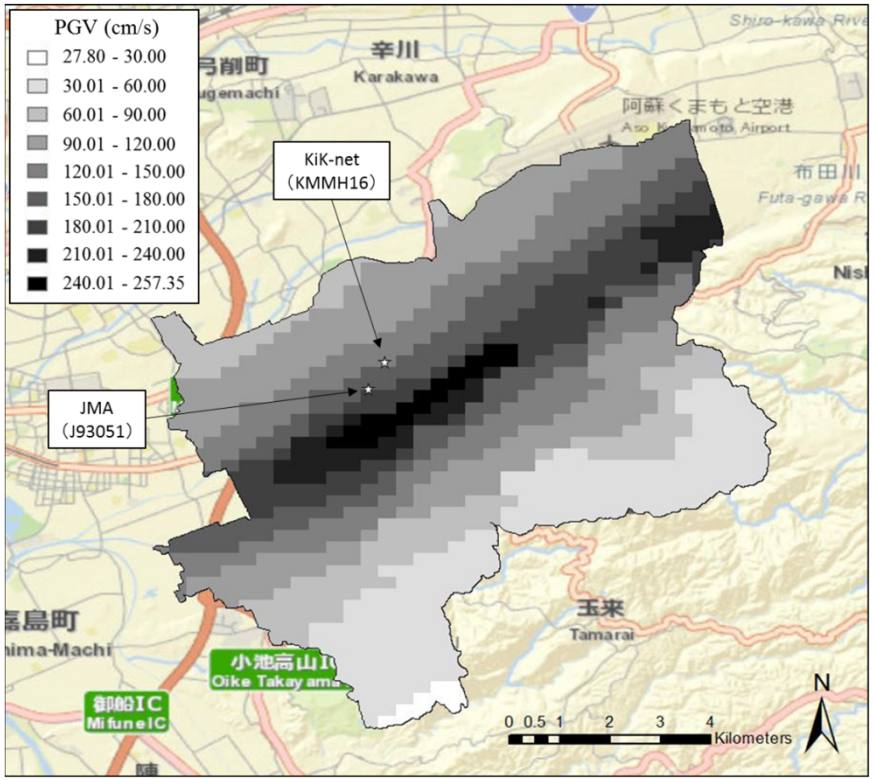




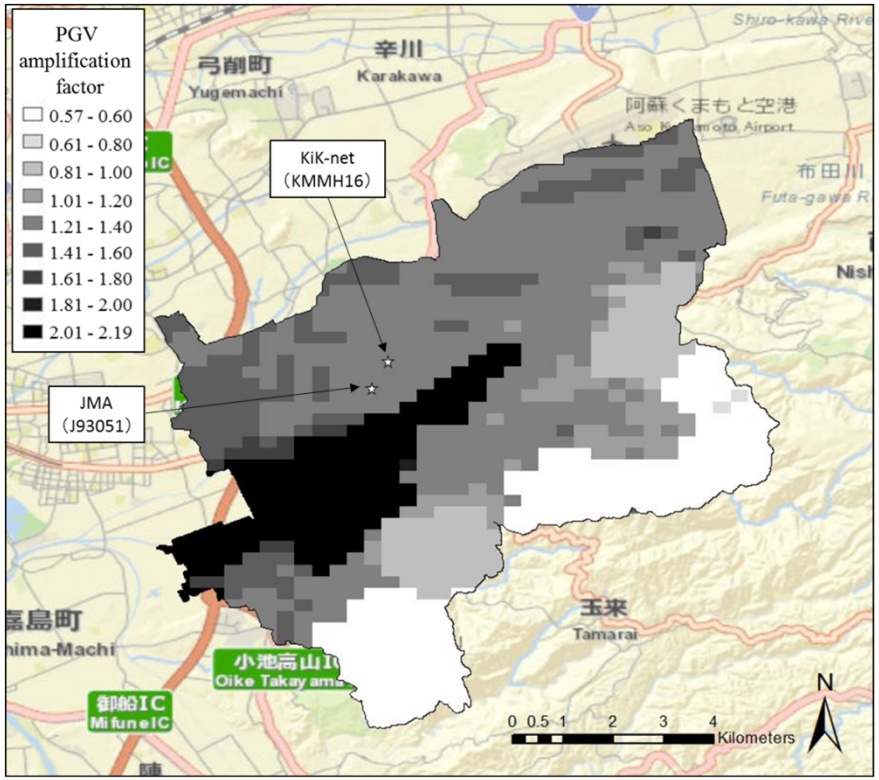
Compares the major damage ratio class for wooden buildings with respect to the construction period for four different datasets in Japan



Estimated peak ground velocity (PGV) distribution and site amplification ratio in a 250-m grid in Mashiki Town

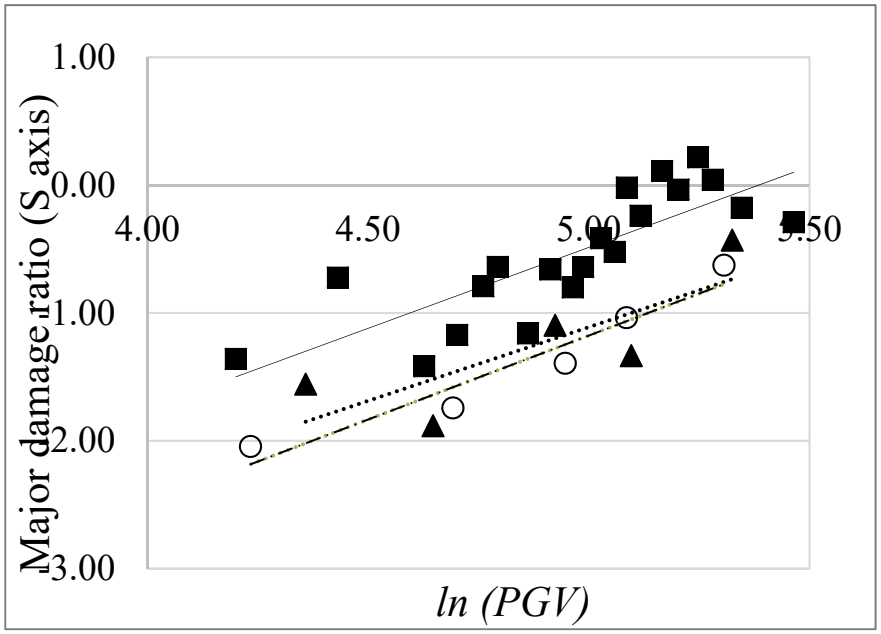


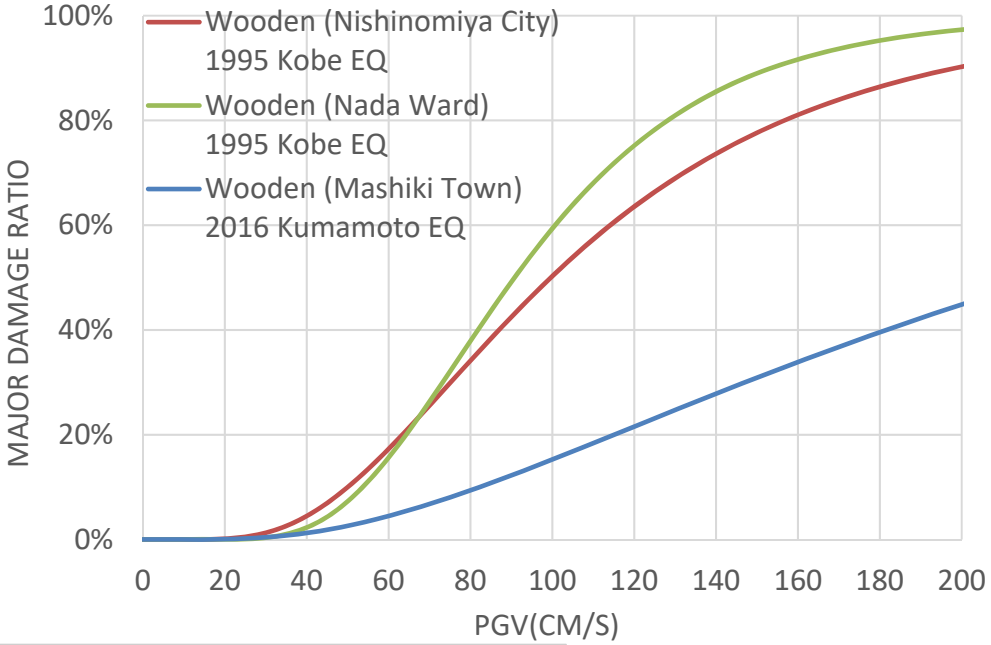
PGV (cm/s)

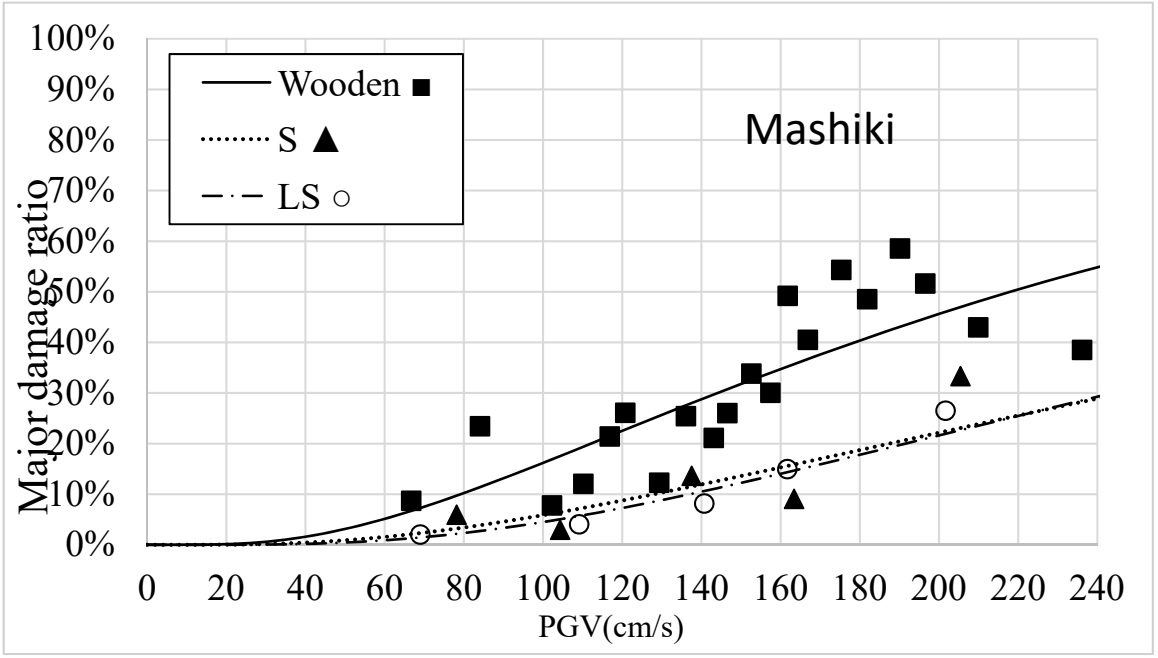


PGV Amplification Ratio

Development of fragility curves for Wooden, S and LS buildings

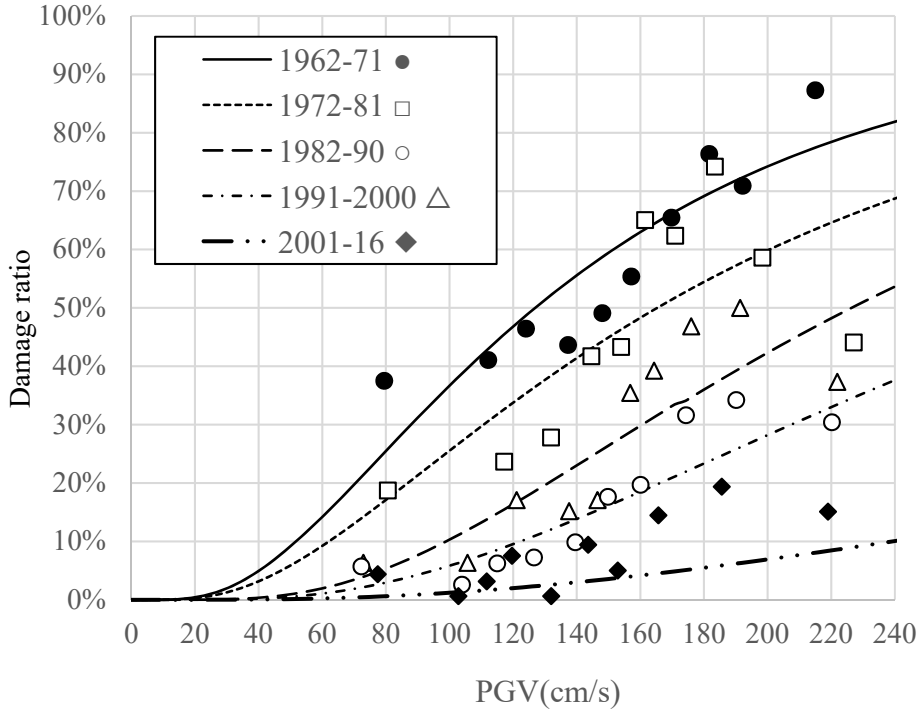


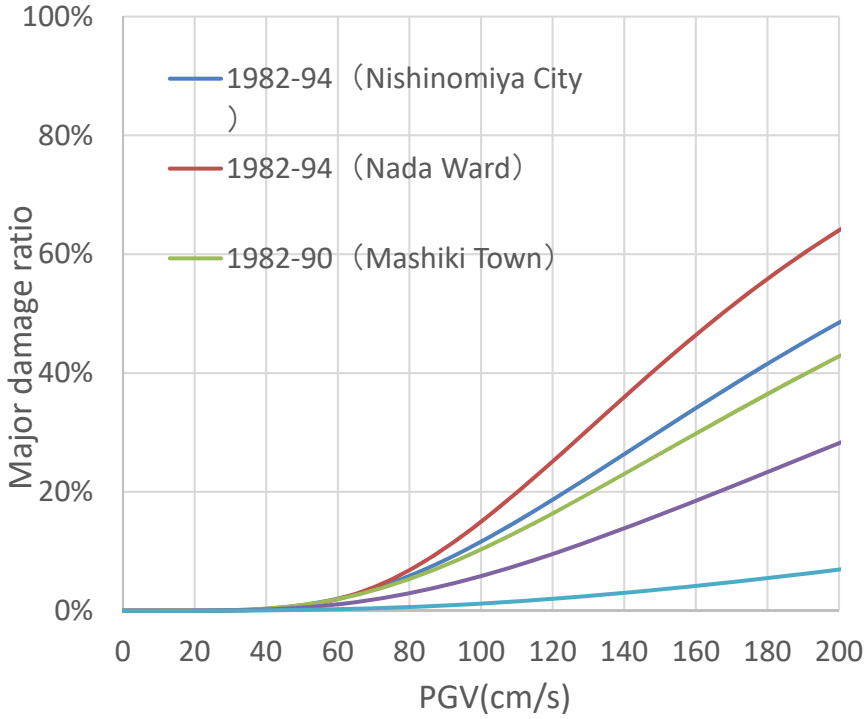




Development of fragility curves for wooden buildings in Mashiki town with respect to the construction period

Major damage





Conclusions

- Building damage data surveyed by Mashiki Town Government were analyzed with respect to the structural material and construction period.

- The damage ratios of buildings in Mashiki Town were similar levels with those in Nada Ward due the 1995 Kobe earthquake.

- Fragility curves were developed for wooden buildings for different construction periods corresponding the revisions of seismic code in Japan. The developed curves are recommended to use for damage assessment of future earthquakes in Japan.


Thank you very much!