



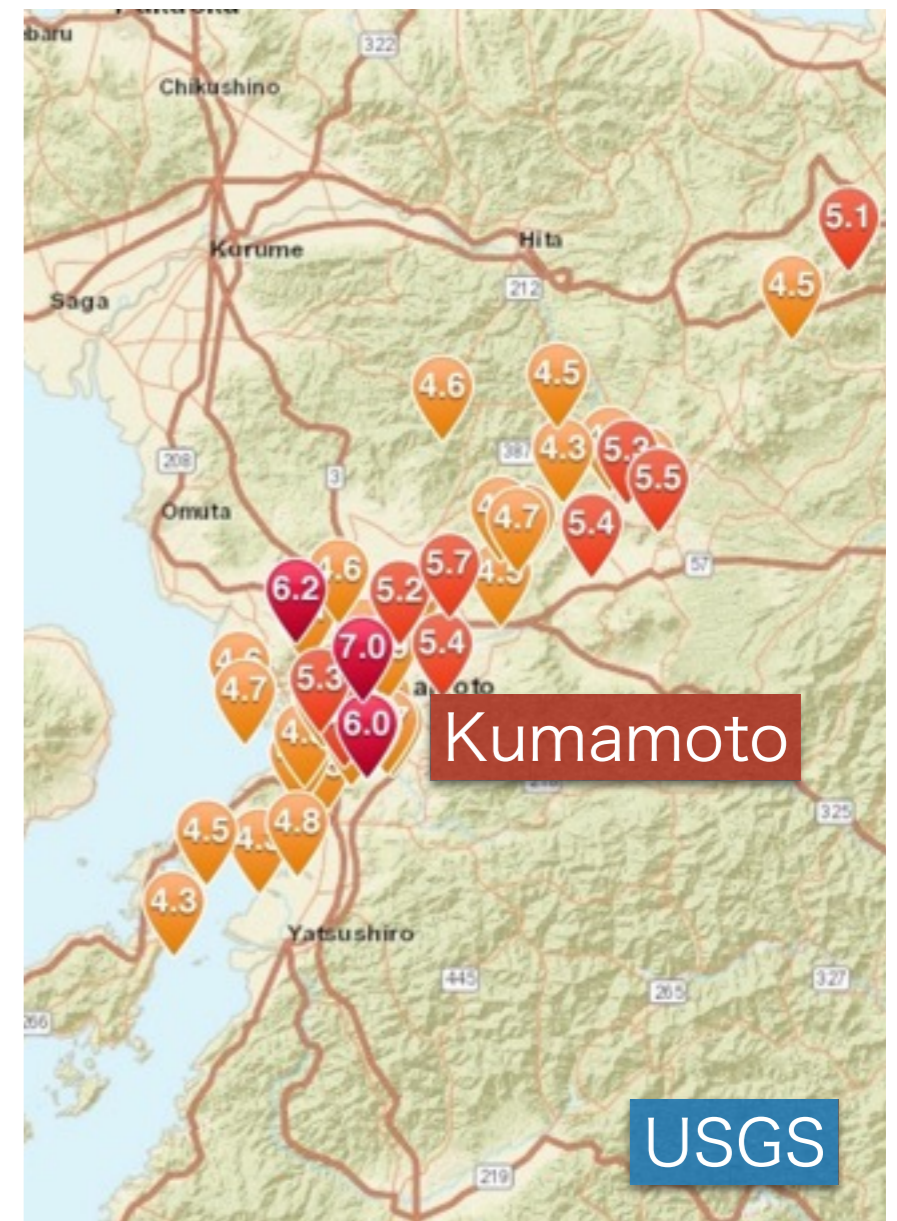
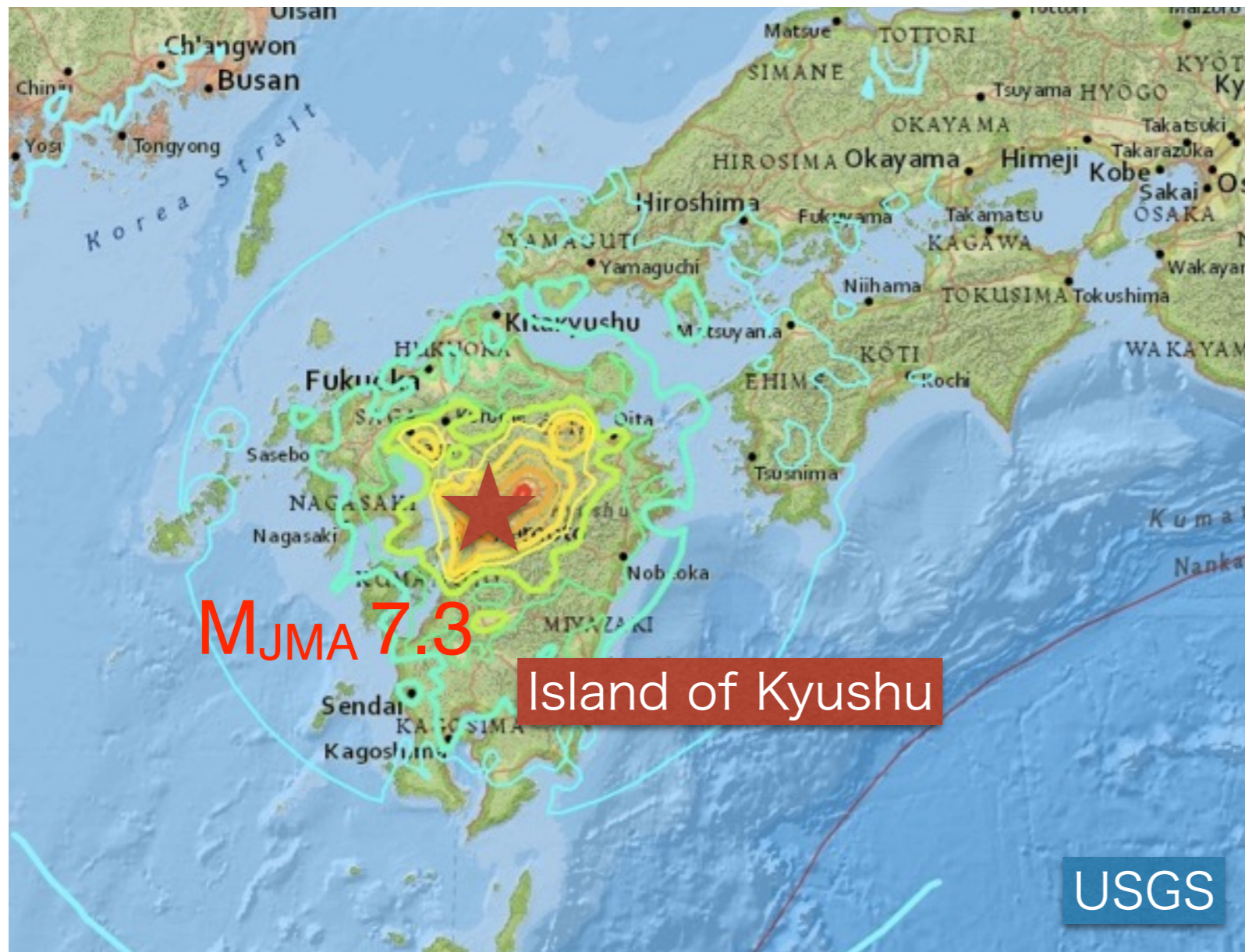
Spring 2016 / Milwaukee

Preliminary Reconnaissance on RC Building Damage by the 2016 Kumamoto Earthquake

Presented by

H. Shiohara PhD, FACI
Professor, the University of Tokyo

2016 Kumamoto Earthquake



Foureshocks

April 14, 21:26 JST MjMA 6.5

April 16, 00:03 JST MjMA 6.0

Mainshock

April 16, 01:25 JST MjMA 7.3

5 days count

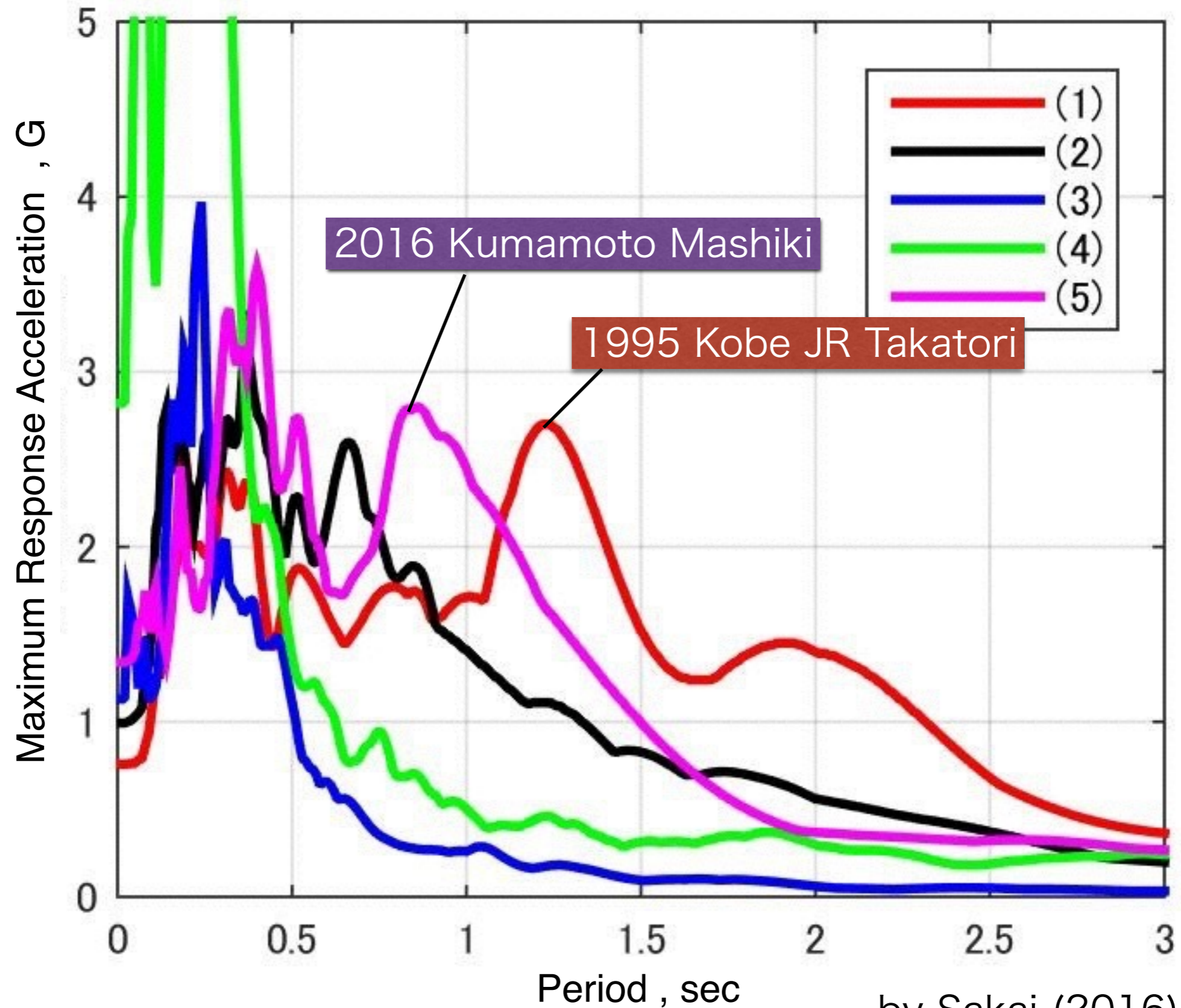
M > 7: 1

7 > M > 6: 3

6 > M > 5: 10

14 in total

Maximum Acc. Response Spectrum



Land slide - Aso





Fallen bridge - Aso

Slope failure of historic civil infra

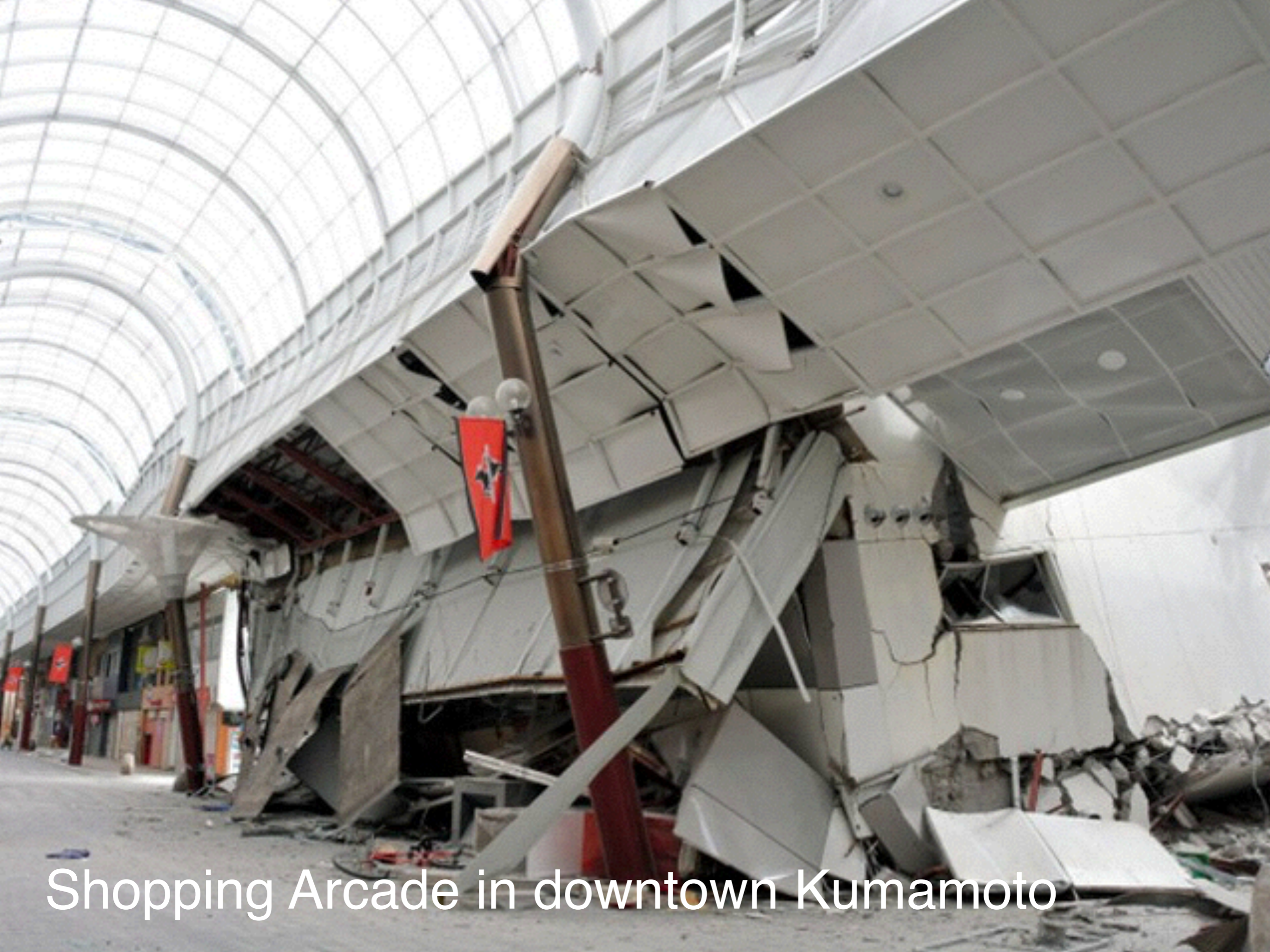




Derailed Shinkan-sen Train

Building collapse





Shopping Arcade in downtown Kumamoto

Revisions of Japanese seismic provisions in codes

1968 1971

1978 1981

1995

2000

2011

● 1968 Tokachi-oki Earthquake

*BSL : Building Standard Law

● Amendment of BSL Enforcement Order

(Prevention of column shear failure)



● 1978 Miyagiken-oki Earthquake

● Amendment of BSL Enforcement Order

(The “shin-taishin”, new standard)



● 1995 Hyogo-ken Nambu Earthquake

(Effectiveness of the 1981 revision was confirmed)

● Act on Promotion of Seismic Retrofitting of Existing Buildings

(To urge building owners to retrofit existing vulnerable buildings)

● 2000 Amendment of BSL Enforcement Order

(Performance based criteria introduced)

I
~ 1971

II
~ 1981

III
1981 ~

● 2011 Tohoku-chiho Taiheiyo-oki Earthquake

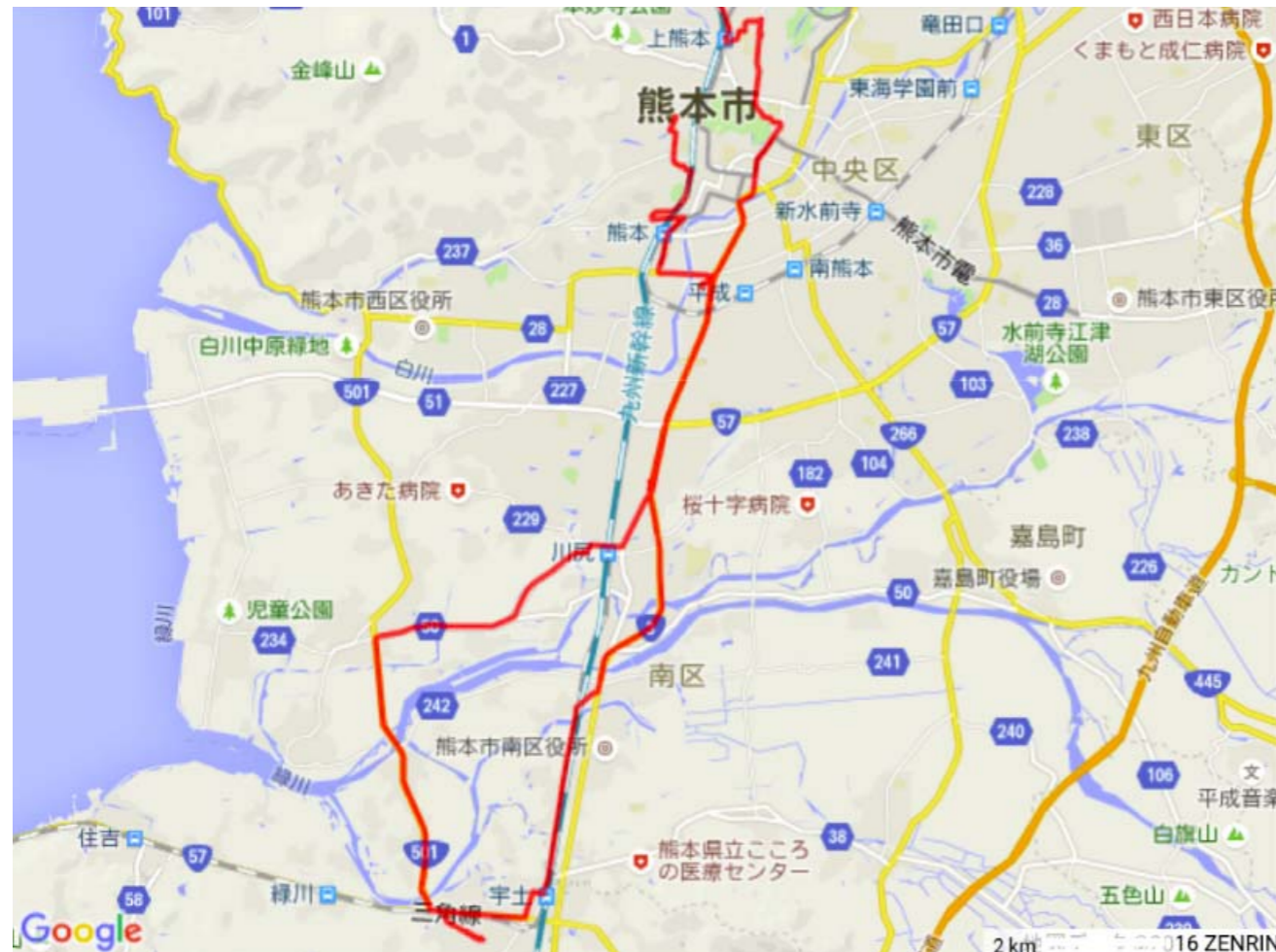
Reconnaissance Team

Two day preliminary reconnaissance
on April 16 & 17.

- *S. Tajiri* (the University of Tokyo)
- *F. Kusuhara* (the University of Tokyo)
- *T. Kabeyasawa* (Metropolitan University of Tokyo)
- *Trivedi Shubham* (Graduate student)
- *Hu Hun-Feng* (Graduate student)

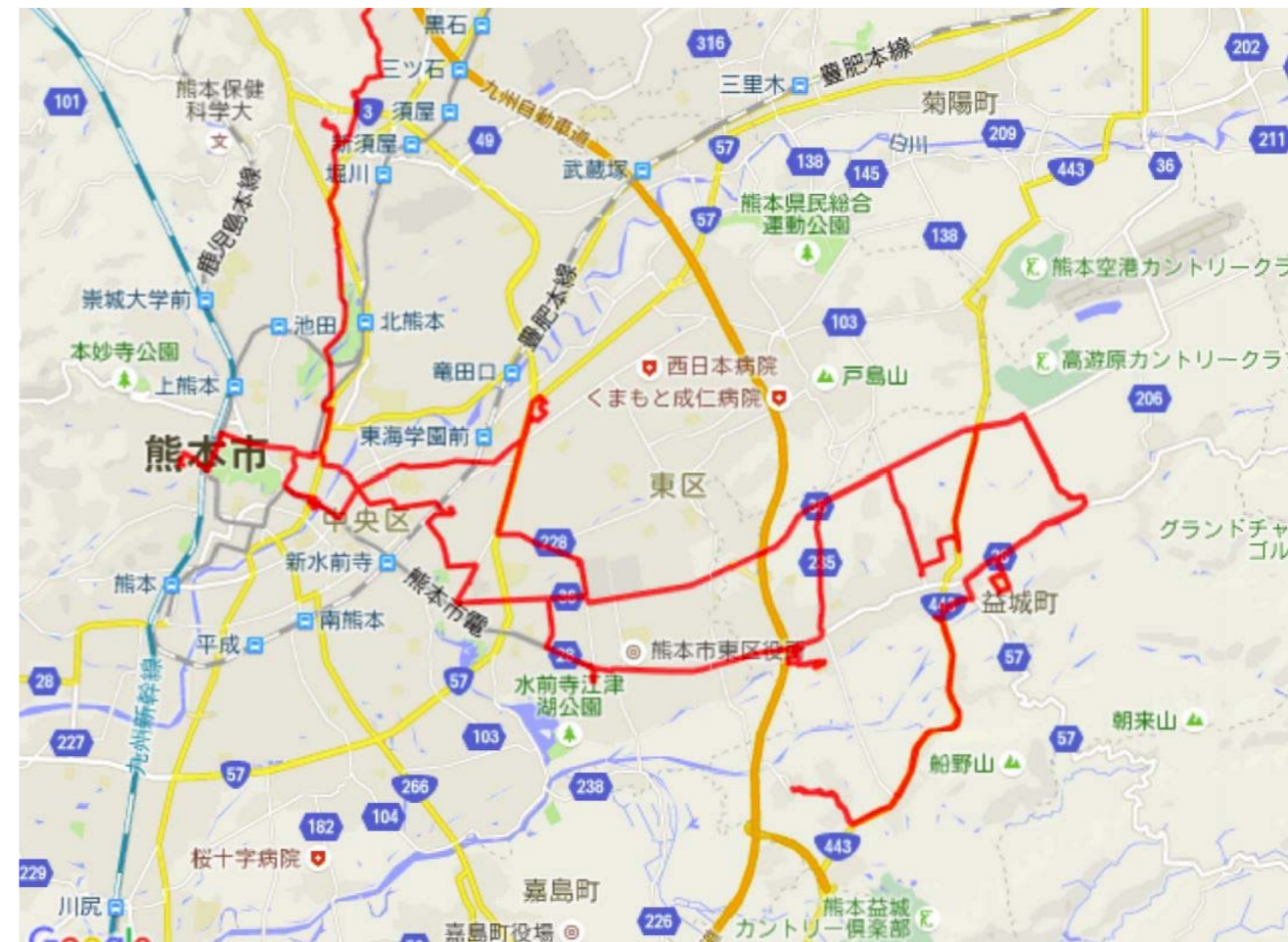
Reconnaissance Route

Day1: April 16, 2016



Kumamoto City

Day 2: April 17, 2016



Kumamoto City and Mashiki Town

Day 1: RC 7-story Residential Bldg (1974) Collapse Soft First Story



Day 1: RC 7-story Residential Bldg (1974) Collapse Soft First Story



Day 1: RC 7-story Residential Bldg (1980) Moderate Damage



Day 1: RC 14-story Residential Bldg (1980) Moderate Damage



Day 1: RC 3-story Office Bldg (approx. 1965) Collapse at 1st story



Day 1: RC 5-story Office Bldg (approx. 1965) Collapse at 4th story



Day 1: RC 5-story Office Bldg (approx. 1965) Collapse at 4th story



Day 1: RC 11-story Residential Bldg Minor damage





Day 2: RC 5-story Fire department training facility (1998) Severe damage



Day 2: RC 3-story School bldg (1981) Seismic Retrofitted



Day 2: RC 4-story Commercial bldg (1981) Collapse



Day 2: RC 6-story Commercial & Residential Complex (1970) Collapse



Day 2: RC 5-story Commercial & Residential Complex (1977) Collapse



Day 2: RC 3-story Dental Office Collapse



Concluding Remarks

- 42 dead (as of April 19, building collapse, land slide)
- 110,000 displaced
- Most of the collapsed RC buildings are old ones.
- Minor damage to non-structural RC wall were to be easily found along the reconnaissance route
- Number of collapsed RC building could be more than that found by the two-day reconnaissance