SHAKING-INDUCED DAMAGE TO BUILDINGS BY M 9.0 EAST JAPAN MEGA EARTHQUAKE ON MARCH 11, 2011

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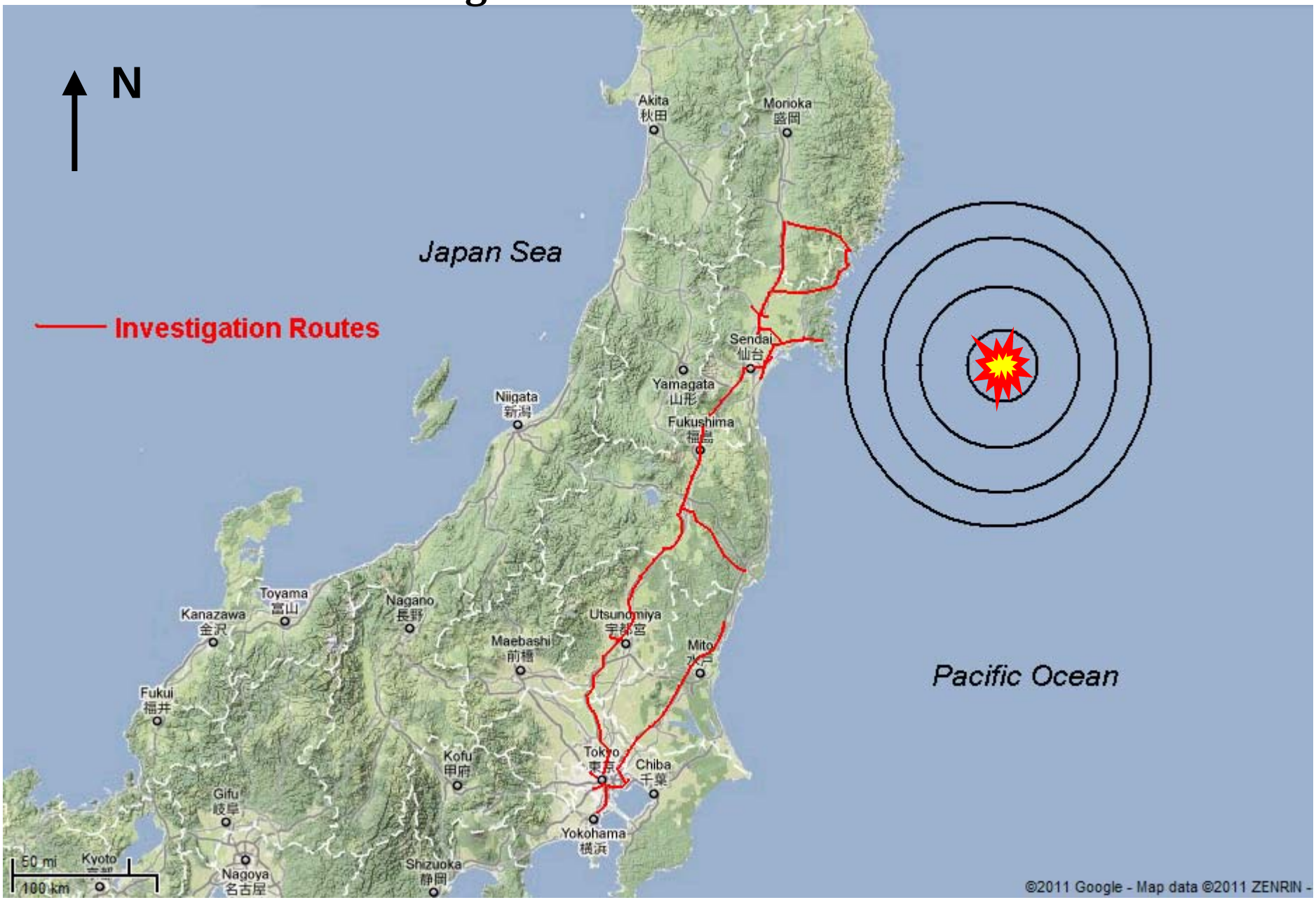
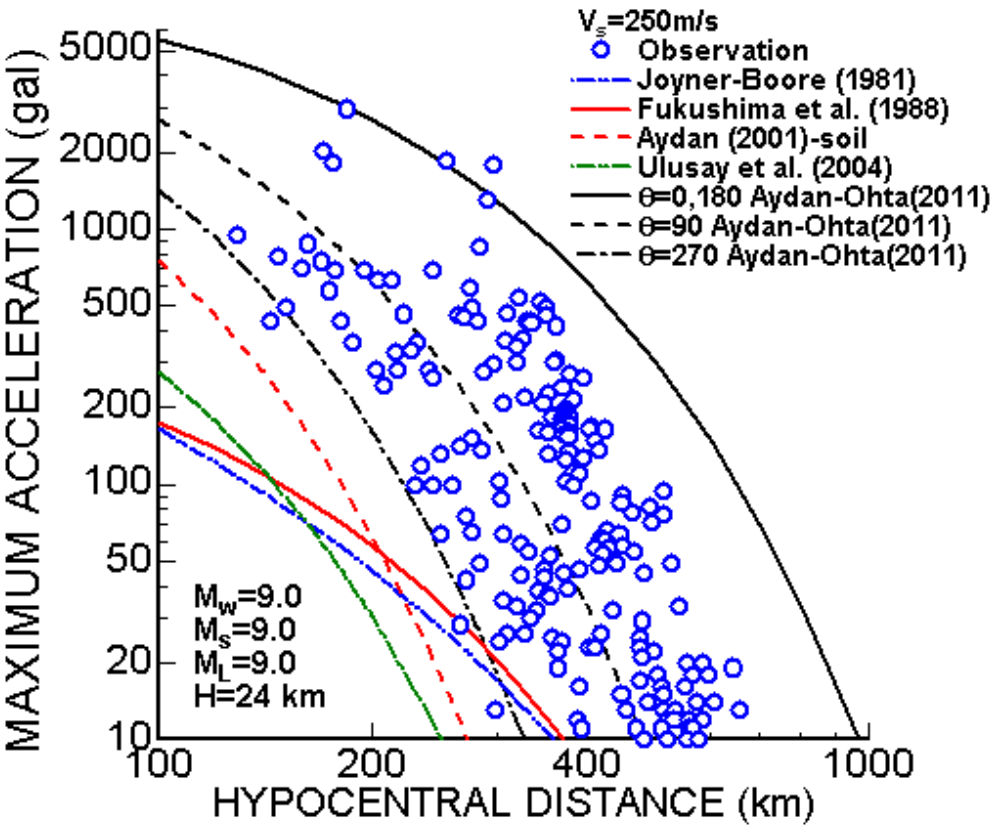
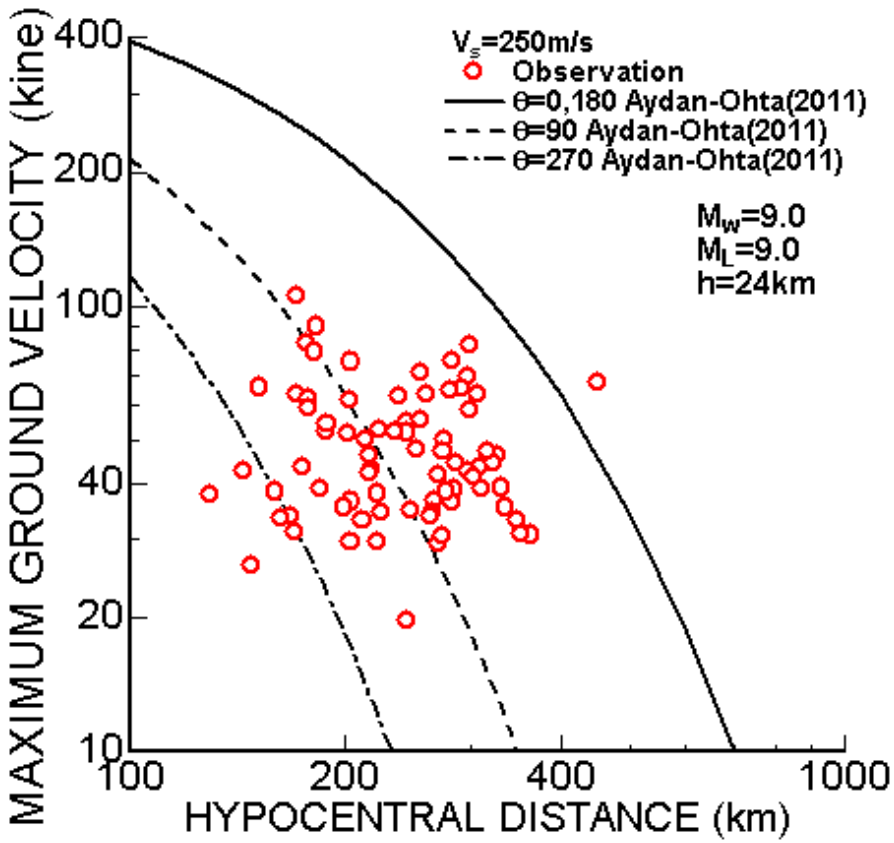
Investigation Routes



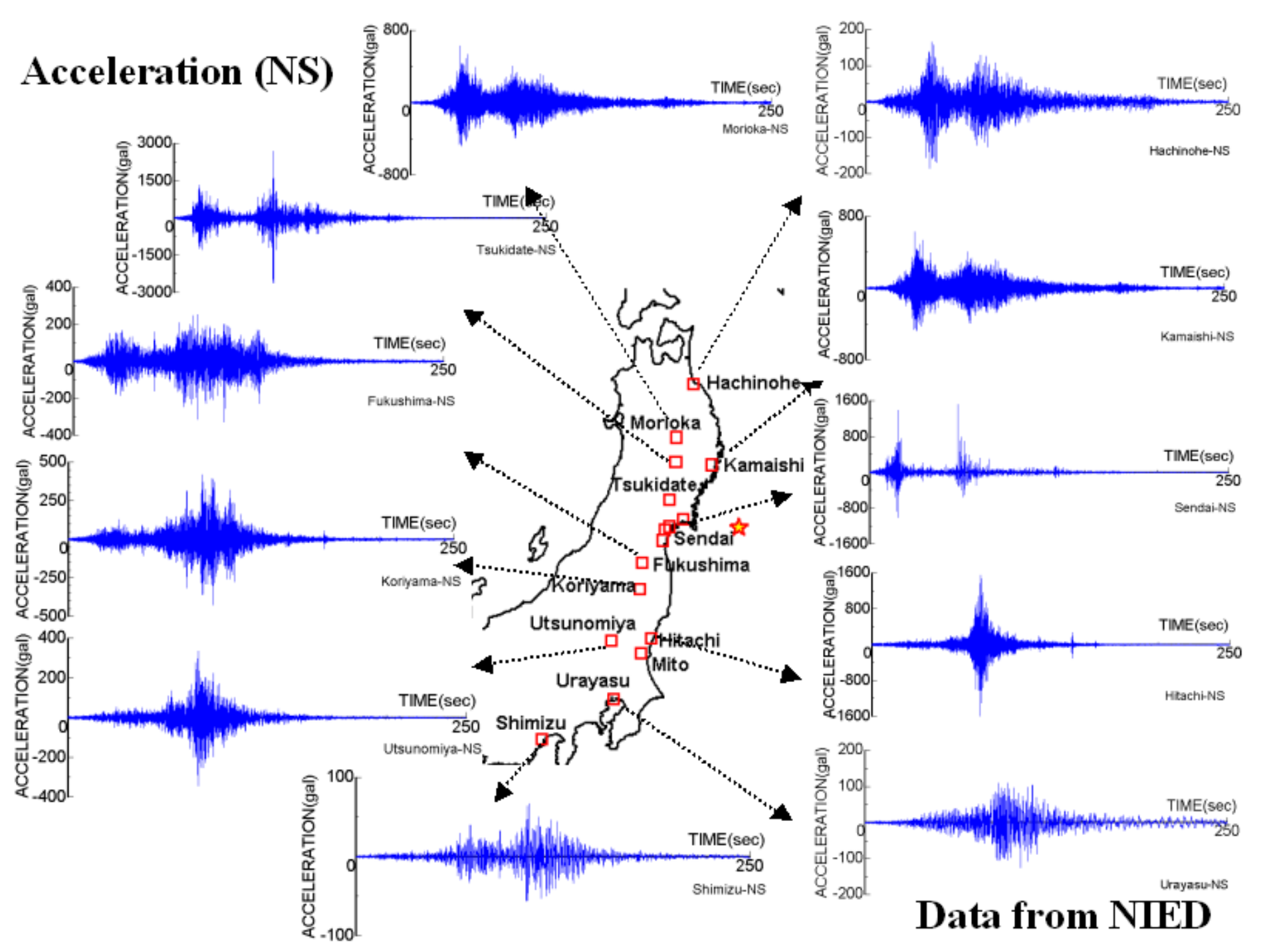
Modified from Google Map

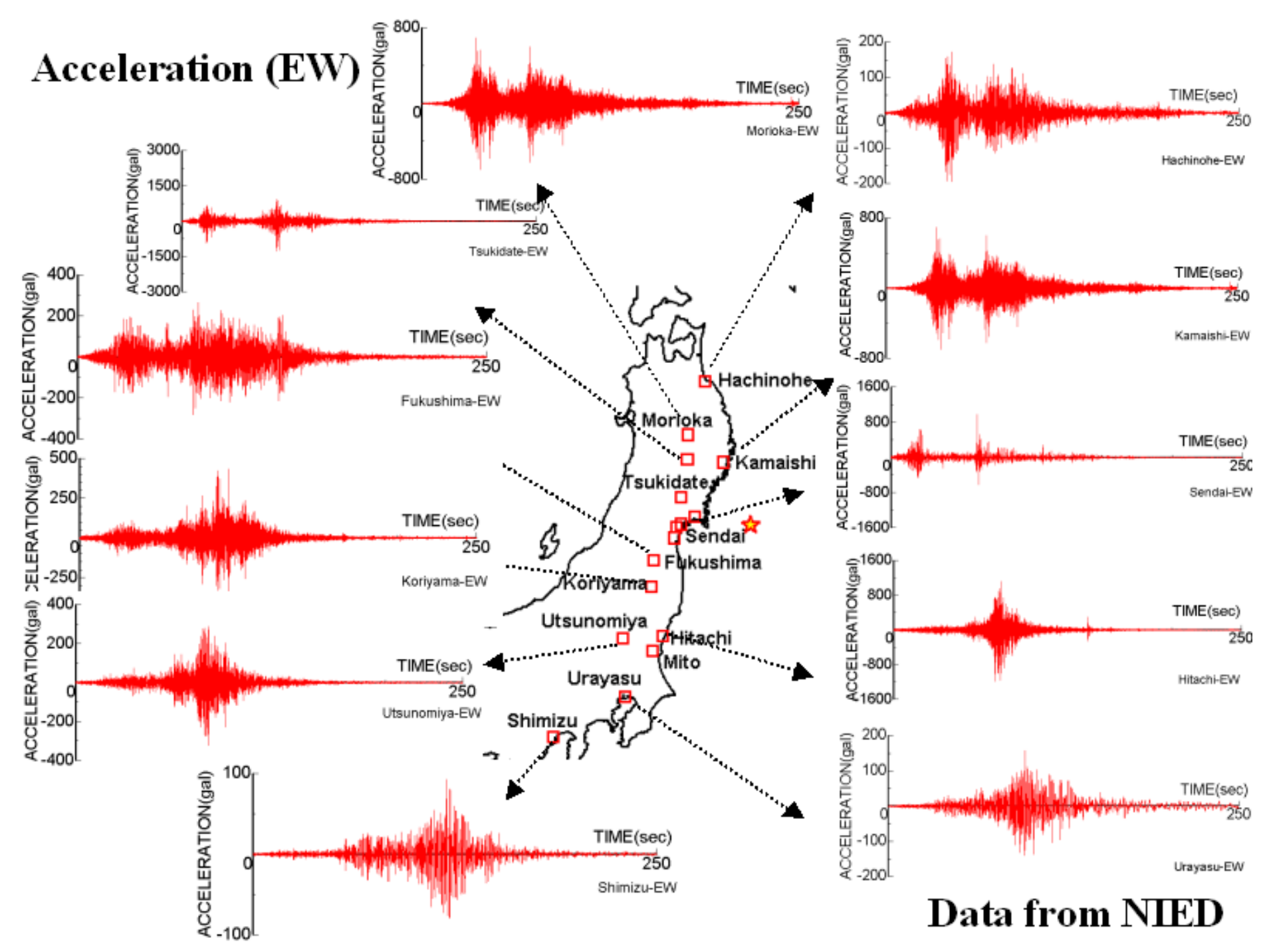
Strong Ground Motions





The most of current attenuation relations are incapable of estimating the attenuation of maximum ground motions except the one proposed Aydan and Ohta (2011).


Acceleration (NS)
ACCELERATION(gal)
TIME(sec)
250
Morioka-NS
Tsukidate-NS
Fukushima-NS
Koriyama-NS
Utsunomiya-NS
Shimizu-NS
Hachinohe-NS
Kamaishi-NS
Sendai-NS
Hitachi-NS
Urayasu-NS
Hachinohe
Morioka
Kamaishi
Tsukidate
Sendai
Fukushima
Koriyama
Utsunomiya
Hitachi
Mito
Urayasu
Shimizu
Data from NIED


Acceleration (EW)
ACCELERATION(gal)
TIME(sec)
Morioka-EW
Tsukidate-EW
Fukushima-EW
Koriyama-EW
Utsunomiya-EW
Shimizu-EW
Hachinohe-EW
Kamaishi-EW
Sendai-EW
Hitachi-EW
Urayasu-EW
Hachinohe
Morioka
Kamaishi
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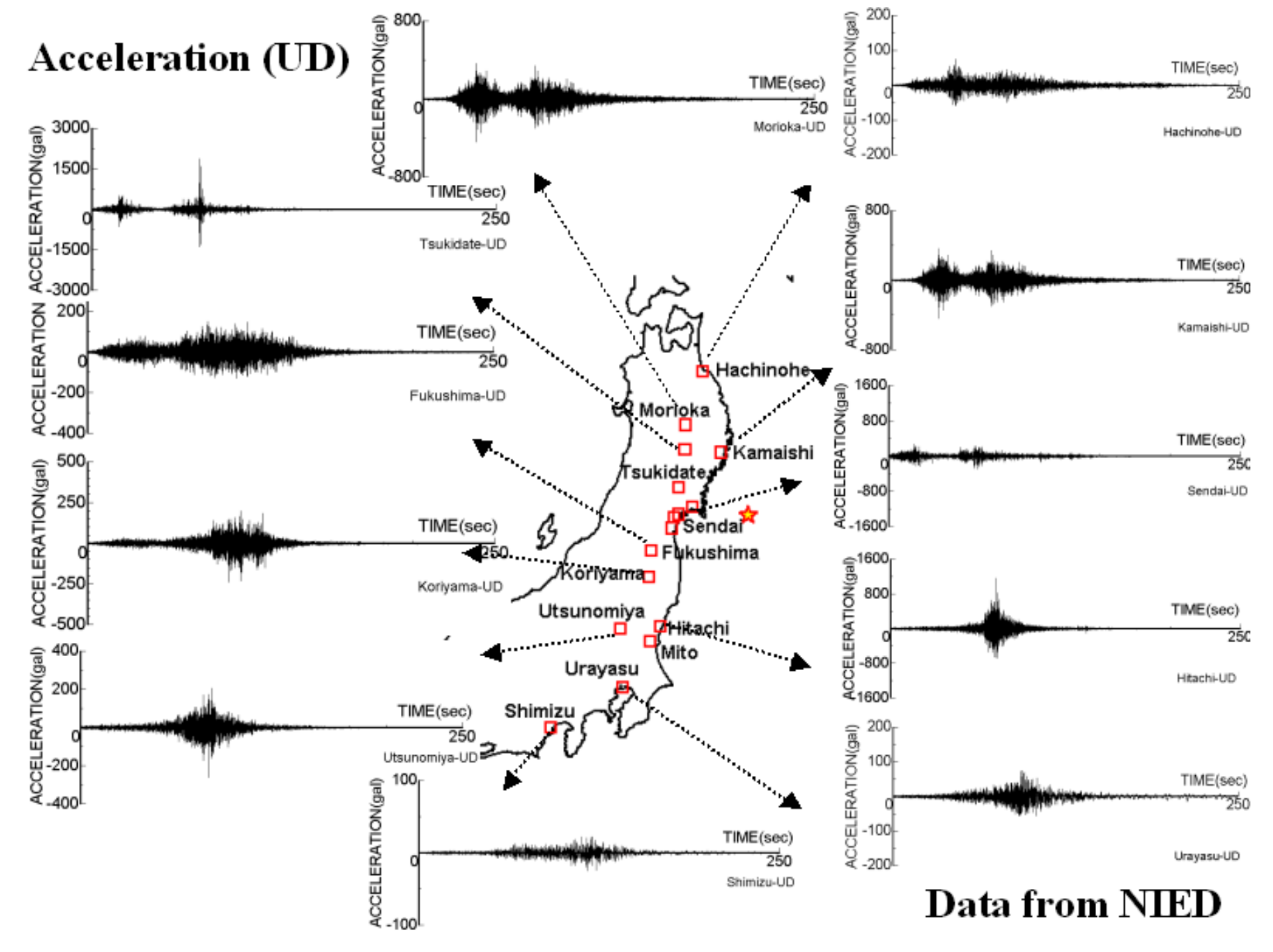
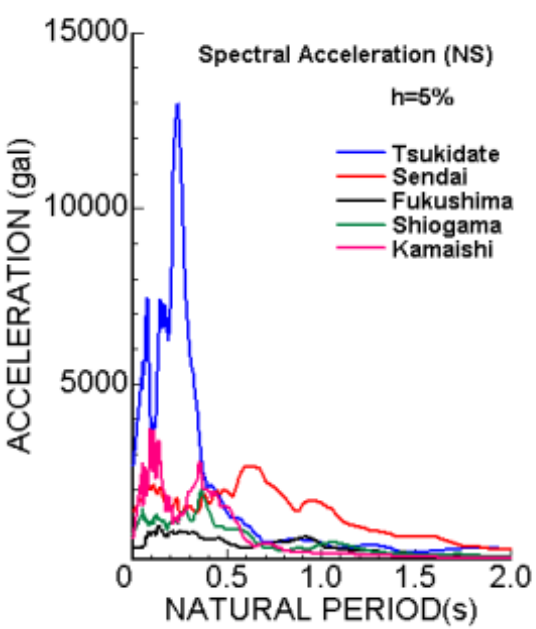
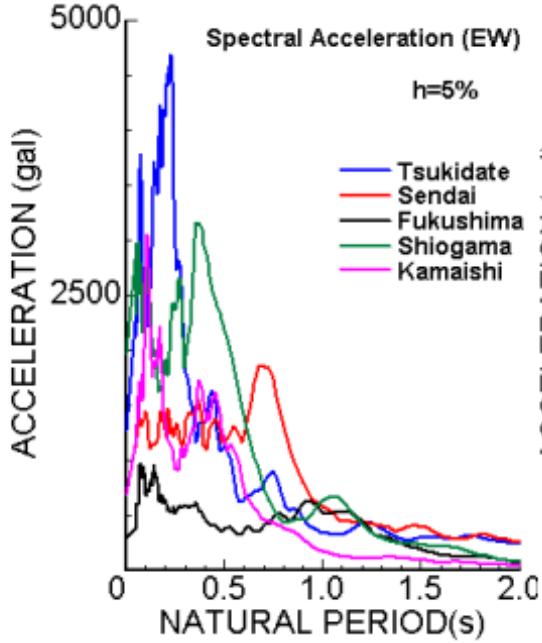
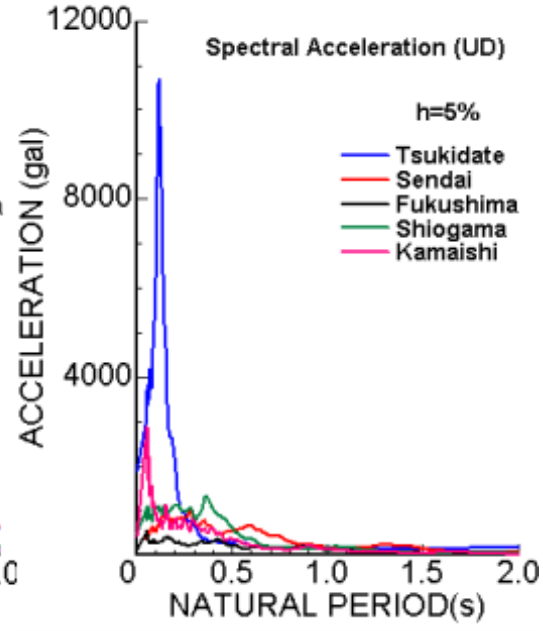
Sendai
Fukushima
Koriyama
Utsunomiya
Hitachi
Mito
Urayasu
Shimizu
Data from NIED

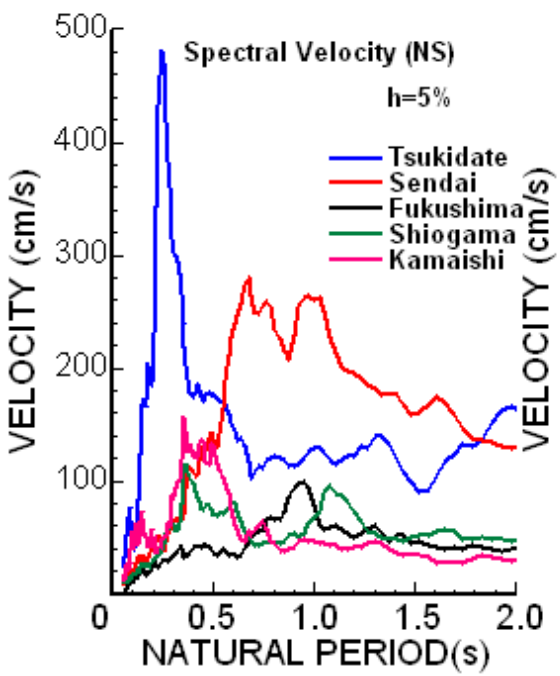

Acceleration (UD)
ACCELERATION(gal)
TIME(sec)
Morioka-UD
Tsukidate-UD
Fukushima-UD
Koriyama-UD
Utsunomiya-UD
Shimizu-UD
Hachinohe-UD
Kamaishi-UD
Sendai-UD
Hitachi-UD
Urayasu-UD
Hachinohe
Morioka
Kamaishi
Tsukidate
Sendai
Fukushima
Koriyama
Utsunomiya
Hitachi
Mito
Urayasu
Shimizu
Data from NIED

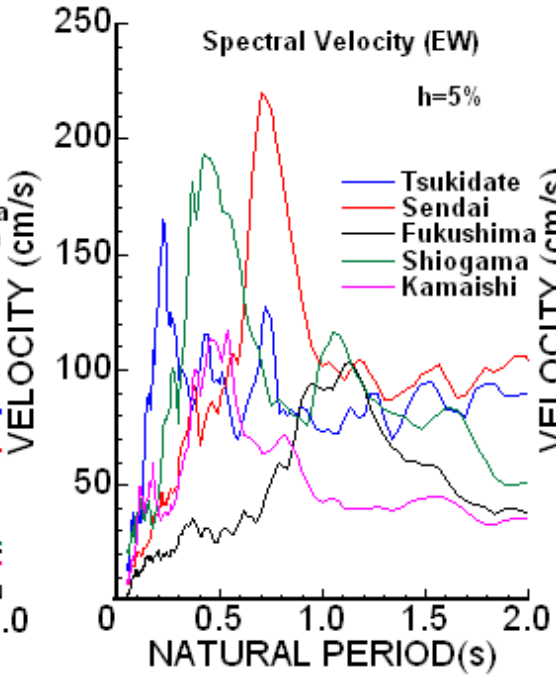
Acceleration and Velocity Spectra of Records at Selected Stations

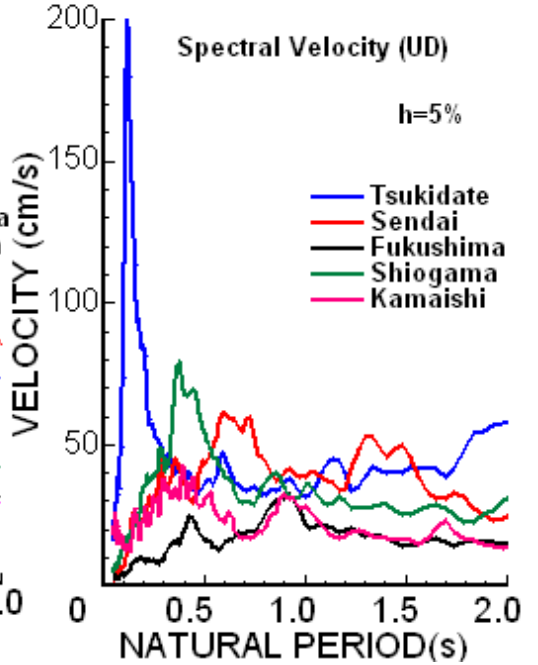












Building Types

1) **Timber Residential Houses**
2) **Masonry Storage Buildings**
3) **Reinforced Concrete (RC) Buildings**
4) **Steel-framed Buildings**

Damage to Timber Houses

Koriyama

Very old timber houses are generally collapsed.

Damage is generally limited to roof with tiles (kawara).

Timber residential houses performed well against ground shaking.

Damage to timber houses occurred built on a soft ground or nearby creeks or rivers.

Damage to Masonry Buildings

Damage is generally limited to roof with tiles.
As the number of masonry buildings are few, no major collapses were observed

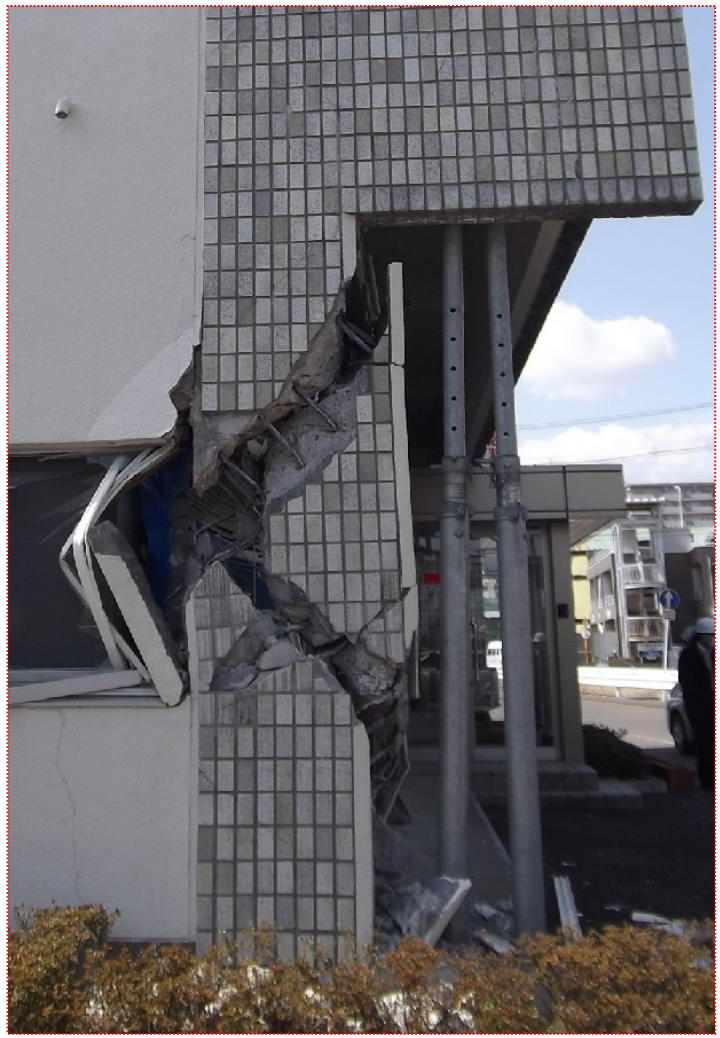
Damage to Reinforced Concrete (RC) Buildings

The damage to buildings due to ground shaking is quite limited. There are some completely collapsed RC buildings constructed before 1978 code revision. Some damage to buildings is also due to ground liquefaction in alluvial ground. These buildings are only limited to Sendai City and a few in Sukagawa and Fukushima Cities.

Completely collapsed RC building

Sendai

Heavily damaged RC building in Sendai



Damage to Retrofitted RC Building of Tohoku University for Civil and Architectural Departments

Damage is concentrated at the interface between 2nd and 3rd Floor

Slightly damaged RC building (Sendai)

Slightly damaged RC buildings (Koriyama)

Tilted RC building due to heavy ground liquefaction in Sendai

Tilting is about 2 degrees

RC buildings damaged due to ground shaking and ground liquefaction in Sendai City

Buildings tilted due to pile damage in liquefied ground

Tilting and settlement damage to RC buildings in Shin-Urayasu

Tilted and displaced RC building due to lateral spreading in Tokai Mura

Damage to Steel-Framed Buildings

Damage is generally caused by the fall of wall infill panels due to ground shaking

ACKNOWLEDGEMENTS

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