Application of Seismic Observation Data in Borehole for the Development of Attenuation Equation of Response Spectra on Bedrock

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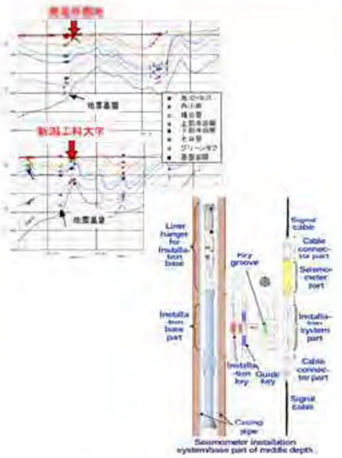
Background

- It is important to develop an attenuation relation for evaluating the strong motion on rock sites directly.
- So far, since the strong motions on bedrock have rarely been observed directly, it is difficult to develop an attenuation relationship on bedrock.
- However, recent vertical array, such as KiK-net, SOBD in Kashiwazaki provides us opportunity to estimate ground motion on bedrock.



SOBD in Kashiwazaki (Wu, 2010)

Development of GMPE for response spectra on bedrock based on the observation data at deep borehole

Selection of Earthquakes and records

↓

KiK-net borehole stations down to bedrock with Vs over about 2km/s (Identification of the substructure for each station)

↓

Strong motion on bedrock based on the borehole records

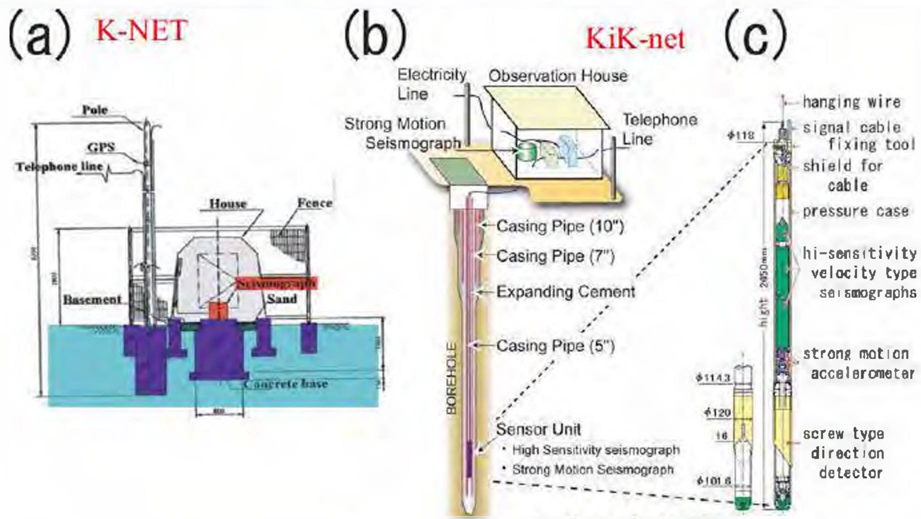
↓ ← Calculation of GMRotI50; ← +RK-net、Dam、F-net

Database of strong motion on bedrock

↓ ← Characteristics of strong motion on bedrock

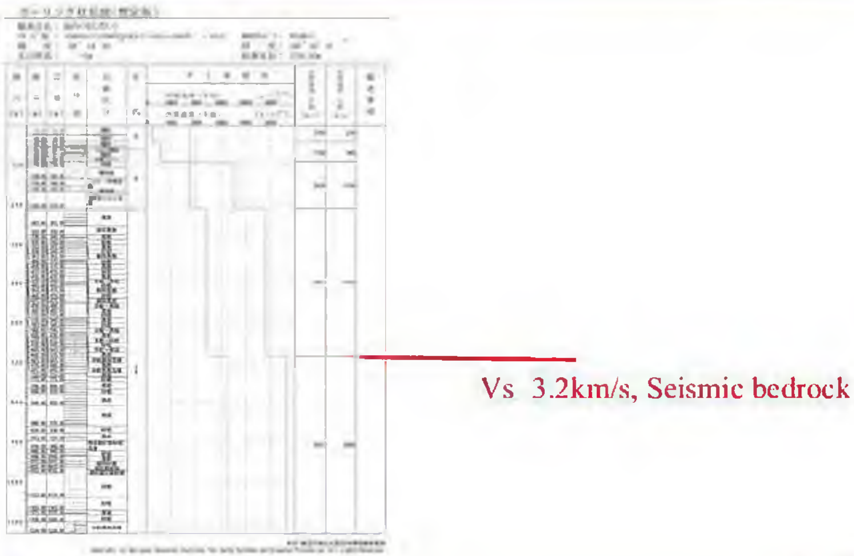
Development of Attenuation equation on bedrock

Strong motion observation on bedrock operated by NIED

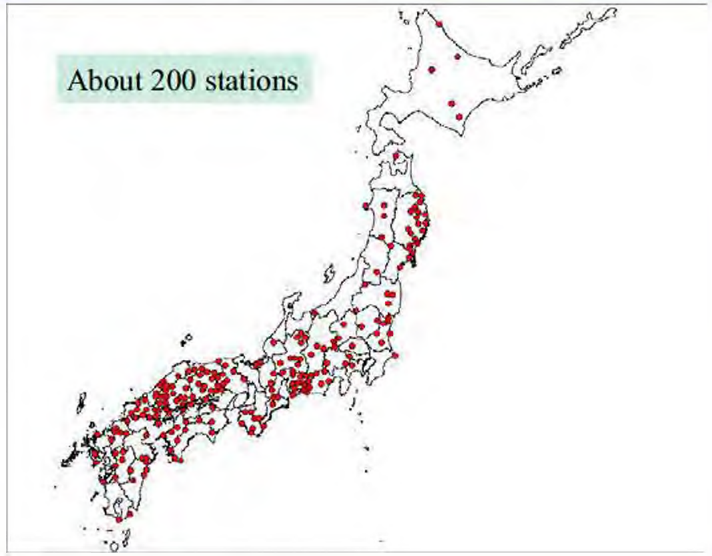


Aoi et al. (2004)

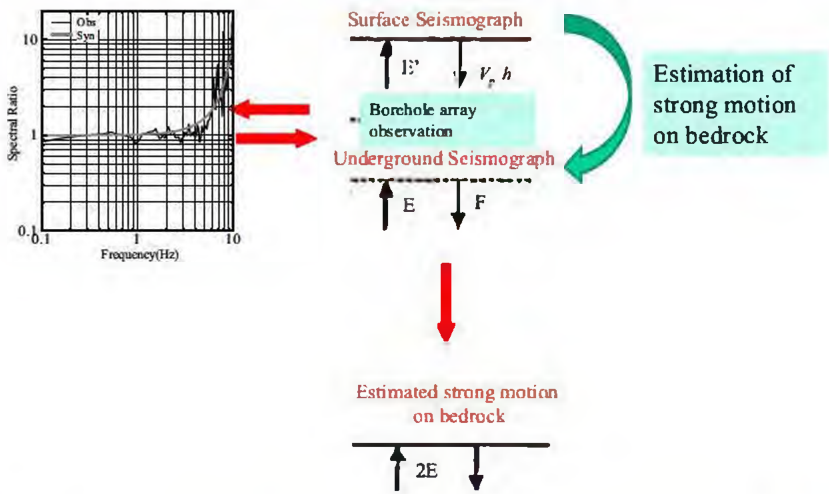
Example of the profile for observation station of KiK-net: MYGH01



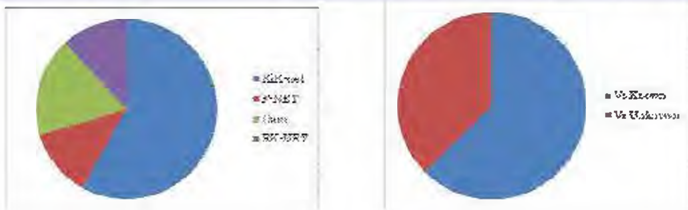
Observation stations of KiK-net with Vs of bedrock over 2km/s

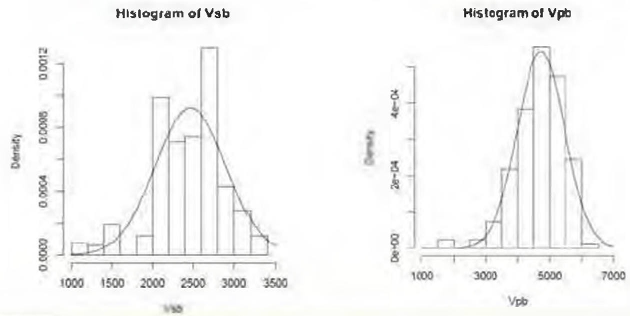


Estimation of strong motion on bedrock based on borehole data



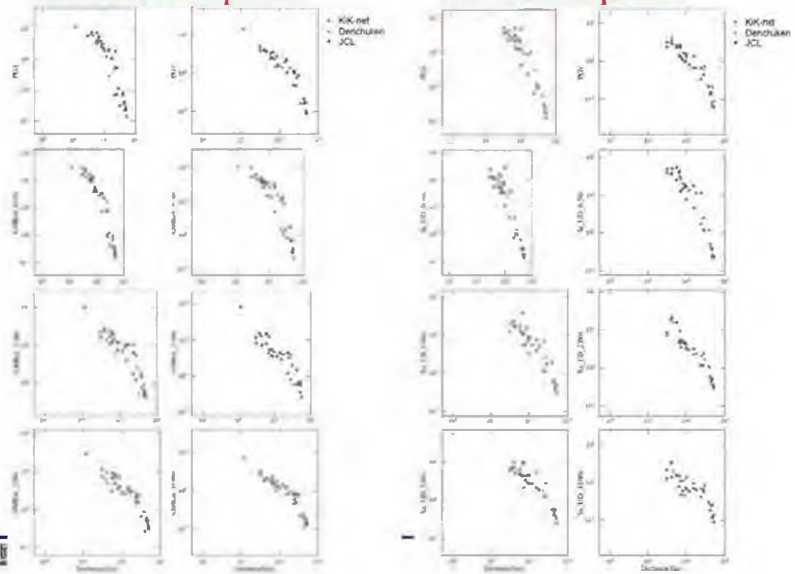
Category of the site conditions in the database



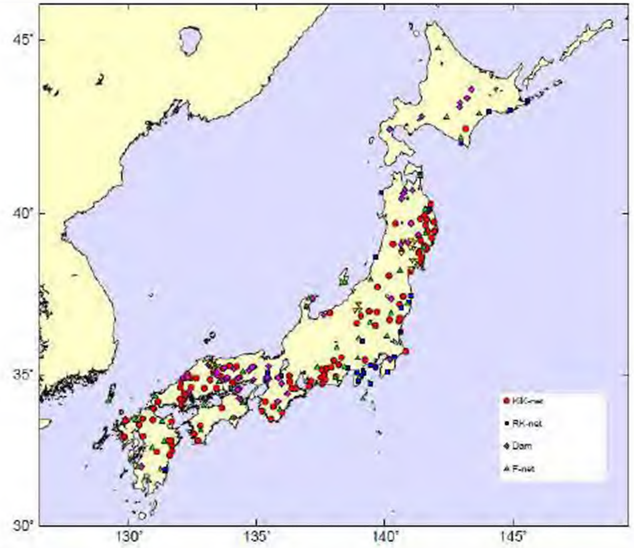


Characteristics of PGA, PGV and GMRotI50 on bedrock: the case for 2008 Iwate･Miyagi earthquake

Horizontal component — Vertical component

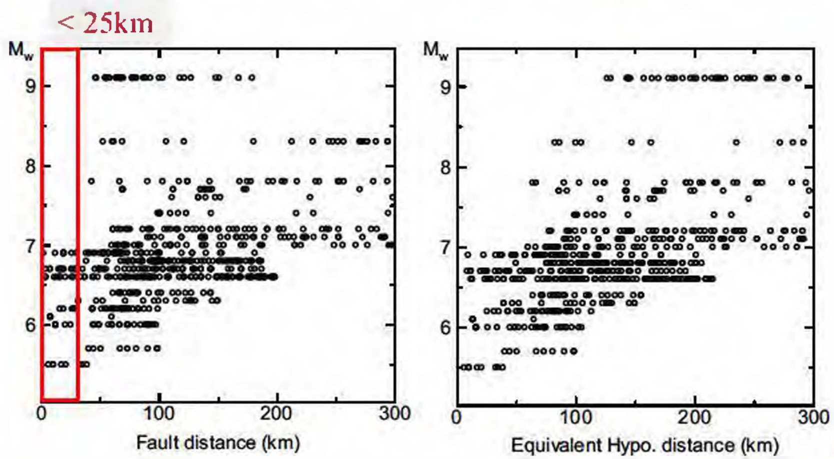


Distribution of observation stations used in this study



Distribution of Mw-Distance

Combined with the data from RK-net、Dam obs. Network, and F-NET, we derived an strong motion observation database on bedrock



The 2nd Workshop on Seismic Observation in Deep Borehole (SODB) and its Applications

Formulation of the GMPE on bedrock

$$\log A(T) = b(T) + g(X) - kX$$
$$A(T): GMRoTI50, PGA, PGV$$

$$g(X) = \begin{cases} -\log(X+C); D \le 30km \\ 0.6\log(1.7D+C) - 1.6\log(X+C); D > 30km \ \& \ X \ge 1.7D \end{cases}$$

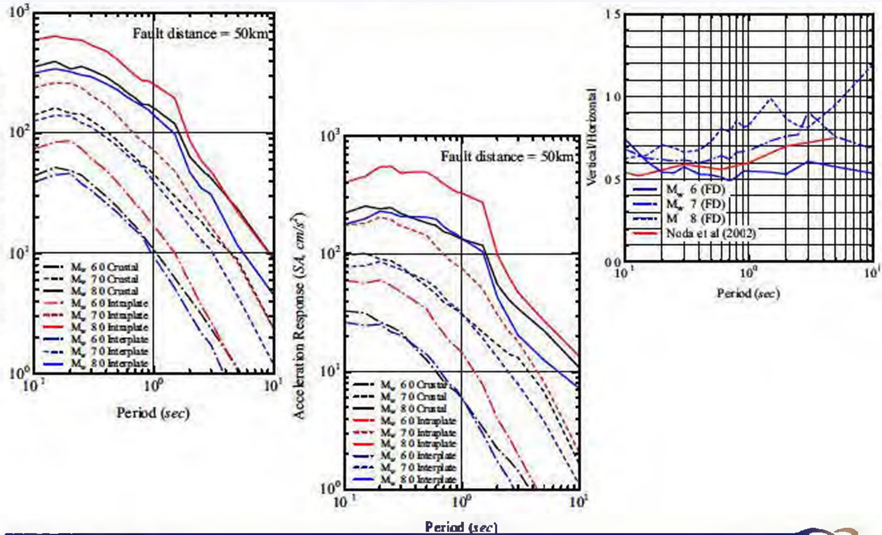
$$C = 0.0055\ 10^{0.5M_w}, T < 0.5s$$
$$= 0.0028\ 10^{0.5M_w}, T \ge 0.5s$$
$$k = 0.003, T < 0.5s$$
$$= 0.002, T \ge 0.5s$$

$$b(T) = \begin{cases} a_1(T)M_w + \sum d_i(T)S_i + h(T)D + \varepsilon_1(T) \\ a_2(T)M_w + \sum d_i(T)S_i + h(T)D + \varepsilon_2(T) \end{cases} \begin{pmatrix} a_1(T), \varepsilon_1(T): M \le 8.3 or M \le 7.5 if T \ge 2s \\ a_2(T), \varepsilon_2(T): M > 8.3 or M > 7.5 if T \ge 2s \end{pmatrix}$$

X is distance, adopted as fault distance (FD) and equivalent hypo. Distance (EHD). C 0 for EHD

The equation is constrained by the data from earthquakes with magnitudes ranged from Mw 5.5-9.0

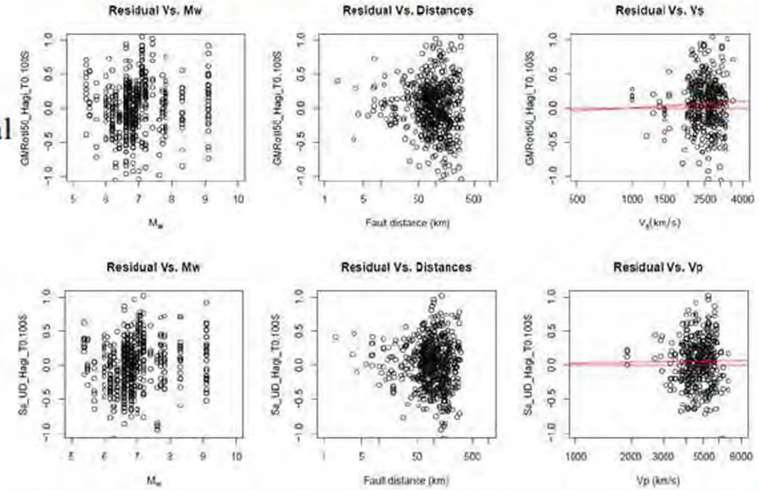
Predicted ground motion at distance of 50 km



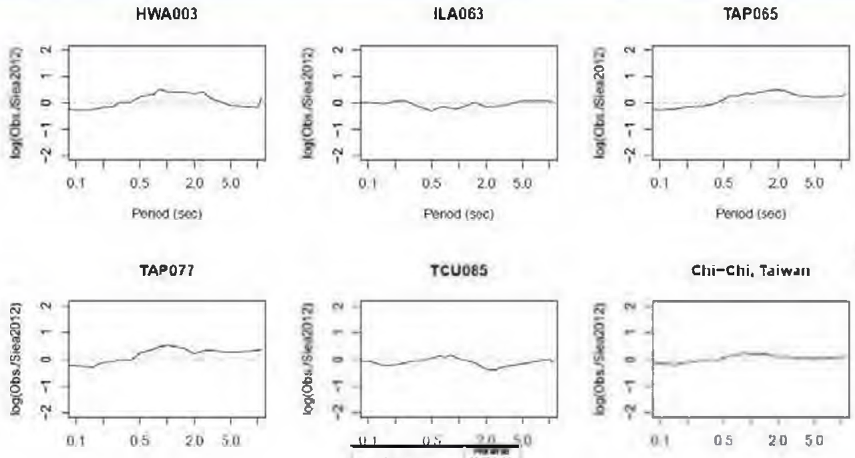
Residuals for response spectra at 0.1sec

Horizontal

Vertical

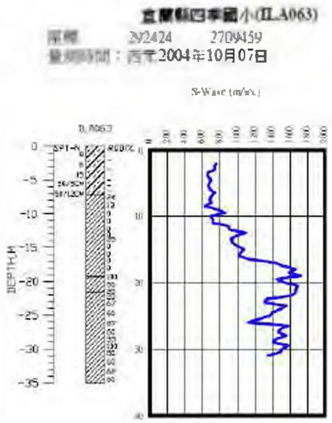


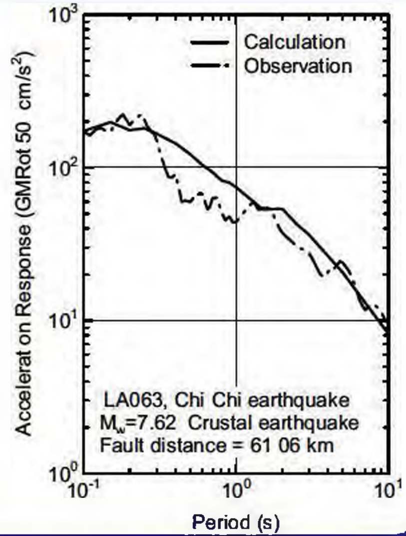
Application to M_w7.62 Chi-Chi earthquake



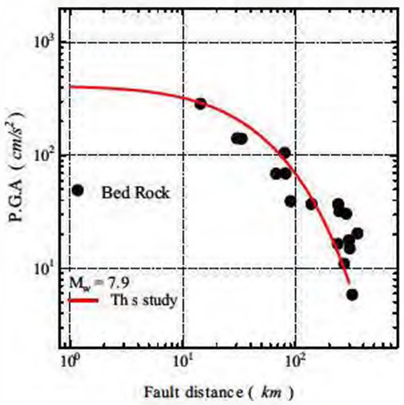
Station Name	[illegible] Vs30 (m/s)
[illegible]	1525.0
TAP065	1023.5
TAP077	1022.8
TCU085	[illegible]
ILA063	[illegible]

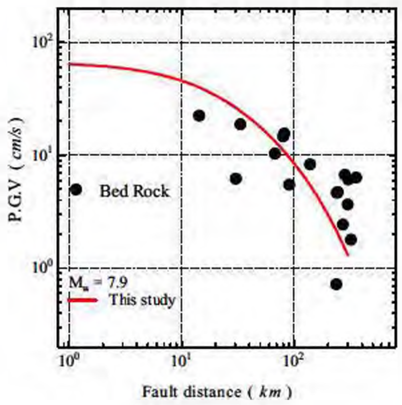
M_w7.62 Chi-Chi earthquake: ILA063





Application to M_w7.9 Wenchuan earthquake





Conclusion remarks

- We have constructed a database of strong motion on bedrock, including the data derived in the near source area. Based on this database, a new attenuation relationship of response spectra on bedrock in Japan is under developed.
- Comparing with the strong motion data observed in the other countries implicated that the preliminary results of GMPE developed in Japan are applicable to the earthquakes in the other countries.

Acknowledgement

- We thank NIED(National Research Institute for Earth Science and Disaster Prevention) for providing the strong motion observations by KiK-net, F-NET and K-NET, also the structure model nationwide on J-SHIS. The thanks also go to CRIEPI(Central Research Institute of Electric Power Industry), JCL(Japan Commission on Large Dams), NILIM(National Institute for Land and Infrastructure Management) and Miyagi county for providing the strong motion records. We thank Dr. Aoi, Dr. Kataoka, Prof. Koketsu, Dr. Miyake, Prof. Ohmachi, Dr. Shiba, and Dr. Tajima for their kind help.
- This study is a corporation with Prof. Midorikawa, Tokyo Tech., and funded by JNES (Japan Nuclear Energy Safety Organization).