Site effects in strong ground motions observed in the Fukuoka City downtown area during the 2005 Northwest off Fukuoka earthquake
- with special reference to the step-wise structure along the Kego fault -

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A very rare earthquake occurred on March, 20, 2005 30km offshore of Fukuoka City. This earthquake brought devastating damage to a small island called "Genkai-jima" (that is, a half of wooden houses inside the island were totally damaged), which is situated in the middle of the rupture zone. Despite of its magnitude (Mjma=7.0) this earthquake did not yield much damage to Fukuoka City. However, we have relatively heavy damage concentration in downtown Fukuoka, namely, Daimyo, Kego, and Imaizumi, west of Tenjin. For example we have two heavily damaged buildings in that area (although they are old) and several recently-constructed buildings are labeled as yellow, which means they have moderate damage. Apparently this anomalous distribution of damaged buildings may be related to the step-wise structure of surface quaternary layers along the Kego fault. In this study we use both strong motions FKO006 observed by K-NET, which was deployed by NIED, and those observed by Intensity Station at Chuo-ku (we call it FKOS01), which was deployed by Fukuoka City and Fukuoka Prefecture to quantify the effects of surface sedimentary layers.

There was a map of surface layers, called "Fukuoka ground map", published in 1981. One of the authors (H.K.) already constructed a sediment model in Fukuoka (Ito and Kawase, 2001). This sedimentary layered model shows drastic depth change along the Kego fault, about 40 to 50m deeper in the northeastern side. Based on a paper (Nakamichi and Kawase, 2002) for damage prediction, we have already predict high amplitude in the northeastern side of the Kego fault.

We use first K-NET station FKO006 to invert input motion at the engineering bedrock level. We use boring data (P-S logging) down to 2m. Then we assume that the bottommost layer of P-S logging continues down to the bedrock. We conducted 3D-FDM calculation based on Graves (1996) for NS and EW directions separately. Main axis is close to the North. PGA at FKO006 is 276.5Gal(NS 成分) and PGV at FKO006 is 55cm/s. After the deconvolution analysis we obtain best (minimum) bedrock motions, which has only 193Gal and 46 cm/s.

By using this deconvolved bedrock motion and S-wave velocity structure, we conducted 1-D simulation in major regions of Fukuoka City. To calculate waveforms we assume that the S-wave velocities of all the layers are the same and the thicknesses of layers will be varied in a proportional manner. We found the largest PGA to be 360Gal at Imaizumi 2-chome. W also found the largest PGV to be 80cm/s at Daimyo 2-chome. When we plot a contour we found that a bright spot with high PGV is situated in the vicinity of Kego fault with a width of about 200m.

Since a depth contour of bedrock may create refraction, reflection, diffraction and surface wave generation, we must see the effects of the 3-D basin. To this end we conducted 3-D basin model calculation by using a depth contour. We assume that a plane wave will come from the bottom of the model. We use a 3-D FDM code (Graves, 1996) with minimum grid size to be 5m, the minimum S-wave velocity to be 110m/s, and the maximum S-wave velocity 1,100m/s. The analyzed region is 3.0km wide, 5.5km long along the Kego fault, and 0.3km deep. We use 2Hz Ricker wavelet and convolve the response with the bedrock motion used in the 1-D analysis. The calculated PGV contour show very similar feature to that obtained by 1-D analysis. This suggests that 3-D scattering effects on the PGV values at the sites near the Kego fault may not be so large. This may be so because the slope of the bedrock, 1 to 3 at maximum, is not large enough to have strong interference among different types of waves.