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Simulation of the strong ground-motion at IWTH25 for 2008 Iwate-Miyagi Nairiku Earthquake using distinct element method

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On June 14 in 2008, Iwate Miyagi Nairiku earthquake occurred. At this earthquake, the peak acceleration at the KiK-net, IWTH25(Ichinoseki-nishi) on the surface located on the hanging-wall side of the fault was recorded at 1143cm/s/s(NS component), 1433cm/s/s(EW component) and 3866cm/s/s(UD component). The peak acceleration at the same site on the bottom of a borehole was recorded at 1036cm/s/s(NS component), 748cm/s/s(EW component) and 640cm/s/s(UD component). The amplitude of vertical component, namely UD component, on the surface showed especially about 6 times as large as that at the bottom of a borehole.

As another aspect, asymmetry of vertical component was observed significantly. The above underground vertical peak acceleration amplitude indicated almost same amplitude to plus direction and minus direction. But the surface record indicated that the peak acceleration to plus direction is much larger than minus one.

Aoi et al(2008) proposed a trampoline effect to explain the significant change of amplitude and asymmetry phenomena. The authors agreed with this theory and expect that the asymmetry aspect of large acceleration to one direction was caused by a series of actions. First a part of foundation is separated and jumps up to the air and fall to the ground freely (tension due to adhesion seems to occur), with the maximum about one gravity of acceleration and finally large acceleration happens to plus direction at the time of contact with the ground.

Simulation of strong ground-motion was carried out to acknowledge the record of the surface motion against the underground motion, focusing on the vertical (UD) motion with the large and asymmetry acceleration. Well-known continuous engineering model such as one dimension SHAKE or two to three dimensional FEM is not properly applied to reproduce these phenomena. The distinct element method (DEM) was, therefore, applied to simulate the actions of free fall or re-contact.

One dimensional model, namely a sphere laminate model, which is no detailed ground model, was adopted to analyze the phenomena simply. The ground model was formed to accumulate 130 units of spheres with 10 cm radius in vertical direction. Horizontal boundary is fixed and vertical one is free. But the bottom element is fixed vertically and underground record were put in to the bottom element. Stiffness of element and joint between elements were assumed from the core drilling data and less strength between elements was applied to express the action of separation.

The analysis reproduced the actual phenomena well. The movement of upper element showed larger to the plus direction and smaller, about one gravity, to minus direction. The joint force between elements indicated no contact between elements during action of minus acceleration. When the separated element contacts the lower element again, large plus acceleration was observed in the analysis.

The result of this study indicated that distinct element method (DEM) with one dimensional sphere laminate model can be effective to reproduce the vertical (UD) motion recorded in IWTH25 (Ichinoseki-nishi). Such trials are expected for more precise simulation in the future as expansion to three dimensional model from one dimensional one, reviewing actual ground model and setting proper characteristics.

Acknowledgmets.

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References.

Shin Aoi, Takashi Kunugi, Hiroyuki Fujiwara (2008), Trampoline Effect in Extreme Ground Motion, Science 322, 727-730, doi:10.1126/science.1163113.