Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS023-16 Room:IC Time:May 23 12:30-12:45

An attempt to replicate the so called "trampoline effect" in computational geomechanics

Akira Asaoka[1*], Toshihiro Noda[2], Shotaro Yamada[2], Takaine Toshihiro[3]

[1]Association for the Development of Earth, [2]Nagoya University, [3]Asanuma co., ltd.

A loosely deposited alluvial sand subjected to a small seismic motion will initially pack together more firmly. But when a large shearing force is repeatedly brought to act on this well compacted soil, the sand will loosen up again and gradually start to swell. In the first stage of the research reported here, the SYS Cam-clay model proposed by the authors[1)] to represent the soil skeleton's elastoplastic constitutive equation is used to replicate a soil behavior of this kind. This model of the elastoplastic constitutive equation is arrived at by incorporating the evolution behaviors of three constituent conceptual of the soil skeleton (structure, overconsolidation, and anisotropy) into the Cam-clay model; the combined model is then capable of reproducing the mechanical behaviors of all soil types from sand to clay, including any intermediate types.

Keeping this representation of the soil skeleton behavior in mind, the present research goes beyond it in using the soil-water coupled finite deformation analysis code ***GEOASIA***[2)], created by mounting the SYS Cam-clay model onto the constitutive equation, to show what occurs when a ground in an overconsolidated state is subjected to an additional strong seismic motion; the soil becomes progressively looser, which may lead to swelling and rising in the ground. The ***GEOASIA*** analysis code makes it possible to carry out a time history analysis of the phenomena taking place in the ground and in the soil structures resting on it, not only for any kind of soil, but also without restriction for any mechanical states involved, stable or unstable, and over all ranges of instability, from deformation to failure, or liquefaction to subsequent reconsolidation in the case of sand. Similarly, the analysis performed can be static or dynamic, and provision can be made for any kind of external disruption affecting the ground. The analysis reported here concerns an event in which the ground resonates with the incoming seismic motion. The large shearing forces repeatedly acting on the soil elements are shown to induce loosening in the soil skeleton, which may result in local swelling and rising at the time of the earthquake. The analysis also shows that the input acceleration applied to the foundation (taken to mean the lower edge of the area analyzed) provokes vertical response movements at the surface, even when the acceleration wave consists only in a horizontal component. Further, it is found that the resultant acceleration wave has a very marked asymmetry in the vertical direction, whereas the waveform in the horizontal direction is symmetrical. This recalls the result of measurements obtained at the KiK-net seismograph station IWTH25 (West Ichinoseki) at the time of the 2008 Iwate-Miyagi earthquake, which indicated a similar powerful seismic motion with marked asymmetry in the vertical component only (Aoi et al., 2008[3)]). The peculiarities in the acceleration wave noted by these authors were a large upward pulse compared with a smaller downward one, the fact that downward acceleration appears to peak at around 1g, and the greater width of the waveform in its downward pulses than in its upward ones (Fig. 1). The given physical ground values, input seismic wave details, etc., required for the analysis are not based on the West Ichinoseki data, but nevertheless the distinctive nonlinear ground response measured there during the earthquake could also be confirmed in the results of the present analysis, using a continuum approximation to earth as an elastoplastic body (Fig. 2).

1) Asaoka, et al. (2002): An elasto-plastic description of two distinct volume change mechanisms of soils, *Soils and Foundations*, **42(5)**, 47-57.

2) Noda, et al. (2008): Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating the SYS Cam-clay model, *Soils and Foundations*, **48(6)**, 771-790.

3) Aoi, et al. (2008): Trampoline effect in extreme ground motion, *Science*, **322**, 727-730.

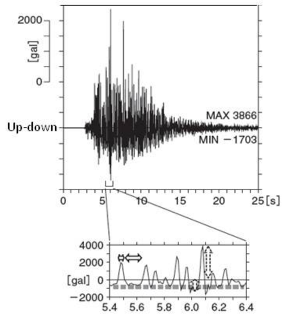

Fig. 1 Time history of ground surface acceleration response (observed results)[3)]

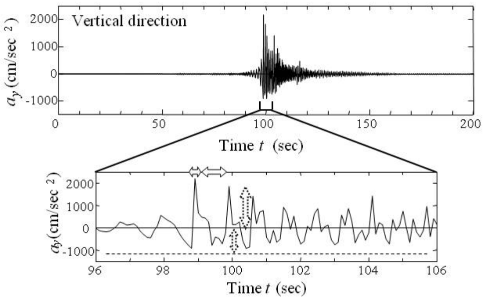

Fig. 2 Time history of ground surface acceleration response (analyzed results)

Keywords: strong motion earthquake, swelling/rising phenomenon, asymmetric waveform, elastoplastic constitutive equation, loosening, resonance