Expansion of liquefaction damage during aftershock induced by groundwater-level rise due to main shock: soil-water-air coupled elasto-plastic finite deformation analysis approach.

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ABSTRACT

In the 2011 off the Pacific coast of Tohoku Earthquake, it is reported that, in Chiba prefecture, the big aftershock occurring 29 minutes after the main shock caused expanding the liquefaction damage in the sandy ground. In this study, using a soil-water-air coupled finite deformation analysis code [1] incorporating the elasto-plastic constitutive equation SYS Cam-clay model [2], it is shown that groundwater level rise due to main shock may expand liquefaction damage during aftershock.

Figure 1 shows the distributions of saturation degree and mean skeleton stress in the sandy ground just before and after the main shock of the earthquake. Figure 2 shows those just before and after the aftershock. It is confirmed that the groundwater level is rising during and after the main shock and the saturation degree is rising further before the aftershock. That is, because the aftershock came at the stage when the saturation degree became higher near the ground surface, the mean skeleton stress decreased more significantly during the aftershock than during the main shock. As shown in this analysis result, one of the possibilities why the liquefaction damages were expanded at the aftershock may be due to the water-level rise in the sandy ground caused by the main shock. A special point of emphasis put in this study is that the results described here could not have been obtained without using the soil-water-air coupled elasto-plastic finite deformation analysis. This is because 1) the generation of positive excess pore water pressure is attributed to the soil contractancy which is described by elasto-plastic model; 2) determination of behavior of unsaturated soil needs to be based on a three phase system analysis; and 3) settlement/displacement of the ground needs to be calculated precisely by sequential computation in a finite deformation regime.

REFERENCES
