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Observations on landslides movements in residential slopes induced by the 2011 off the Pacific coast of Tohoku Earthquake

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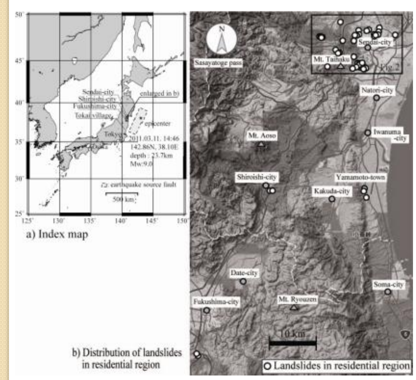
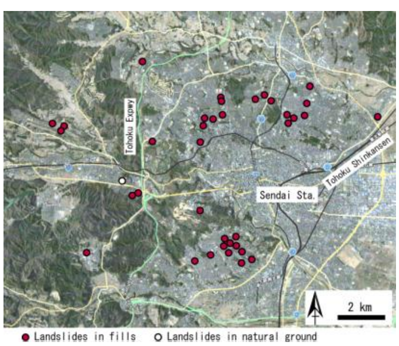
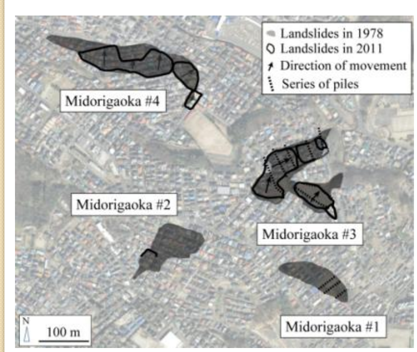
The 2011 Tohoku earthquake & Landslides



The Major landslides in Sendai City



The Midorigaoka Landslides

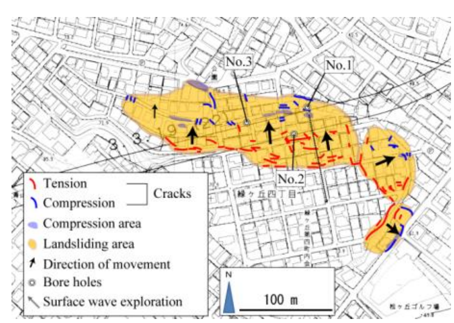


Landslides in Midorigaoka #4

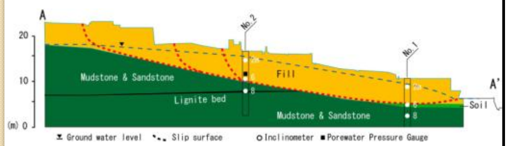
Head of the landslide

Foot of the landslide

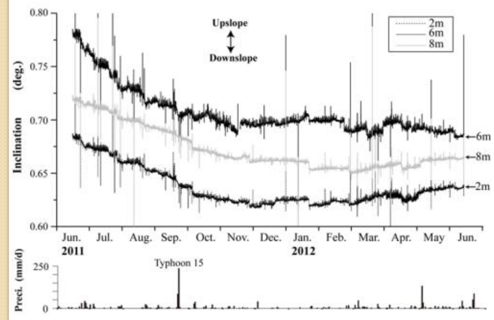
The plan view of the landslides



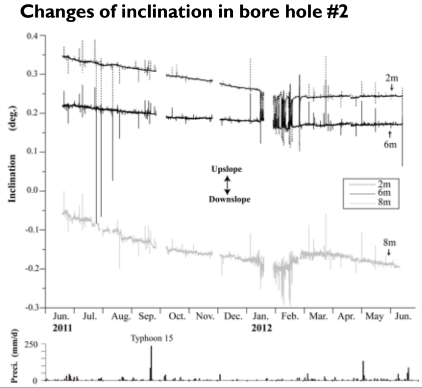
Cross section & depth of observation of the landslide



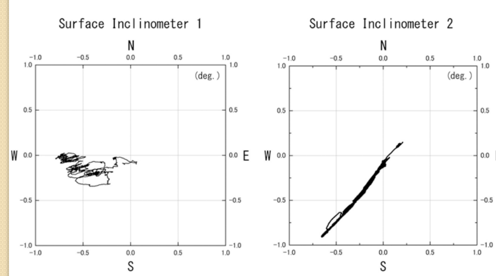
Changes of inclination in bore hole #1



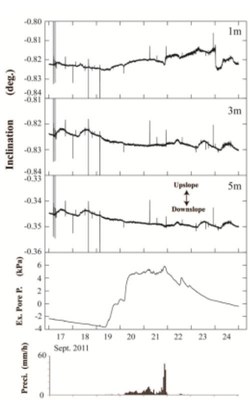
Changes of inclination in bore hole #2



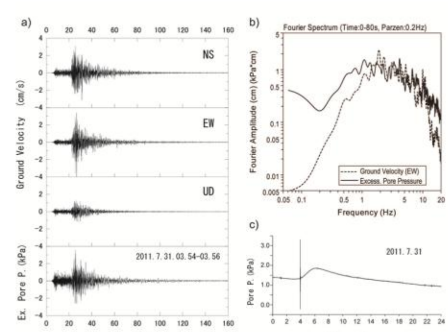
Changes of surface inclination at #1 & #2



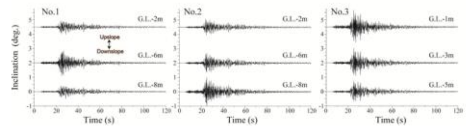
Changes of inclination in bore hole #3 during heavy rain fall



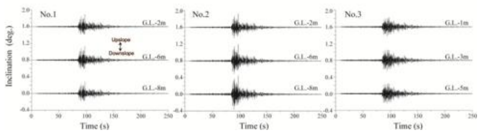
Changes of pore water pressure in bore hole #2



Changes of inclination during seismic shaking

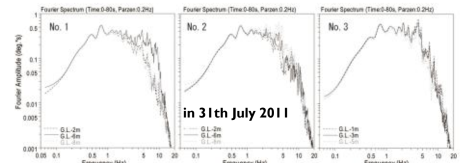


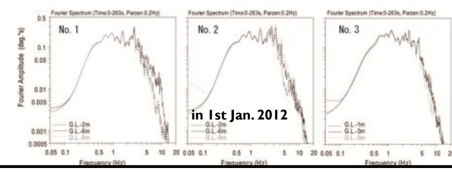
in 31th July 2011



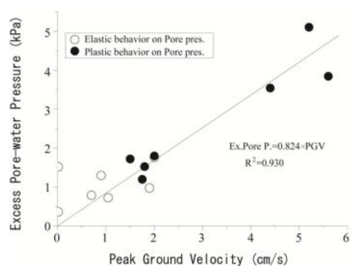
in 1st Jan. 2012

Fourier spectrum of changes of inclination during seismic shaking

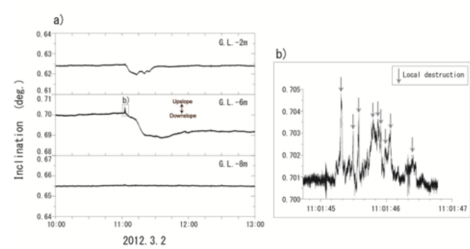




Relationship between PGV and Pore water P.



Landslide movement & local failure



Conclusions

1.After effect of the 3.11 main shock has been continued until few month later.

2.The self-dumping at the weak layers in ground structure was found.The effects of self-dumping varied depend on the thickness of weak layers and distance from epicenters.

3. Excess pore water pressure in the landslide increased in direct proportion to horizontal peak ground velocity (PGV) during earthquakes.

4.The failure process at the slip layer of landslide developed from small local failures to landslide movement was found by chance.

Observations on landslides movements in residential slopes induced by the 2011 off the Pacific coast of Tohoku Earthquake

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Abstract

The report on field observations of landslide movements in residential area induced by the 2011 off the Pacific coast of Tohoku Earthquake (M9.0) was conducted. The Midorigaoka 4-chome (Midorigaoka #4) subdivision in the southern part of Sendai City sprawled across the flatland stretching between the terrace and valley floor. The large landslides, the Midorigaoka #4 landslide, occurred in the widening fills of the lower part of this subdivision. The fills consist of soft and loose mixed bedrock material, sand, clay, and sandy silt with gravel. The humid top soil of original ground surface was found at the boundary of the fill and bedrock. The ground water level was very shallow - 0.5 m to 1.1 m below the ground surface - indicating that the fills were nearly saturated by ground water. Measurements on ground inclination using borehole inclinometers, and pore water pressure changes were made from June 2011 with high precision time interval of 100 Hz. Surface seismic velocity was observed at the head of the landslide in 200 Hz. The longtime slow landslide movements including bedrocks were observed from the beginning of the observations until December 2011 to January 2012 as the after effect of the main shock. The inclination rate at the top soils was greater than two times of the rate at the bedrock. The contrast in strength between the fill and bedrock is clear, and soft top soils exist at the boundary. Thus the major landslide is thought to move along the bottom of the fill, and the top soils should be considered as the slip layer of the landslide. The largest seismic response of inclination was found at the weak layers, at the top soils of the base of fills and at the fragile lignite layer of bedrocks. In contrast, the reduction of response at the upper part of fills was remarkable in case that the weak layers developed at the lower. These results indicate the self-dumping at the weak layers in ground structure. The effects of self-dumping varied depend on the thickness of weak layers and distance from epicenters. Excess pore water pressure in the landslide increased in direct proportion to horizontal PGV during earthquakes. This relation suggests that the landslide was initiated by the fully loss of shear strength of slip layer caused by increase of excess pore water pressure during the strong seismic motion over 80 cm/s of PGV of the main shock. The failure process at the slip layer of landslide developed from small local failures to landslide movement was found by chance. The performance of landslide during strong motion has not been discussed based on observed facts. Precise field observation on landslide movement during earthquake should be significant to mitigate the landslide risk in urban region.

Key words: The 2011 off the Pacific coast of Tohoku Earthquake, Landslides, Artificial fill, Seismic response