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Preliminary results for the topographic change by the 2011 Tohoku tsunami at the Arahama area in Sendai City

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A Great Tohoku Earthquake(Mw9.0)occurred on 11th March, 2011 (hereinafter the 2011 Tohoku Earthquake). The earthquake triggered huge tsunami, and the tsunami damaged to the wide range of the coastal areas in the northeast Japan. The Sendai City was also damaged by the tsunami and the earthquake, and at least 859 people died or were missing, and 3190 houses were fully destroyed according to the report of the Miyagi Prefecture on 28th April.

We conducted field survey to explore a topographic change by the tsunami flow and ground subsidence before and after the 2011 Tohoku Earthquake, and to explore the effect of liquefaction.

We set 4 km long transect until the inundation limit perpendicular to the coastline at Arahama area in the Sendai City, one of the most severely damaged area by the tsunami in the city, on the early April. Sampling of the tsunami deposits were performed every 100 m along the transect. We also studied damages and inundation heights of the Tsunami, and conducted kinematic GPS measurement by using Promark3 in order to study the topographic change before and after this earthquake. In addition to the field survey, we analyzed several satellite images, aerial photographs, and topographic maps to estimate the large scale topographic change by the tsunami as well as the seismic subsidence in the area, and distribution of liquefaction. Moreover, we compared topographic data before (5 m DEM, provided by The Geospatial Information Authority of Japan: GSI) and after the 2011 Tohoku Earthquake.

High-resolution topographic profiles before and after the 2011 Tohoku Earthquake revealed approximately 30-40 cm subsidence in this area. The result is consistent with the shifting of the electric reference points.

Field survey results show different grain size and thickness of the tsunami deposit at each pit with distance from the coastline. In the beach area (0-150 m from the coastline), tsunami impact is minor and, in fact, even the offshore breakwater had not been damaged. Moreover, beach sands seem to have not been moved significantly. On the other hand, in the coastal forests behind the onshore wave breaker (150-700 m from the coastline), most of the trees were devastated landward by the run-up wave. The thickness of the tsunami deposit is less than 12 cm, and mostly it is less than 3 cm. Moreover, its grain size is medium to course sand. Current ripples are usually observed on top of the deposits. In the rice field (700-4000 m from the coastline), there are many traces of the liquefactions and sand boil is frequently observed. Clay to very coarse sand layers with less than 27 cm in thickness were deposited on the rice paddy. However, these sand layers were locally deposited and we interpreted that sources of the sands are probably the beach/sea or liquefaction. Maximum extents of the sandy tsunami deposits and the tsunami inundation are approximately 3500 m and 4000 m, respectively.

Our observations of the various images and topographic maps revealed that most of the telegraph-poles and coastal trees located in about 150-700 m from the coastline were broken landward by the run-up flow. The backwash flow was concentrated in an old channel near the beach and eroded this channel. As a result of this erosion, the coastline was cut immediately after the tsunami, but it has been recovered quickly at least until 24th March.

Keywords: the 2011 Tohoku Earthquake and the tsunami, topographic change, liquefaction, tsunami deposit