

Total volume of sand and mud deposited by the 2011 Tohoku-oki tsunami at Sendai Plain

ABE, Tomoya^{1*}, GOTO, Kazuhisa², SUGAWARA, Daisuke³

¹Nagoya University, ²Chiba Institute of Technology, ³Tohoku University

A relationship among the volumes of the sediments, landform, and magnitude of the tsunami were pointed out based on the field surveys after recent tsunamis (e.g. Matsumoto et al. 2010). Moreover, the hydraulic experiment further showed that 80 % of the volume of the sand can be accounted by sediment transported from the land near the shoreline (Harada et al. 2011). Nevertheless, the relationship between the volume of sediment and its source is still uncertain. In fact, total volume of sediments (sand plus mud) was estimated in the previous studies. However, because there is a potential that the sources of sand and mud are different, the volumes of sand and mud should be estimated separately.

In this study, we report the relationship among the volume of sand and mud, landforms, sediment sources, and magnitude of the 2011 Tohoku-oki tsunami at Sendai Plain based on field survey on April, June, and August 2011.

We set 6 transects with about 0.6-4.0 km inundation distance in and around Sendai Plain. We observed thickness of the tsunami deposits at totally 166 pits every 10-340 m along each transect. Volumes of sand and mud deposited per unit width and area of the coastal zone are calculated based on the cumulative thickness of the deposits along each transect. We also conducted kinematic GPS measurement of the topographies. Land condition is classified based on field observation and analysis of satellite images and aerial photographs.

Beach distributes 0-150 m from the shoreline along transect. Coastal forest (sand dune) distributes 60-880 m from the coastline. Rice paddy field extends between 180-280 m and 330-4030 m from the shoreline, and occupies a great part of most transects.

Volume of sand deposited per unit width along each transect is estimated approx. 30-180 m³/m and the volume is in proportion to the inundation distance. Volume of mud deposited per unit width is calculated approx. 1-60 m³/m and, as like sand volume, the mud volume is also in proportion to the inundation distance. Moreover, mud volume relates to the width of rice paddy field, suggesting the source of mud is mainly the rice paddy. In fact, mud volume is very minor component if the transect is covered with narrow rice paddy field. On the other hand, it is interesting to note that the volume of sand per unit area (m²) along each transect is remarkably similar in range (approx. 0.037-0.054 m³/m²), which is probably controlled by the duration of the sand suspension by the bore front at the shallow sea and the beach. In contrast, mud volume deposited per unit area is calculated about 0.002-0.018 m³/m², the volume is in proportion to the width of rice paddy field.

The volume of sand per unit width (approx. 30-180 m³/m) is approximately 1-5 times that reported for the 1998 Papua New Guinea tsunami (approx. 36 m³/m, Gelfenbaum and Jaffe, 2003), where the run up height was 10-15 m and the inundation distance was 0.75 km along the transect, and the 2004 Indian Ocean tsunami (approx. 78-83 m³/m, Fujino et al. 2006; Matsumoto et al. 2010), whose run up heights were 4-10 m and the inundation distances were 1-2 km along the transects. Our survey transects in Sendai Plain, the run up heights were 10-20 m (Mori et al. 2011) and the inundation distances were 0.6-4.0 km, respectively. The landform condition of Sendai Plain is suitable for the transportation and the deposition of tsunami sand because the area is characterized by the remarkably flat and low rice paddy fields. As the results, these conditions promote the transportation and deposition of significantly large volume of sand by the tsunami on land at Sendai Plain. Moreover, if we consider the volume of mud, the total volumes of sediments (sand plus mud) per unit width are about 30-230 m³/m, resulted in remarkably larger volume of sediments deposited on land than those by the recent tsunamis.

Keywords: 2011 Tohoku-oki tsunami, tsunami deposit, volume of sediment, Sendai Plain