Disaster-Proneness of Residential Land and Efforts towards Improvement

Ikuo Towhata
Department of Civil Engineering
Kanto Gakuin University
Yokohama, Japan
towhata.ikuo.ikuo@gmail.com

Keywords- residential land development; earthquake; heavy rain; safety during natural disaster

The important target of geotechnical earthquake engineering has long been the safety of infrastructures and important industrial facilities. Because of this, unfortunately, most people do not recognize the importance of the discipline. When the author was the President of the Japanese Geotechnical Society, an additional aim was proposed in order to improve the situation. The new aim was to help people from the threat of natural disasters.

The 2011 Tohoku earthquake in Japan demonstrated clearly that people's properties are prone to natural disasters and that people do not understand it. Fig. 1 compares two different situations of houses within a few hundred meters of distance in Sendai City. One house was significantly damaged by the collapse of foundation (Fig. 1a), while the other was intact (Fig. 1b). This dramatic difference was related with different subsoil conditions; the former rested on a filled shallow valley and the other on a cut slope. Note that a standard land construction in a hilly area consists of cut and fill procedures. People are not aware of the different soil conditions when they purchase the land. Note that good seismic resistant design of houses (superstructures) does not improve this situation because the weakness lies in subsoil.

(a) Fill part (b) Cut part

Figure 1. Different extents of seismic damage in residential land in Sendai City during the 2011 Tohoku earthquake.

Figure 2a addresses a similar problem after the 1993 Kushiro-oki earthquake. Houses rested on a fill that was placed on very soft peaty soil. Because this fill was situated in a former valley where ground water flowed in, the constructed fill was quickly saturated with ground water and its weight increased. During the earthquake, the increased weight made the seismic inertia force greater which the underlying soft peat could not resist. Consequently, the entire fill collapsed and houses were destroyed. The problem was that this mechanism damage was not understood correctly then and that the same fill was reconstructed after the quake. Thus, another earthquake in 1994 repeated the damage (Fig. 2b). This case shows the importance of geotechnical knowledge in disaster mitigation. Similarly, the 2016 Kumamoto earthquake in Japan showed house damages induced by collapse of retaining walls and foundation soils (Fig. 3).

(a) Damage in January, 1993

(b) Damage in October, 1994

Figure 2. Damage of residential land resting on fill underlain by soft peat.

Figure 3. House damage due to collapse of retaining wall.

Apart from earthquakes, another important natural threat is heavy rain and debris flow. In August, 2014, Hiroshima City was affected by heavy rain of more than 200mm in 3 hours and many slope failures occurred in unstable hilly areas. Because of the recent urban expansion, there were many residential developments in hill slopes and the induced debris flows destroyed houses there to claim 74 victims at midnight. The problem is that people prefer to purchase residential lands in high sloping ground where landscape is good and soil condition is dry. Such a place is found in alluvial fans that were produced by debris flows in the past. In 2014, debris flows traveled along the original routes and destroyed houses on the way (Fig. 4). It has not been a custom to consider such a risk in urban planning.

Figure 4. Debris-flow damage of houses in Hiroshima, 2014.

Geotechnical engineering should work directly with people. To achieve this goal, the Japanese Geotechnical Society established in 2013 a new professional title of "Qualified evaluator of subsoil quality for safety of residential land" in collaboration with several other engineering institutions [1]. This evaluator is not a volunteer but a job. Those who have basic qualification such as registered engineer, architect, etc. take examination that specializes construction of residential land, natural disasters and concerned regulations to be approved with the title. The awarded title is valid for 5 years, after which a short course is taken for title extension. After many efforts since 2013, this title was officially approved in early 2018 by the Government as one of the important qualifications operated by private sectors.

Most important activity of the evaluator is to give advices to people who are aware of the disaster-proneness of their own residential land. Because the current practice of site investigation is far less sufficient, detailed site investigation may be advised. According to the quality and amount of advices, reasonable fee is charged.

Another important activity is knowledge exchange with judges and lawyers who deal with many troubles about quality of residential land. It is unfortunately true that differential settlement of houses and instability of retaining walls cause many court fights and precise knowledge should be provided to them on geotechnical engineering practice. More details are available in the website of the Japanese Association of Geotechnical Evaluation (https://jiban-jage.jp/).

Lack of geotechnical concern among people is a significant cause of disasters. When people choose a place to live, attention is paid to price, landscape, less humidity and convenience in life (commuting, shopping, etc.). In contrast, safety from natural disaster is seldom considered until disaster does happen. Dissemination or public education on disaster mitigation is certainly important and many efforts have been made by both public and private sectors. Moreover, media reports many disasters every year. It is, however, true that people's attitude has not changed very much. People suppose as what follows;

1. Ground is stable and does not move: interval of strong earthquakes and slope failures at the same place is hundreds of years and the memory of the previous disaster is lost after a few generations.
2. Money should be spent on daily life and expenditure on disaster mitigation is of lower priority; matter of probability.

The first point may be improved by raising stone monuments on site in order to record what happened during past disasters. Because such monuments reduce the value of real estates in the area, general agreement of the community is necessary. The second issue is more difficult because everybody has to survive "today." Probably,

- building codes should include not only the disaster safety of superstructures but also of the foundation,
- more soil investigation should be compulsory for new construction in order to know the disaster proneness, and
- construction of safe residential land should be financially promoted by reduced real-estate tax or better disaster insurance.

More study is needed in this direction.

[1] Towhata, I. and Nakamura, H. (2015) Qualified evaluator of subsoil quality for safety of residential land, International Conference on Soft Ground Engineering (ICSGE2015), Singapore, Pape No. 180.