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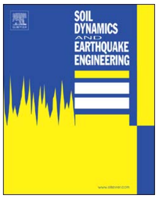

Qualification of residential land from the viewpoint of liquefaction vulnerability

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ABSTRACT

While the assessment of liquefaction potential by using borehole data has a long history since 1970s, its target users are still limited to professional engineers and experts. This situation is not favored by ordinary people who are seriously concerned with the reliability and preservation of their real estates during strong earthquakes. The demand of the people is that the liquefaction vulnerability of their residential land is precisely and clearly but concisely demonstrated so that people without engineering background can understand the real extent of risk. In this regard, the authors, under the governmental support, proposed a simple manifestation of the extent of liquefaction vulnerability of private houses in terms of the thickness of the surface unliquefiable crust and the vertical weighted average of the factor of safety or its equivalence. This achievement was made possible by introducing the ageing effects of soil on liquefaction resistance in addition to using geotechnical data base of subsoil conditions. During the work, it was found that existing borehole data may not be fully reliable and that experts who have sufficient knowledge of the local subsoil should assess the vulnerability. This requirement is satisfied by the qualification of special engineers that has been initiated by the Japanese Geotechnical Society in conjunction with several other institutions. The proposed method of subsoil qualification is used not only for individual residential land but also for regional hazard assessment.

1. Introduction

Mitigation of seismic liquefaction has a history since late 1960s and has achieved a variety of technologies that can protect important structures from damage. Nevertheless, the gigantic earthquake in east Japan, 2011, provided many lessons to be learned on seismic risk of modern communities. Among them it is noteworthy that liquefaction made severe damage of less expensive structures such as lifelines and river levees as well as residential houses that were not well protected by mitigation technologies from liquefaction [10,22]. As a consequence of vast house damage, it was recognized to be necessary that a simple damage criterion is established in order to assess the extent of liquefaction vulnerability of residential land. This is considered particularly urgent because more gigantic earthquakes are feared in many other parts of the country. Notably the public sector's involvement in liquefaction resistance of private houses is a new attempt because the quality of private properties had been considered to be the owners' responsibility and the public sector had been reluctant to be engaged therein except knowledge dissemination.

It is well known that liquefaction is most likely to occur in young loose cohesionless and water-saturated soil that is subject to strong shaking. This kind of subsoil is found in recent man-made islands, abandoned river channels and backfill of lifelines among others [20,21,24]. Such a geomorphological criterion is neither quantitative nor spatially detailed enough for individual land owners. Moreover, any effort to improve soil conditions is not considered by a geomorphological approach.

Liquefaction potential of subsoil has been assessed conventionally on the basis of SPT-*N* or other sounding data together with the design intensity of the ground surface acceleration [11,12,15]. The assessed results have been presented as the factor of safety against liquefaction (F_L) changing with depth and experts made further decision whether or

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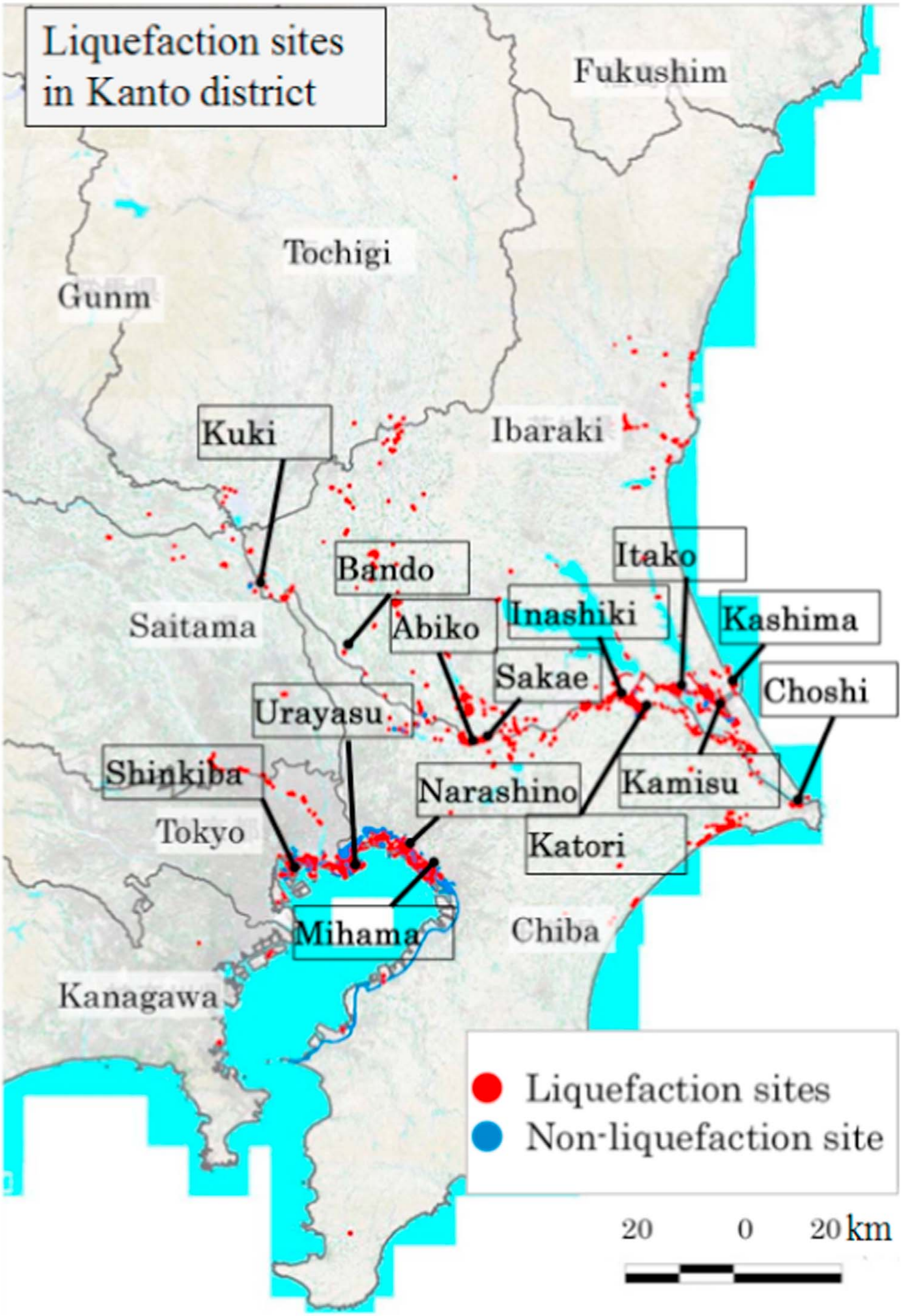

Fig. 1. Distribution of studied sites in south Kanto district.

Table 1
Observed maximum horizontal acceleration at ground surface $\sqrt{EW^2 + NS^2}$.

Site	Acceleration (G)	Site	Acceleration (G)
Shin-Kiba	0.15	Inashiki	0.27
Urayasu	0.18	Kuki	0.25
Narashino	0.25	Choshi	0.18
Mihama	0.19, 0.25	Kashima	0.51
Kamisu	0.23, 0.24	Sakae-cho	0.34
Itako	0.53	Abiko	0.27
Katori	0.31, 0.53	Bando	0.47

Mihama and Kamisu have two values because of two nearby K-Net stations.

not to improve vulnerable soils. However, presenting this F_L-depth diagram to non-professional land owners or people is not good enough because people do not have good knowledge of soil mechanics. The present study aims to propose a methodology by which subsoil conditions in private land is demonstrated to non-engineering people. Hence, it was decided to classify residential land into several categories, varying from “very good” to “poor”, for example, so that people could understand the extent of liquefaction risk underlying their houses. Certainly the methodology of qualification has to be brief and clear so that non-engineering people would make no wrong interpretation. The proposed method is going to be presented in what follows and its verification against the recorded liquefaction damage during the 2011 gigantic earthquake is described as well.