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Main shock-aftershock interval effect on the liquefaction damage in Tohoku Region Pacific Coast Earthquake

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During the Tohoku Region Pacific Coast Earthquake, extensive liquefaction damages were observed over a wide range of reclaimed coastal land. The following two characteristics have been pointed out: (1) Large liquefaction damages occurred even under small ground acceleration. (2) Intermediate soils with large fine fraction content that have been considered to be hard to liquefy also exhibited extensive liquefaction. While long duration of the seismic motion may be one of the main reasons for them, the authors previously focused on the stratum organization. That is, soft alluvial clay located directly under the alluvial sand on the inland side is thin, where liquefaction damage is relatively small. The thickness of this clay layer increases as it approaches to the coastal side, where liquefaction damage becomes severe. Based on the 1D elasto-plastic seismic response analysis, the authors indicated that a thick soft clay layer below the liquefied layer can amplify seismic waves over a range of longer periods, and the resulting large plastic strain may cause severe liquefaction damage even in clayey sand that normally resists liquefaction.

The third characteristic will be (3) large aftershock generated only 29 minutes after the main shock expanded the liquefaction damage, considerably. In this study, authors focused on the influence of main shock-aftershock interval to the liquefaction damage. Before the elasto-plastic seismic response analysis, elasto-plastic soil properties were precisely identified by the various soil tests in laboratory using undisturbed soil samples obtained through boring exploration in the Urayasu city, details for which will be delivered later.

The difference of the thickness of clay layer affects greatly on the liquefaction damage as shown in Fig. 1(a). Fig. 1(b) indicates the time-excess pore water pressure ratio relationships during the aftershock that occurred 29 minutes after the main shock. D foundation with a very thin clay layer does not exhibit any liquefaction during both main shock and aftershock. To the contrary A and B foundations with a thicker clay layer, liquefaction was clearly observed both during the main shock and during the aftershock. The C foundation exhibited interesting behavior. The C foundation is on the relatively thin clay layer, and this foundation does not exhibit liquefaction during main shock. However, 29 minutes after the main shock the foundation reaches liquefied state during aftershock (Fig.1 (b)). This is, of course because 29 minutes is not long enough for the dissipation of excess pore water pressure even for the sand which is covered with reclaimed clayey soil layer of small permeability. Suppose that the aftershock occurred one day after the main shock. Fig. 1(c) shows the time-excess pore water pressure ratio relationships during the aftershock. No foundations from A to D exhibit any liquefaction during the aftershock. One day interval will be long enough for the excess pore pressure dissipation through the top clayey sand layer. Short interval between main shock and aftershock may have enlarged liquefaction damage in Tohoku Region Pacific Coast Earthquake.

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