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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Effects of relative density and accumulated shear strain on post-liquefaction residual deformation" *by* J. Kim et al.

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Above all, we thank Prof. Robb Moss for the thorough review on the manuscript.

About major comment: As referee pointed out, the paper by Shamoto et al.(1998) provides precious information about the relationship between residual strain and volumetric settlement during post-liquefaction process. Nevertheless, we cited two other papers by Shamoto et al. presented in 1996 and 1997 as key references, rather than the paper by Shamoto et al.(1998) because of some reasons as below:

As Shamoto et al.(1998) mentioned in the paper, their main focus was to suggest a new pragmatic chart based on the model developed by Shamoto et al.(1997). Although the relationship between post-liquefaction ground settlement and lateral spreading (e.g.

Fig 5 in the paper by Shamoto et al.(1998)) was directly related to the paper that we submitted, they basically referred their previous research published in 1997 to establish the main background of the study. Therefore, we also mostly used the paper by Shamoto et al.(1997) as a key reference.

Figure 16 in our manuscript and Figure 5 in Shamoto et al.(1998) has the following differences.

1. In the paper by Shamoto et al.(1998), they rely on the result of cyclic torsional test, but they suggest the constitutive model focused on the theoretical investigation. Strictly to say, it is hard to say that this is an empirical approach.

2. The laboratory testing program used by Shamoto's research group was a case study to find the result by the two independently performed testing program to suggest the constitutive model. It means that they theoretically combine the volumetric model through drained cyclic shear and the residual strain model through post-liquefaction monotonic loading. This significantly differs from integrated testing program that we suggested.

3. They used different definitions for loading history. In Shamoto et al.(1998), the maximum shear strain is used to define the magnitude of loading history (or the degree of liquefaction), but we accumulated the loading history (shear strain) to indicate physical quantity of loading history applied by various stress paths, termed 'accumulated shear strain'.

4. Shamoto et al.(1998) suggests linear relation for inverse relation between post-liquefaction lateral spreading and ground settlement, but we suggested that nonlinear(curvy shape) relation could be possible.

We rewrite to make some addition and modification here (page 1582, line 25).

"Shamoto et al.(1998) presented that post-liquefaction shear strain and volumetric strain is not independent each other using constitute model, which developed based

on the cyclic torsional shear test results and the theory of plasticity. However, quiet few experimental methods that can evaluate the relationship between residual shear strain and residual volumetric strain directly have provided."

The supplementary explanation is added to Fig. 16(page 1592, line 3). "Although this inverse correlation coincides with that of Shamoto et al.(1998) who showed linear inverse correlation between residual shear strain and residual volumetric strain, the result in this study shows curvilinear relationship, not linear."

We added Shamoto et al.(1998) in references. Shamoto, Y., Zhang, J. M. and Tokimatsu, K.: New charts for predicting large residual post-liquefaction ground deformation, Soil Dynamics and Earthquake Engineering, 17, 724-438, 1998.

About minor comment:

We added the following papers to replace Stewart et al.(2001, 2004) and Wartman et al.(2003).

Ishihara, K., Yasuda, S. and Nagase, H.: Soil characteristics and ground damage, Soils and Foundations, Special Issue on geotechnical aspects of the January 17 1995 Hyogoken-Nambu earthquakes, 109-118, 1996. Tetsuro, I. and Koarai, M.: Wide-area land subsidence caused by "the 2011 off the Pacific Coast of Tohoku Earthquake", Soils and Foundations, 52(5), 842-855, 2012.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 1579, 2013.