GEOASIA Bulletin No.6

ALL SOILS ALL STATES ALL ROUND

GEO-ANALYSIS INTEGRATION

For finding soil deformation and collapse in sandy, intermediate and clayey soils, and for static or dynamic interests

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Message from the Society President

In connection with my past professional involvement, I am currently serving on the Seismic and Volcanic Countermeasures Subpanel of Shizuoka prefecture's Academic Council for Atomic Energy. I was commissioned for this work on account of my previous responsibility as head of the external assessment committee for the design of the tsunami defense wall at the Hamaoka atomic power plant run by Central Japan Electric Power. Readers will know that at the end of March this year (2012), a Cabinet Office Discussion Committee for the Model of a Massive Nankai Earthquake adopted the new assumption of a huge-scale 9.1 M continuous earthquake occurring extensively along the 750 km length of coast from the Fujigawa-Kawagichi fault zone in Shizuoka to the Hyuga sea zone off Miyazaki as a basis for "predicting" a chain of 20 m tsunamis striking locations up and down the Pacific seaboard. With scenarios on this scale, what else is there left to be called unforeseen"? There have been similar revisions elsewhere for predictions of seismic movements; many areas previously assessed by the Central Disaster Prevention Council as facing the risk of a force 6 tremor have had this raised to force 7. But Shizuoka is one of the prefectures most strongly "affected."

It is obviously out of the question to design hard countermeasures for "predictions" of this intransigent sort; however, Shizuoka prefecture has opted to pursue hard disaster prevention measures capable of withstanding external forces of a magnitude predicted to occur "once every hundred years." Other prefectures along the Pacific coast can be expected to pursue similar programs, with just some local variation over whether the reference period is to be "once every hundred" or "once every thirty" years. Once again, civil engineering has its work cut out for it.

Some years ago, I recall having raised the question: "In the aftermath of the (1995) Hanshin-Awaji Earthquake, is civil engineering and geotechnology doing enough to stay up with the breathtaking advances of seismic science?" Leaving aside "the advances of seismic science" this time, it still bears asking whether we are indeed keeping up with the stiff demands of new disaster prevention measures. What is most essentially needed in geotechnical engineering today is a rapid shedding off of outmoded practices involving "seismic coefficient method," "safety factors," "FL and PL indices" and so forth, and a changeover to a design method grounded in a "sufficiently clear and detailed descriptive prediction of damage content" of the sort obtained from a continuous geomechanical representation incorporating all three of the "alls": all soils, all states, and all round geo-analysis.

Just the other day (August 9, 2012), the Japanese Geotechnical Society held a "First Workshop on Constitutive Equations" (committee chair Akira Asaoka, event chair Teruo Nakai), and, considering the five years that have now passed since the appearance of this Bulletin's inaugural issue (August, 2007), I must say that I left this event with slightly dour feelings. There were various views of the kind "When the density (pore ratio)

Photo 1 President Asaoka's address

(First Workshop on Constitutive Equations, main ground floor conference room, Japanese Geotechnical Society) of sand changes it becomes a different material, so it's plain common sense to change the parameter to fit, the way everyone does," or "When everyone does it like this in ordinary life, isn't a bit self-complacent for ***GEOASIA*** people to stand up and say 'Well, that's not the way we do it? …" But in this day and age we are beginning to understand the mechanics behind sand (or for that matter, clay). Coming away, I felt more convinced than ever of the importance of putting aside these ad hoc expedients when dealing with complex foundations, pursuing steady, solid research and revealing the underlying theory. It takes exertion, but I trust that all of our society members are ready to exert themselves.

Akira Asaoka,
Senior research advisor, the Association for the Development of Earthquake Prediction (reg. foundation);
Emeritus professor, Nagoya University

Feature article: Generating an earthquake inside a computational machine!?

If loading is increasingly continued on a highly structured naturally deposited clay soil under conditions of controlled displacement, the displacement will become localized, resulting in a circular slip failure, and then a decline in the soil's bearing load. But, on the same kind of soil, if loading is carried on under controlled load conditions, after rising to the same peak as before, the load will then be maintained at almost the same level while, again, a circular slip failure will occur, resembling the one found under controlled displacement (Figs. 1, 2). One difference this time, however, is that the failure proceeds all in one go and at an accelerating pace (Fig. 3). A problem of this sort, in which a foundation becomes incapable of resisting external forces and collapses in one "crash," cannot be analyzed as an equation of equilibrium among the forces obtained when inertial force is ignored, but only by faithfully integrating the equation of motion against time. The capacity to solve problems irrespective of whether they are static or dynamic is one of the strengths of ***GEOASIA***, and the calculation result here is a good example of how important this can be.

Here is another example illustrating the further possibilities that can be opened up by this capacity to solve static and dynamic problems without distinction. The waveform shown in Fig. 4 is a model of the vertical acceleration motions accompanying a ground failure at a point (indicated by the arrow in Fig. 2) well away from the failure zone. Interestingly, the waveform of this vertical acceleration motion not only resembles that of a seismic wave, but also shows a maximal value of around 200gal which is of the same order as frequently found in actual seismic measurements. The waveform in Fig. 4 has an extremely short period, but, interestingly again, if the same problem is solved in a similar but scaled up version for a cycle length 300 times greater, long-period constituents appear and the predominant periods again resemble those of a real seismic wave. This invites further questions as to how a relatively simple waveform of the sort shown in Fig. 3 comes to generate the far more complex one in Fig. 4. In fact, the implications of this are endless and fascinating. In the Society we are looking upon this as a pointer to how an earthquake simulation might one day be generated inside a calculating machine and we are considering ways of tying this idea in with an informative contribution to seismic studies.

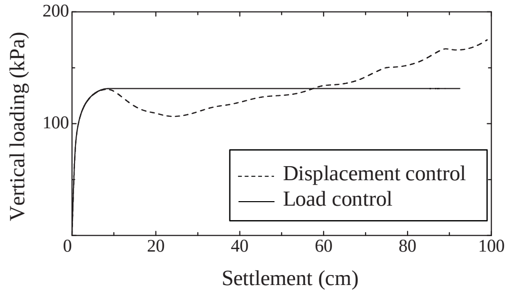

Fig. 1 Relation between loading and settlement

Fig. 2 Distribution of shear strains after failure (Load controlled)

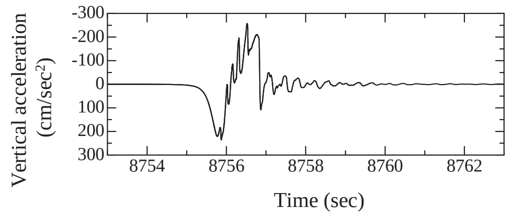

Fig. 3 History of vertical acceleration motions in foundation at time of failure

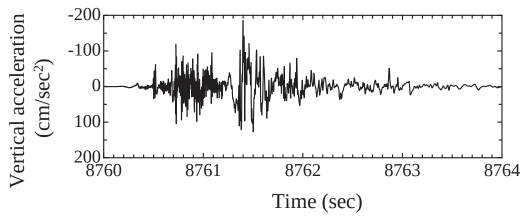

Fig. 4 Shock of failure spreading to adjacent soil

① A reconsideration of countermeasures against residual settlement of soft ground due to highway construction in Vietnam

A replicating calculation was performed of settlement behavior at a site on the Saigon East-West Highway in Vietnam, where the placement of an embankment load on an area of soft ground has resulted in an incidence of residual settlement in excess of initial estimates and still continuing at present. In addition to surveying the causes for this occurrence of delayed resettlement, a retrospective discussion was also included of what preventive measures ought originally to have been taken against the threat of residual settlement.

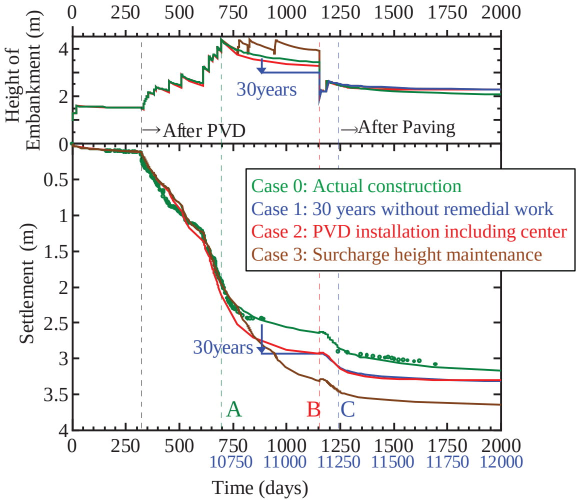

Fig. 5 Replication of actual measured settlement with predictions of the residual settlement to be expected in the case of various types of remedial measures

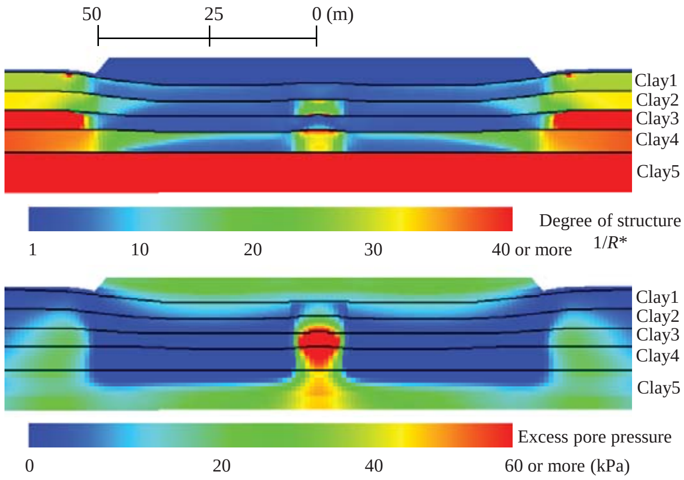

Fig. 6 Degree of structure and distribution of excess pore pressure immediately after removal of load (with embankment portion magnified)

② Prediction of deformation following liquefaction of a seawall on reclaimed land, with a discussion of the remedial effect of SCP installation

A deformation prediction was performed for a recently reclaimed plot of coastal land, and the remedial effectiveness of land improvement using the SCP method of concrete casting was discussed. The seawall is first thrust out toward the sea through the liquefaction of the top layer of alluvial sand, As1, and this is followed by a process of delayed compression in the clay layer, Ac1, underneath. In locations where reclamation or embankment loading has occurred shortly before an earthquake, the stress ratio will be high, causing an amount of subsidence notably greater than in the adjoining vicinities. Regarding the land improving effect of SCP casting, the resulting gain in rigidity can be expected to have some restraining effect on deformation provided the area of improvement extends through the whole of the liquefaction layer.

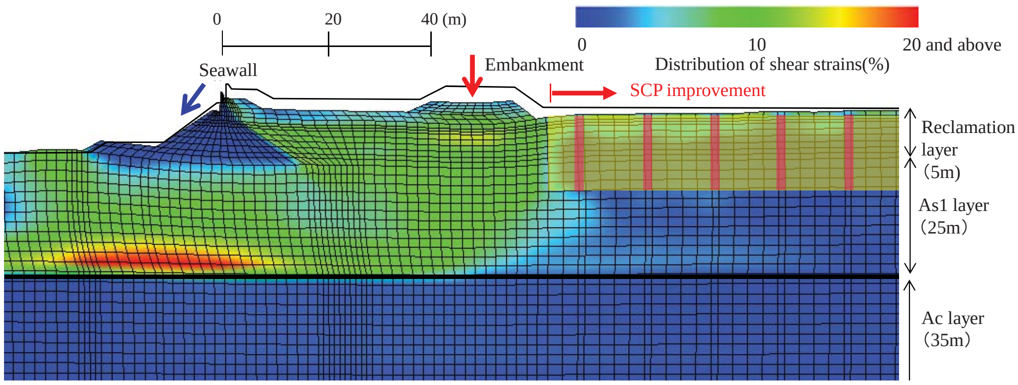

Fig. 7 Prediction of deformation in a reclamation zone following an earthquake (with seawall portion magnified)

③ 3-D seismic response analysis of a small top-heavy structure on a site exposed to liquefaction

A 3-D model of a small top-heavy structure on a soft sandy foundation site was used to investigate the seismic stability of the combined foundation-structure system during and after an earthquake. The results showed 1) that on a liquefied sandy foundation this structure would be prone to horizontal tremors with a fairly long period of between 1 and 4 seconds; and 2) that the structure on top would then be subject to uneven settlement with an inclination towards the side of greatest mass. However, this second hazard can be avoided by extending the breadth of a concrete raft foundation laid under the ground as a prior countermeasure.

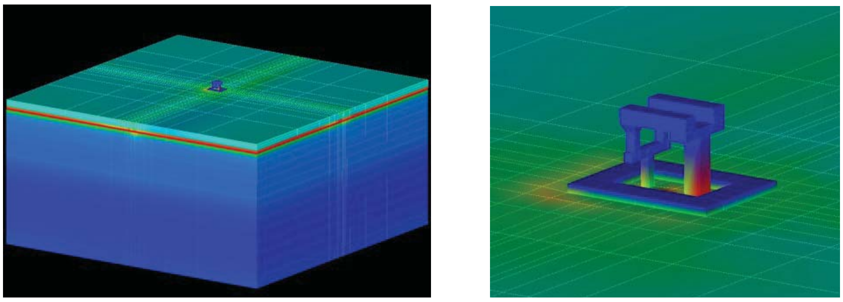

Fig. 8 3-D model of small structure (right: magnification of the structure)

② Influence of deep layer composition on the liquefaction of a soil containing numerous fine particles

Reclaimed coastal land in Urayasu, Chiba prefecture, suffered major liquefaction damage in the Tohoku Pacific Offshore Earthquake of 2011, despite containing large numbers of small particles, a property conventionally thought to make it unsusceptible to liquefaction. In this research, the foundation soil was modeled and the factors leading up to its liquefaction discussed. One factor frequently pointed out was the long continuation of the tremors. But another characteristic of this earthquake was that the degree of liquefaction damage was non-uniform from one spot of space to another, and that the spread in these local differences was large. This has often been attributed to the heterogeneities in the foundation materials, but the results of the present analysis show that even assuming homogeneous foundations, considerable heterogeneity would still have existed in the soil strata and hence also in the ground deformations which depend on them.

※ The Society President, Akira Asaoka, gave a presentation based on this content at the 2011 Autumn Conference of the Seismological Society of Japan. He was then interviewed by the NHK, who aired the topic on a news program (broadcast October 13, 2011).

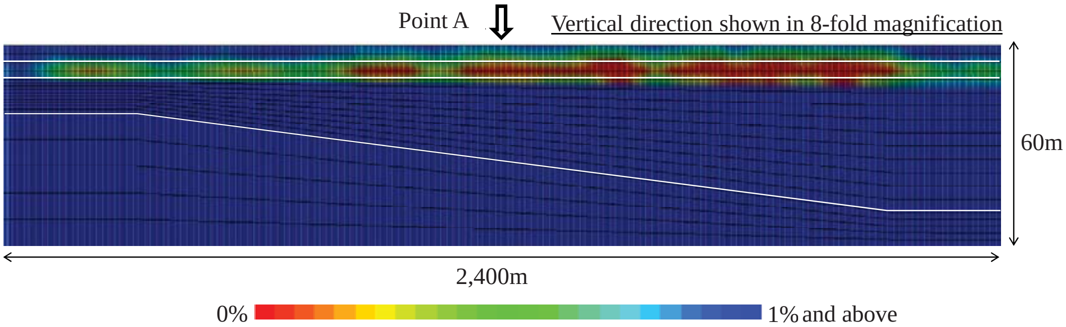

Fig. 9 Distribution of shear strains 3minutes after earthquake

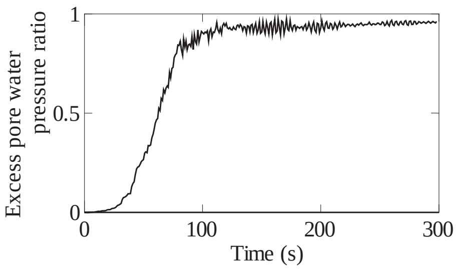

Fig. 10 Time history of excess pore water pressure ratio at point A

Principal publications etc. in Academic Year 2011 (including the first half of AY 2012)

Academic papers:

【*Japanese Geotechnical Journal*】

Reproduction of large-scale landslide failure after earthquake of embankment on inclined ground thorough soil-water coupled finite deformation analysis, Vol.7, No.2, pp.421-433.

International conferences:

【*International Conference on Computational & Experimental Engineering and Sciences, ICCES' 12* (Greece, Crete, March 2012)】Seismic stability assessment of a structure constructed on liquefiable ground with different soil-layer profiles.

【*6th International Workshop for New Frontiers in Computational Geotechnics* (IWS-Takayama, Japan, Takayama, May 2012)】

① Inertia effect on deformation and subsequent triggered acceleration during shear band in overconsolidated clay.
② A three-dimensional analysis of gas-governor located on a liquefiable soft ground.
③ Numerical simulation of failure behavior of naturally deposited clay soil with dynamic motion.
④ The effect of stratigraphic composition and dip of deeper layer on the occurrence of subsurface liquefaction.
⑤ Shearing behavior of embankment materials and seismic response analysis of embankments with different compaction properties.

Domestic conferences:

【*66th Japan Society of Civil Engineers 2011Annual Meeting* (Matsuyama, September 2011) 】2 papers.
【*61st National Congress of Theoretical and Applied Mechanics* (Tokyo, March 2012) 】2 papers.
【*21st Technical Report conference of Investigation, Design and Construction* (Nagoya, June 2012)】1paper.
【*48th Japan National conference on Geotechnical Engineering* (Hachinohe, July 2011) 】16 papers.
【*24th Chubu Geotechnical Symposium* (Nagoya, August 2013)】8 papers.

Seismological Society of Japan:

【*2011Autumn Conference* (Shizuoka, October 2011)】

The influence of deep layer composition on the liquefaction of a sandy surface soil layer containing numerous fine particles.

Japan Geoscience Union:

【*Meeting 2012* (Makuhari, May 2012)】

Non-uniformity of surface layer liquefaction damage caused by layered system organization and dip of deeper layer.

Award for Research using *GEOASIA* Geotechnical Analysis Tool

【*Japanese Geotechnical Society 2011 Research Encouragement Award*】

Mutsumi Tashiro: Prediction of Settlement in Natural Deposited Clay Ground with Risk of Large Residual Settlement due to Embankment Loading, (*Soils and Foundations*, Vol.51, No.1, pp.133-149)

Main Forthcoming Activities in 2012

The Great East Japan Earthquake of March 11, 2011 raised public awareness of the serious social threat posed by earthquake-related soil and foundation disasters such as ground liquefaction and the collapse of valley-filling embankments. At the same time, it also helped to make us more aware of the effectiveness of earthquake countermeasures, from ground improvement to earth reinforcement. The ***GEOASIA*** analysis apparatus is one effective tool for helping people to know "What happens in an earthquake?" and one which has a contribution to make to the mitigation of ground damage disasters through such services as the provision of seismic performance evaluations, the pinpointing of seismic reinforcement needs, and the verification of ground stabilization technologies. In 2012, once again, the Society has plans to carry out survey and research requests, to supply information and technical guidance, and to engage in dissemination and development work. The fruits of these activities will be published in presentations and academic papers in this country and overseas, in the geomechanics and geotechnology fields, but also in seismology. A prominent calendar date will be the 18th (quadrennial) International Conference for soil Mechanics and Geotechnical Engineering to be held in Paris in September, 2013. Surveying work is also continuing in the zones affected by ground liquefaction, mainly in and around Urayasu in Chiba prefecture and research is being pursued to arrive at a clearer understanding of the liquefaction mechanism.

This year is also notable for the appearance of the Society's first textbook written to provide an introduction to the ***GEOASIA*** analysis technology and the elasto-plastic constitutive model (the "SYS Cam-clay Model") that is built into it. The Society is now running a busy schedule of tuition sessions, invitation classes, addresses, and publicity engagements to ensure that the knowledge of this basic constitutive equation behind the ***GEOASIA*** analysis and of the soil test data required for its operation can be readily accessed and understood both by our members already within the Society and by the wider general public outside.

Editorial Afterword

This is now the sixth year since the foundation of the ***GEOASIA*** Research Society as what was then an informal private organization. Gratifyingly, the number of members has risen steadily, reaching a total of 69 individual and 28 corporate members as of July 2012. In addition, 11 ***GEOASIA*** Masters have so far graduated, and the Society has consolidated its organized strength as a body capable of undertaking requested research activities. Since the Great East Japan Earthquake of 2011, there has been a particular increase in requests for earthquake-related analysis tasks such as seismic performance evaluations of infrastructure works, and verifications of the effectiveness of ground reinforcement technologies. For activities that still lie ahead, we rely on the continuing goodwill and support of our loyal members.

An English language version of the Society's homepage was set up in October, 2011. Check it out for additional news and information.

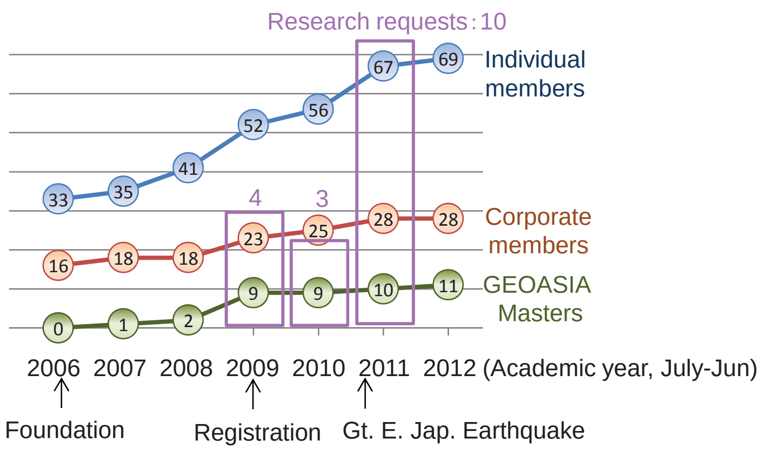

Fig.11 Progress in membership, ***GEOASIA*** Master awards, and research requests.

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