GEOASIA Bulletin No.7

ALL SOILS ALL STATES ALL ROUND

GEO-*A*NALY*S*IS *I*NTEGR*A*TION

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

Issued August 23, 2013

Edited by *GEOASIA* Research Society Office

Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan TEL: +81-(0)52-789-3834

FAX: +81-(0)52-789-3836 E-mail: office@geoasia.jp URL: http://www.geoasia.jp

Message from the Society President

My message this year is a succession of good news items. Last year, ***GEOASIA*** Research Society member Takashi Nanba, a 1979 graduate of the Geomechanical Course at Nagoya University and now employed in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), completed a term as Vice Director of the Kyushu Regional Development Bureau and returned to a post in the Minister's Secretariat in Tokyo as Deputy Minister for Technical Affairs. I vividly recall the opportunity that our Society was given before Dr. Nanba's departure for Kyushu, when he was Director-General of the Port and Airport Department in the Kanto Regional Development Bureau, of carrying out a ***GEOASIA*** -based analysis in his presence to bring to light the details for the basic calculation for the new Runway D design at Haneda Airport. The subsequent analyses performed to assess the change in state of the Runway D site following the Tohoku Earthquake of 2011 and further deformations over time are already concluded and some of the results have been published indicating that almost no damage was sustained. The society will need to remain ready to respond positively to calls from its Dr. Takashi Nanba as he seeks to promote unbiased technical evaluations and ever advancing standards of technology for achieving them. I expect to have more to announce in this matter over the year to come

The second piece of good news is the achievement of another ***GEOASIA*** Research Society member, Mutsumi Tashiro (Nagoya University), in earning the Young Scientist's Prize for 2013, a Commendation in the field of Science and Technology from the Minister of Education, Culture, Sports, science and Technology. The work for which the award was given was "Research regarding the Simple Assessment and Prediction of Large Residual Settlement in a Soft Clay Ground" which had previously received a 2011 Research Encouragement Award from the Japanese Geotechnical Society and was further recommended by the JGS president Toru Sueoka. It was a pleasure, once again, to show that the people with achievements to offer in geotechnical engineering are the real scientists who go beyond experience.

There is one episode that I would like to share in this connection. In June, a sort of calculating contest was held for predicting future developments in a test embankment. Following the same procedure as always, Dr. Tashiro first recreated the stages of the preceding construction process and then carried out an inverse analysis to obtain the corresponding initial state and physical properties of the multi-layered ground in a way that enabled all of the data obtained during testing to be replicated without omission or contradiction, before proceeding to the final prediction. The result, which also drew on the authority of the recent macro-element method, was admirably convincing. But it provoked a remark from a consultant engineer who happened to be in attendance who recalled having similarly written in a paper that after taking every possible step to ensure that past observations and test measurements could be faithfully replicated, the next thing to do was to supply a prediction. Here, a referee had noted "A leap in logic," a comment which he found hard to follow. What was probably meant was that there is a pitfall implied in moving from an inverse analysis to a prediction, since a soil is not a medium out of which an admission of future intent can be extracted by interrogation. A soil is not an elastic body, and to treat it as one by insisting on its "modulus of elasticity being such and such a value" is a pointless operation that cannot achieve any predictive purpose. Rather than extorting a result by force, what is needed is a more compliant scientific model and computation that can draw the soil more gently into telling its own story. This model and computation are a prerequisite for inverse analysis, and consequently need to be in place before it begins. If ***GEOASIA*** is the tool most trusted in geo-engineering, the real reason lies here.

In a recent order submission from the Chubu Regional Development Bureau relating to the verification of the seismic performance of shore protection works on Port Island in the Port of Nagoya, the particular specifications include a demand for the use of the all-round geo-analysis program ***GEOASIA***, a further example of the still rising social demand for our Society's services. On the other hand, it cannot be said that all is going so well with the training of young technicians and ***GEOASIA*** master students. Preparations are in hand for the publication of a ***GEOASIA*** textbook in the coming year, but, not to put too fine a point on it, the Society is still struggling to reconcile its two tasks of developing ***GEOASIA*** (through research) and disseminating it (through education and practical use). The only right way of looking at this, in reality, is to say that just as "with no understanding of clay, there can be no understanding of sand either," so too, "without more research there can be no dissemination, and without more dissemination no research." My message for this year ends on the hope that all members of the Society will work even more strenuously for the challenges facing us ahead.

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

Special Feature:
A principled and natural extension of the functions of the macro-element method

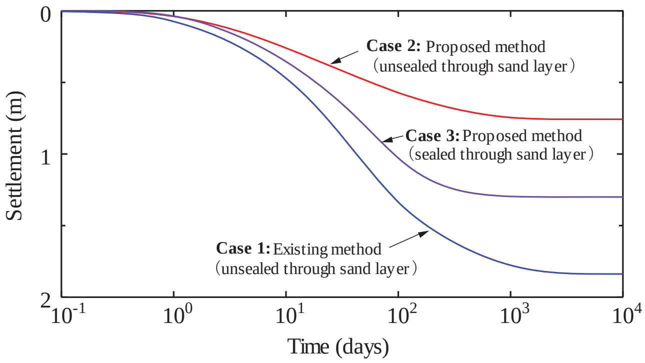


Fig. 1 Time-settlement relation

Soil-water coupled finite analysis makes use of a macro-element method developed by Sekiguchi et al., which allows elegantly for the effects of vertical drainage by simply including it as a computation factor. It is certainly of technical convenience to be able to assume that every soil element shares this draining function, corresponding to the flow of water out of soil pores, which can then be included in the overall calculation as an equivalent for the effect of installing vertical drains without any of the intricacy of having to divide the mesh into smaller units around each individual drain. However, the method also implies that the water flowing out of the soil elements into the drains somehow vanishes into empty space instead of being channeled along real drains to the points of discharge at the surface. To put it another way, water that is lower down in the ground is made to look as if it flows up and over water that is higher up on its way out to the surface. This oddity in the treatment does not matter as long as the amount of pore water flowing in a drain is smaller than the discharge capacity of the drain, but in certain cases such as unmistakable conditions of well resistance it can lead to prediction glitches in which consolidation settlement is assigned to occur at a far earlier point in time than will actually be the case.

This unreal side of the existing macro-element method needs to be eliminated, and to that end an amendment has now been proposed. In the macro-element method, the amount of water flowing hourly out of all the soil elements into the drains is determined as a function of the difference between the pore water pressure in the soil and the water pressure in the drains. Hitherto, this drain water pressure has been a condition assigned by the analyst, but in the proposed amendment it is treated as an unknown variable the value of which is determined as a result of the analysis. As an aid for dealing with this increase in the number of field variables, a simultaneous equation has also been set up, called the "continuity equation through drains," and a system has been devised for its solution. In this amended form of the macro-element method, if drainage capacity is insufficient the water pressure in the drains will be higher than previously assumed, and will consequently have a restraining influence on the compression in the soil elements, thus delaying the process of consolidation settlement. For reasons of sound principle, well resistance will occur instead. It should be stressed that this amended method is a purely natural extension of the original one, reflecting the way in which the drained water is channeled to the surface.

The accompanying Figs. 1 and 2 show analysis results for a problem in which the amended method has been used. Three cases of analysis are illustrated for a ground in which a layer of sand lies interposed between two layers of clay. In Cases 1 and 2, a vacuum consolidation method of ground improvement has been applied, and the result has been analyzed using the existing macro-element method in Case 1 and the amended method in Case 2. In both of these cases, the drains simply pass through the sand. Case 3, also using the amended method, features a different condition in which the drains in contact with the sand layer are previously treated by being wrapped in sealing material. Case 1, based on the existing method, appears to indicate a sufficient effect of pressure release extending far underground in spite of the presence of the sand. But Case 2, based on the amended analysis, shows that the water pressure in the drains has ceased falling as a result of being absorbed into the sand so that the required release in pressure is effectively not achieved. The graph in Fig. 1 shows the consequence of this analysis error in terms of the differences in surface settlement. In Case 3 (based on the amended method, with drains sealed), the release in pressure has genuinely penetrated deep down and, as seen from Fig. 1, the amount of settlement achieved is greater than in Case 2. In this way, with the aid of the proposed new method, it is possible to obtain a principled and natural representation of how the vacuum consolidation method of ground improvement is affected by the presence of a layer of sand and of the effectiveness of sealed drains as a measure for dealing with this.

At present, the Society is wholeheartedly engaged in analyses of consolidation settlement in a peat soil in Tsuruga, a project involving integral use of the proposed new method. One of the distinctive features of ***GEOASIA*** is its versatility in dealing with both dynamic and static soil problems, but we would also wish it to be more widely known that in addition to analyses of seismic response in soils and soil structures, it has equally creditable achievements to show in analyses of consolidation settlement in soft grounds.

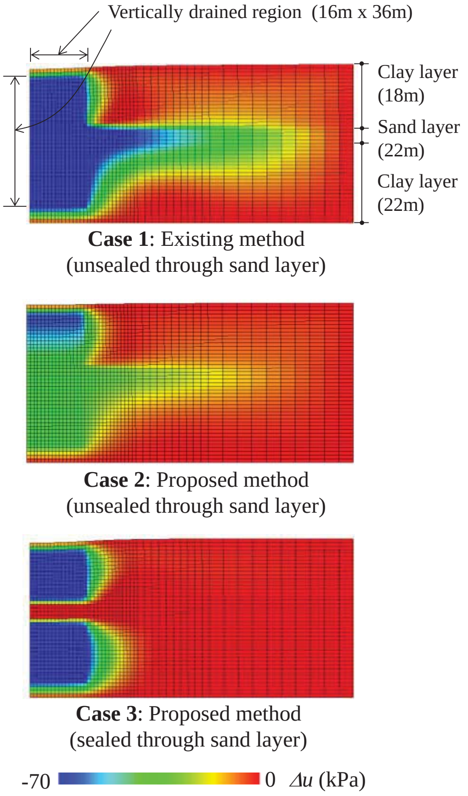


Fig. 2 Distribution of changes in pore water pressure.

Report of activities in Academic Year 2012

① Seismic assessment of river embankments constructed on a low N-value soft ground

The damage sustained by the right and left embankments took different forms. While the right-hand embankment underwent settlement during and after the earthquake as a result of liquefaction in the As1 layer (sand), in the left-hand embankment the restraining sheet pile driven through the Ac2 layer (clay) was unable to withstand the lateral flow of soil in the Ac1 and As1 layers. This illustrates the dangers posed by a diminution in the section area of a river following a rise in the level of the riverbed.

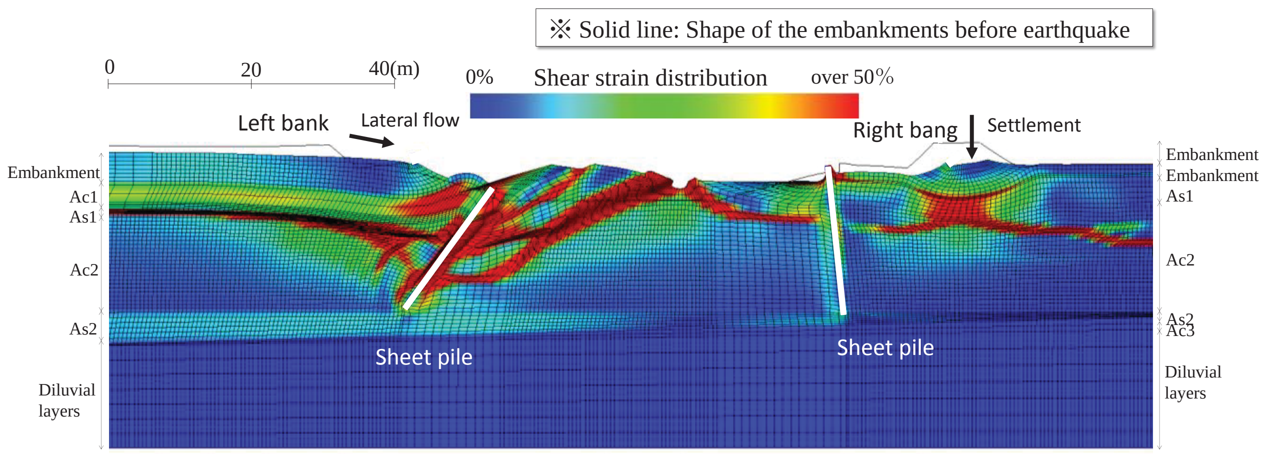
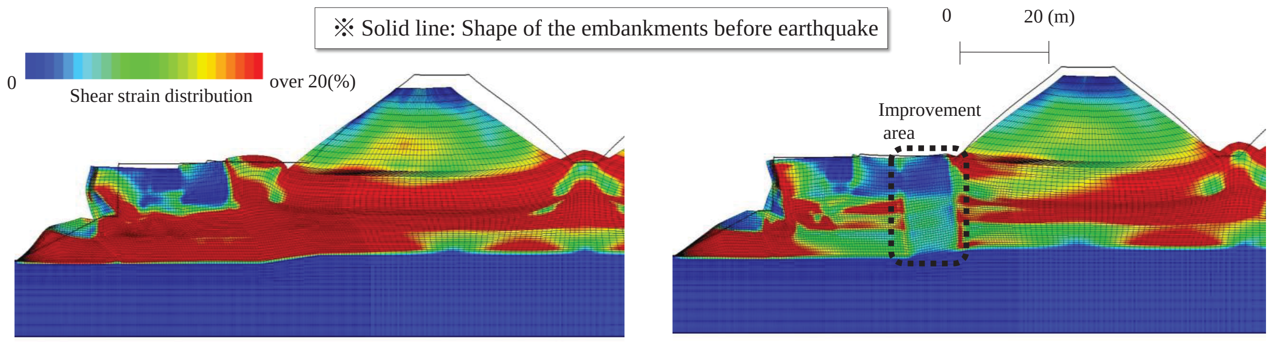


Fig. 3 Collapse of river embankments due to multi-slip damage at time of earthquake.

② Seismic response of a quay wall structure on a foundation of sandy soil and soft clay layers

A seismic response analysis was performed for a quay wall structure which was backed by a ground that included layers of fine-grained sand and sandy clay with an N-value of zero. These layers present a weakness in the event of any liquefaction due to seismic movement and could result in a ground deformation in which the embankment loading causes the quay wall to be pushed out farther into the sea. Methods of seismic improvement were discussed and it was shown that the amount of deformation could be reduced by around 70% by replacing the toe of the embankment with a dense sand.

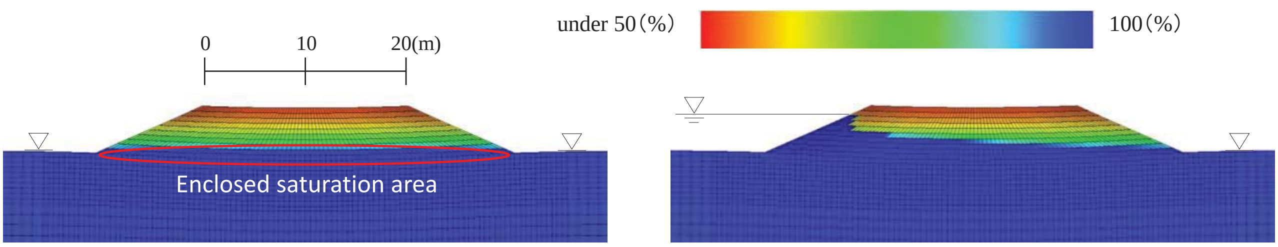


(a) Before improvement (b) After improvement (replacement of embankment toe with denser sand)

Fig. 4 Ground deformation and effect of seismic improvements for a quay wall structure built on layers of sandy clay and soft clay (portion around the coastal defense wall magnified).

③ A post-construction rise of the phreatic surface leading to the formation of an "enclosed saturation area" in an embankment and a post-seismic rise of the surface

A new code has recently been developed for soil-water-air coupled finite deformation analysis for use in both static and dynamic response problems. If an unsaturated silt embankment is built on a more or less saturated clay ground, consolidation settlement will lead to the formation of an "enclosed saturation area" in the lower part of the embankment (Fig. 5 (a)). As the water level on the left goes on rising, this will lead in turn to a rise of the phreatic surface inside the embankment (Fig. 5 (b)). Future research will be required to investigate the deformation and destruction mechanisms involved when an unsaturated earth structure or ground of this kind is subjected to external events such as an earthquake or extreme rainfall, and naturally discussion will then be needed as to what preventive measures are appropriate.



(a) At end of consolidation stage (enclosed saturation area) (b) Rise in phreatic surface

Fig. 5 Change in saturation distributions in an unsaturated earth structure built on a saturated clay ground in response to a rise in water level.

Principal publications etc. in Academic Year 2012 (including the first half of AY 2013)

Academic papers:

【*Japanese Geotechnical Journal*】

Three-dimensional evaluative analysis on peripheral circumference due to compaction in loose sandy ground, Vol.8, No.2, pp.239-249, 2013.

【*Journal of Japan Society of Civil Engineers, Ser. C (Geosphere Engineering)*】

Experimental validation of five failure modes and the proposal of seismic reinforcement in the railway embankment, Vol.69, No.2, pp.174-185, 2013.

【*Journal of Japan Society of Civil Engineers, Ser. A2 (Applied Mechanics)*】

① Excavation analysis of ground using SPH method, Vol.69, No.2, pp I_341-I_350, 2013.
② A study on the seismic reinforcement method considering about failure forms of railway embankment on earthquake, Vol.69, No.2, pp I_403-I_414, 2013.

International conferences:

【*15th World Conference on Earthquake Engineering, 15ECEE* (Portugal, Lisbon, September 2012)】

An attempt to replicate the so-called "trampoline effect" in computational geomechanics.

【*18th International Conference on Soil Mechanics and Geotechnical Engineering, 18th ICSMGE* (France, Paris, September 2013)】

① Prediction of and countermeasures for embankment-related settlement in ultra-soft ground containing peat.
② Dependency of nonuniform ground surface liquefaction damage on organization and slope of deep strata.
③ Interpretation of mechanical behavior of cement-treated dredged soil based on soil skeleton structure.
④ Oscillation of Acceleration Accompanying Shear Band and Subsequent Time-Dependent Behavior in Overconsolidated Clay under Undrained Plane-Strain Conditions.
⑤ Simulation of Delayed Failure in Naturally Deposited Clay Ground by Soil-water Coupled Finite Deformation Analysis Taking Inertial Forces into Consideration.
⑥ Seismic stability assessment of a steel plate fabricated column constructed on liquefiable grounds with different soil-layer profiles.
⑦ Interpretation of the Effect of Compaction on the Mechanical Behavior of Embankment Materials Based on the Soil Skeleton Structure Concept.
⑧ Effect of Seismic Waves with Different Dominant Frequencies on the Delayed Failure Behavior of a Soil Structure-Ground System

【*3rd International Conference on Geotechnique, Construction Materials and Environment*, GEOMATE 2013 (Japan, Nagoya, November)】

① Simulation and prediction of large-settlement in ultra-soft peat ground by deducing the in-situ initial conditions considering artesian pressure.
② Development of SPH method with an elasto-plastic constitutive model considering soil skeleton structure and its application to excavation problems.
③ Seismic response analysis of geotechnical structures built of cement-treated dredged soil.

Domestic conferences:

【*67th Japan Society of Civil Engineers 2012Annual Meeting* (Nagoya, September 2012) 】9 papers.
【*62nd National Congress of Theoretical and Applied Mechanics* (Tokyo, March 2013) 】1 paper.
【*18th Computational Engineering Conferences of JSCES* (Tokyo, June 2013)】3 papers.
【*48th Japan National conference on Geotechnical Engineering* (Toyama, July 2013) 】22 papers.
【*25th Chubu Geotechnical Symposium* (Nagoya, August 2013)】1 paper.

Japan Geoscience Union:

【*Meeting 2012*　(Makuhari, May 2013)】

① Numerical analysis of failure of soil ground due to surface loading and generation of vibration induced by the failure.
② Main shock-aftershock interval effect on the liquefaction damage in Tohoku Region Pacific Coast Earthquake

Award for Research using *GEOASIA* Geotechnical Analysis Tool

【*Japanese Geotechnical Society 2012 International Conference Young Best Paper Award*】

Takayuki Sasaki: Interpretation of the Effect of Compaction on the Mechanical Behavior of Embankment Materials Based on the Soil Skeleton Structure Concept.

【*Young Scientists' Prize for 2013 , Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology*】

Mutsumi Tashiro: Research regarding the Simple Assessment and Prediction of Large Residual Settlement in a Soft Clay Ground.

Main Forthcoming Activities in 2013

In academic year 2013, the Society intends to continue with its existing activities of undertaking survey and research requests, supplying information, providing technical instruction, and developing and disseminating the technology. It will be presenting and publishing research achievements in Japan and overseas, in the academic fields of geo-mechanics and geo-engineering as well as in seismology. In cooperation with programs of academic bodies such as the Japanese Geotechnical Society's Committee for Surveys and Research in Response to the Great East Japan Earthquake ("Seismic Response Committee") and Committee for Research into the Mechanisms of Ground Deformation (chaired by Akira Asaoka), wide-ranging assistance will be given to research and surveying activities through analyses obtained with the use of the ***GEOASIA*** technology. In addition, further efforts will be made to upgrade the constitutive equation underlying the technology, with a view to a still wider palette of applications including unsaturated soils and soils affected by ground improvement.

Just before the 2013 General Meeting, the Society aims to hold what will be the first in a series of mini-courses offering a simple introduction to the constitutive "SYS Cam-Clay Model" of elastoplasticity which is the driving element for the ***GEOASIA*** analytical apparatus. This will also be the year in which the Society's President, Akira Asaoka, is able to apply himself in earnest to the writing of his awaited textbook on Geo-mechanics and Geo-engineering, which he aims to have published next year.

Editorial Afterword

Over the past year, the Society's secretarial office has received numerous enquiries about membership and requests for research, which seems to reflect a steady growth of interest in the ***GEOASIA*** analysis technology and in the research activities surrounding it. As of August 2013, the Society had 73 individual and 32 corporate members, and at the General Meeting in August two new awards of the ***GEOASIA*** Master degree were approved, bringing the current total to 13. In 2014, we plan to enrich the contents of the Society's homepage and put more effort generally into public relations work and the dissemination of the ***GEOASIA*** technology. To close, we would like to thank all members in advance for their unfailing future support of the Society's research activities.

Bulletin No.7 Issued August 23, 2013 Edited by *GEOASIA* Research Society Office TEL:+81(0)52-789-3834 E-mail:office@geoasia.jp