GEOASIA Bulletin No.11

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

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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

At the 52th Japan National Conference on Geotechnical Engineering held at the Nagoya International Congress Center between July 12 and 14 this year (2017), members of the *GEOASIA* Research Society succeeded in presenting more than ten papers. These were highly diverse in their topics and contents, starting from subjects such as: ① An unsaturated soil analysis based on a 3-phase soil skeleton-water-air coupled analysis, ② An increase in software application scope thanks to a full (***u***-***w***-*p*) formulation of a soil skeleton-water coupled analysis, with its future perspectives, ③ Analysis of liquefaction and ground improvement by means of a constitutive equation of "combined loading elastoplasticity," ④ A 2-D, 3-D calculation of surface waves and the reproduction of a long-period, long-duration strong seismic tremor, ⑤ Back-analysis of a seismic recording for a strong tremor in the case of a nonlinear surface-layer ground response, with an estimate of input vibration, ⑥ Shaking table experiment for a model saturated soil embankment slope, with particular regard to natural frequency and input vibration, …, …, and continuing on to: ⑨ Assessing the physical soil quality characteristics of earthquake debris and tsunami deposits, and ⑩ The relationship between slaking in crushed mudstone and grain diameter at the time of compaction, etc. Varied as they were, each one of these presentations provided a lively talking point for the conference and it was heartening to see the Society's young researchers engaged so warmly in their discussions and responses. I was also struck by an astute question with which one of them challenged another presenter enquiring into something called "liquefaction probability": "Liquefaction can't just be a question of one or zero, something that happens or doesn't happen. Doesn't it include a whole dense range of varied complex phenomena between one and zero? How can you turn that into a 0 – 1 scale ...?" Questions like this are a sign of the widening confidence now being placed in the *GEOASIA* approach and the *GEOASIA* Research Society, I felt.

Another noteworthy event this year, at the general Conference of the Japanese Geotechnical Society in June, was the Best Paper (English) award that went to authors Noda, Yamada, Nonaka, and Tashiro for their use of the *GEOASIA* software tool, functionally extended so as to take in a macro-element method, in a numerical analysis of the effectiveness of excess pore water pressure dissipation (EPWPD) as a precautionary measure against liquefaction. Awards are always welcome, whatever the occasion, but what especially impressed me here was the high quality of the article, subsequently included in the journal under the title "Receiving the Geotechnical Society's Research Paper Award." After describing EPWPD as a method, the paper adduced three reasons why problems of this type had previously defied analysis. Then it turned to the matter of whether a sandy soil was more likely to liquefy or consolidate and showed that this was a question demanding just the sort of seamless analysis that no tool except *GEOASIA* can provide, during the seismic event, naturally, but also afterward. The overwhelming superiority of *GEOASIA* to the two or three more traditional "specific programs for liquefaction" now in circulation was set out lucidly in a row of comparison points. The importance of this paper goes far beyond its straightforward case value as an application study for the macro-element method. The *GEOASIA* Research Society has already picked up a number of research paper awards of this kind, but among them all this is probably the paper that deserves the crown. It will be carried in the August 2017 issue, and I wish all of our members enjoyment in their reading of it.

Speaking of this great superiority of *GEOASIA* to more traditional "specific programs for liquefaction," a paradox that seems to be arising lately, even as awareness of this superiority spreads and deepens, is a tendency in both engineering departments and the construction world, to regard *GEOASIA* and the *GEOASIA* Research Society as "inward-looking." This is certainly not a description of the Society's real attitude.

As the surest means of overcoming "inwardness," our most pressing priority now is the creation of a Geomechanics textbook, of inspiring content, to prepare budding geotechnical specialists in *GEOASIA* Master or similar courses. What is needed in fact is a third revolution in geotechnical education texts to continue the impulse of the Cam-Clay approach that came to us from Taylor through Schofield and Wroth. In *The Fundamentals of Soil Mechanics* (1948), Taylor delivered the general summary of soil-type mechanics that had grown out of the work of Terzaghi. In *Critical State Soil Mechanics* (1968), Schofield and Wroth showed how this needed extending to take in the findings of elastoplastic theory. What fundamentally new element is required now, then, as the third advance in this revolutionary chain? Mere refinements of the elastoplastic constituent equation to allow for finite element methods, numerical computations, mixed soils and so on are not enough, taken singly, to warrant the use of a term like "revolution." The time has come for a more heated discussion of how to combine all of these issues into one integral analysis: *All Soils All States All Round Geo-analysis Integration*.

This demand for a textbook is equaled, if not surpassed in urgency, by the issue of the long awaited release and diffusion of the *GEOASIA* program package itself. *GEOASIA* has its roots in a concern for "laying foundations." A true foundation is not completed by "giving form and substance to a construction ground and then subjecting it to its own weight." To take the instance of a river levee on an alluvial foundation, there are all kinds of diverse factors – the nature of the alluvial sediments, the structure of the levee, the dredging of the river course, to mention only some – that need to be attended to before an earthquake occurs. For our local port of Nagoya, we are currently engaged in calculations to track the loading history of shore defenses back to the (pre-1867) Edo period for use in a model reproducing the present-day state of the ground. Enhancing *GEOASIA* to the level of numerical operability required for work of this kind is no easy challenge, but we are making steady progress with it, as well as with all the other associated tasks of how to improve our pre-post processor, arrange elastoplastic ground data parameters into a single data bank, and so on. It will be worth the wait.

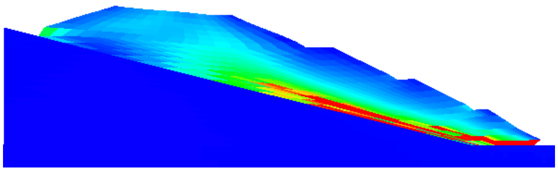
We are confident that the more chances engineering professionals have to put *GEOASIA* to the test, the more its latent potentials will blossom forth. All that remains for me to do otherwise is to appeal to all readers, especially to members of our Society, to give their constant support.

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

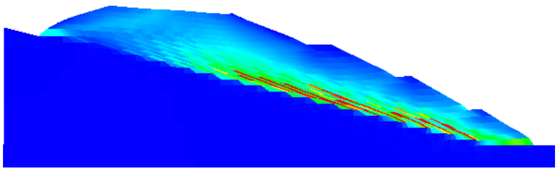
Research Results in 2016

(1) The effectiveness of foundation stepping for the enhancement of earthquake-resistance in an embankment constructed on a sloping foundation

In an investigation of an embankment built on a sloping foundation, the seismic responses were analyzed and discussed for two contrasting cases in which the foundation was or was not initially treated by cutting steps into the slope. Results for the case in which no stepping treatment was performed showed that an earthquake would cause considerable amounts of shear strain along the interface of the embankment with its foundation. Where stepping was performed, however, areas of high and low strain response occurred separately and without coupling. As a result, the settlement at the crown of the embankment was found to be around 20% less than in the untreated case.



(a)With no stepping

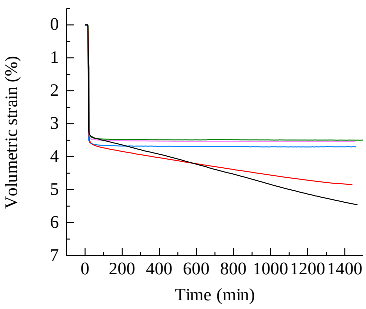


(b) With stepping

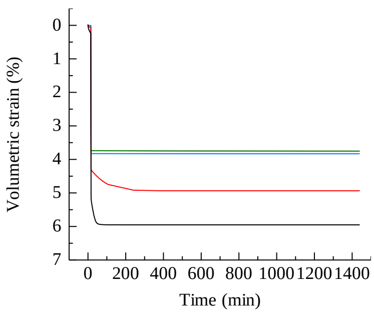
Figure 1. Sear strain distributions

(2) A numerical analytical study of the influence of a permeable ceramic disc on the results of a triaxial unsaturated soil test

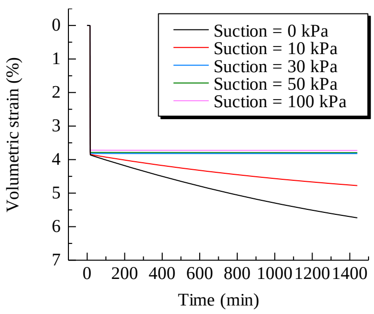
The SYS Cam-clay model extended with a function for suction effect was used to perform a three-phase coupled analysis simulating a suction apply and isotropic consolidation in a triaxial unsaturated silt test of the kind reported by Kodaka et al., including the subsequent sequence of processes up to drained and exhausted shearing. Figure 2 shows actual test results for variations of volumetric strain during the suction apply and isotropic consolidation process (a), along with two sets of computed results, one making no allowance for the presence of the ceramic disc (b) and the other allowing for it (c). It is clear that a good simulation of the experimental results can be achieved when the presence of the disc is allowed for. Figure 3 shows pore water pressure distributions computed for the same point of time in the suction process, first without any regard for the disc (a) and then with regard for it (b). In both cases, the suction inducing the increase in water pressure from the bottom of the sample is taken at 0kPa. It is clear from the two samples that the low permeability of the ceramic disc blocks the adsorption of water at the bottom end. Construing the triaxial test as an initial value / boundary value problem in this way prompts the suggestion that the impermeability of the disc has a large bearing on the test results.



(a) Actual test results



(b) Computed results, without disc



(c) Computed results, with disc

Figure 2. Volumetric strain against time

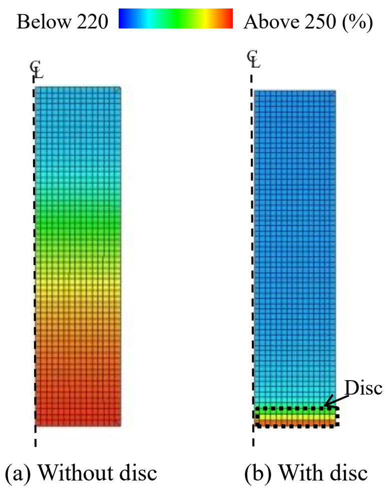


Figure 3. Pore water pressure distributions

(3) Simulation of shear strain development in cylindrical cement piles used for ground improvement

The SYS Cam-clay model adapted for use with cylindrical cement piles used in a ground improvement system was used in a triaxial analysis to simulate shear development. In the process reproduced, a shear plane formed along a nick running slantwise up the side of the test piece while, in an accompanying process, a deviation was found to occur from the apparent path of uniform stress-strain deformation.

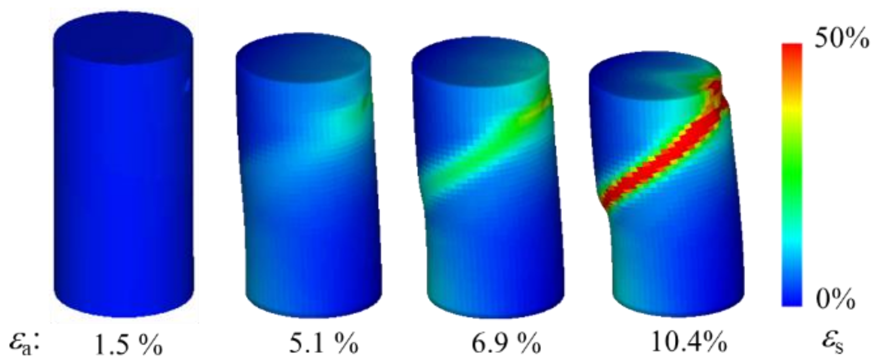


Figure 4. Shear strain distributions

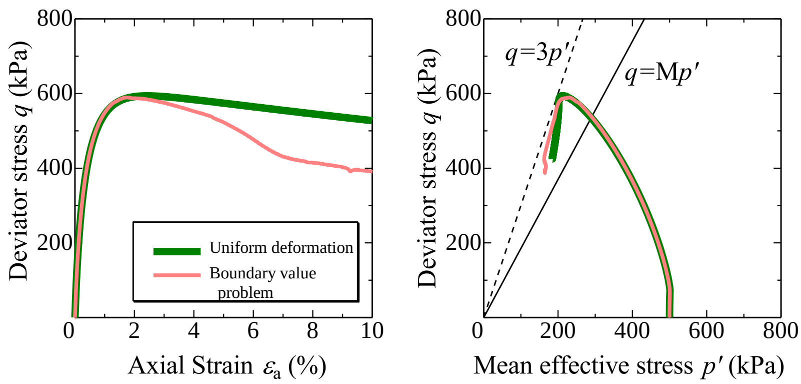


Figure 5. Apparent behavior as an element

(4) Simulation of a seepage model test using a soil skeleton-water-air coupled finite deformation analysis

A simulation was performed of a seepage model test based on a soil skeleton-water-air coupled finite deformation analysis, in order to clarify the mechanism of a type of river levee seepage failure that occurred in 2012, during torrential rains, along the Yabe River in Northern Kyushu. The analysis section is as shown in Figure 6. The foundation on which the levee was built consisted of a low-permeability surface layer, 3cm thick, overlying a high-permeability layer beneath. Water seeped into the levee to the right at a certain constant level. Figure 7 shows shear strain distributions, and Figure 8 the mean skeleton stresses. Due to the seepage, the mean skeleton stress at the foundation layer boundary are close to zero, giving rise to a boiling phenomenon that then leads to progressive surface slips. In this, the result of the simulation closely reproduces that of the model test. Assuming a rather thicker low-seepage layer of 5cm, the test result indicates almost no deformation damage and the result is similar in the numerical analysis. In this sense, the simulation also succeeds well in locating the division between the two cases of failure and non-failure.

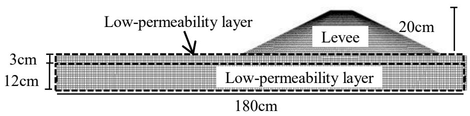


Figure 6. Analysis section

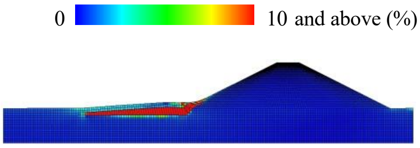


Figure 7. Shear strain distributions

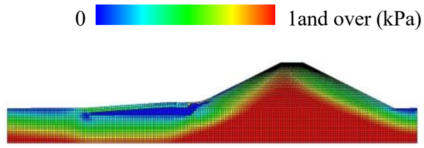


Figure 8. Mean skeleton stress distributions

(5) Seismic and post-seismic behaviour of the ground beneath the base of a spherical gas-holder

This research discusses 2-dimensional plane strain conditions and the likelihood of uneven seismic and post-seismic settlement in the ground beneath the base of a spherical gas-holder built on an exceptionally soft ground comprising a liquefaction-prone sandy top-layer resting on a 15m deposit of clay sediment so weak as to have an N-value of almost zero. Assuming that this ground is subjected to an L2 earthquake of sufficient intensity to completely destroy the ground piles, a 2-dimensional model of conditions affecting the gas-holder was created by making the wave frequency conform to the natural period of the structure. As can be seen in Figure 9, the final amount of settlement is relatively large, at approximately 60cm. However, the shear strain distributions (Figure 10) indicate that in spite of the lack of left-right symmetry in the ground under the structure base, there is very little appearance of uneven settlement.

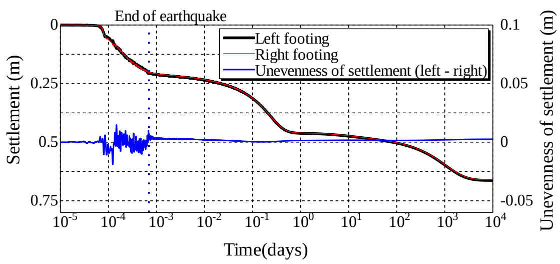


Figure 9. Amount and unevenness of settlement

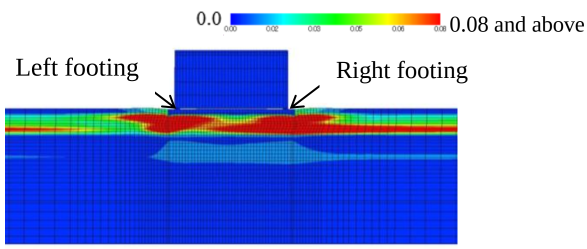


Figure 10. Distribution of shear strains at the end of post-seismic consolidation

Principal publications etc. in Academic Year 2016 (including the first half of AY 2017)

Academic papers:

【***Soils and Foundations***】

Verification of a macro-element method in numerical simulation of the pore water pressure dissipation method -a case study on liquefaction countermeasure with vertical drains under embankment-, Soils and Foundations, Vol.57(3), 2017.

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

Seismic assessment of input seismic wave on ground-chimney interaction system, Vol.72, No.2, pp. I_409-I_418, 2016.

Domestic conferences:

【71th Japan Society of Civil Engineers 2015Annual Meeting (Sendai, September 2016) 】8papers.

【2016 Seismological Society of Japan fall meeting (Nagoya, October,2016) 】2 papers.

【20thSymposium on Applied Mechanics(Kyoto, May, 2017) 】2papers.

【Japan Geoscience Union Meeting 2016（Makuhari, May, 2017)】2papers.

【22th Computational Engineering Conference（Niigata, May,2017)】2papers.

【52h Japan National conference on Geotechnical Engineering (Nagoya, July 2017) 】11 papers.

Awards for Research using the *GEOASIA* Geotechnical Analysis Tool

【***Japanese Geotechnical Society 2016*: *The research/paper awards (English category)***】

Toshihiro Noda, Shotaro Yamada, Toshihiro Nonaka, Mutsumi Tashiro: Study on the Pore Water Pressure Dissipation Method as a Liquefaction Countermeasure Using Soil-water Coupled Finite Deformation Analysis Equipped with a Macro Element Method. (https://www.jiban.or.jp/images/hyosyo/H28JGSaward07.pdf)

Editorial Afterword

The photograph at the top of the first page of each issue of the *Bulletin* shows the Society President in a recent likeness. For this issue, we chose a shot taken last year (2016) at Professor Akira Asaoka’s 70th birthday (Japanese: “Koki”) celebration. It is a thoroughly dashing portrait, a far cry from what would ordinarily be associated with “threescore years and ten”, but that is all the more reason to celebrate. Another cause for jubilation, already recalled in the Message from the President, was the bestowal of the 2016 Japanese Geotechnical Society research/paper (English) award on our board member Professor Noda and three of his colleagues. The macro-element method featured in their paper is now incorporated into the *GEOASIA* software and available for application to practical calculation tasks. Members are urged to make use of it. It should also be mentioned that the Society’s homepage was renovated in 2016 and will now provide fuller access to a wide variety of information about *GEOASIA*, including the contents of the *Bulletin*. We will continue to spare no efforts in meeting the demands and expectations of all of our members, only asking in return that they remain loyal to us in their unflinching support.

(Toshihiro Takaine)