GEOASIA Bulletin No.2

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

A year has gone by since the inaugural appearance (August, 2007) of the ***GEOASIA*** Bulletin, and it is now time for a second issue. Thanks to the cooperation of the Research Society members, research activities have continued vigorously in the interval, with a large crop of results, as reported below. They are all solutions to problems which could not even be tackled without the use of the ***GEOASIA*** soil analysis tool, and I am sure that the members who were involved in the research and analysis work will be delighted with the attainments.

The purpose of ***GEOASIA*** is to provide a transient response analysis of all that occurs in a foundation or earth structure, in ***ALL SOILS***, including sand, clay, intermediate and artificially processed, in ***ALL STATES***, through deformation to destruction, and for ***ALL ROUND*** applications to static or dynamic problems. In the past year we have been blessed with opportunities for presenting this in practice. One such opportunity was my own chance to deliver a special address to the 57th National congress of Theoretical and Applied Mechanics of the Science Council of Japan (SCJ). The main convener of this event is the SCJ, but in addition to being cosponsored by the Japan Society of Civil Engineers (JSCE) and the Architectural Institute of Japan (AIJ), it also draws attendance from numerous other academic associations in fields including aeronautical and space sciences, mechanical engineering, fluid mechanics, and mathematics. This year it was fortunate that The Japanese Geotechnical Society (JGS) was the presiding association, so that I had the chance to deliver the address as the Society's representative. I spoke for an hour under the three content heads of "the constitutive equation of a soil material", "soil-water coupled finite deformation analysis" and "application examples", and made the point that it is a thing of the past now to make statements of the sort "we can compute the compression consolidation of clay, but we cannot compute the compaction of sand". Another opportunity to introduce ***GEOASIA*** was an address given by one of the Research Society's directors Toshihiro Noda to the 43rd Japan National conference on Geotechnical Engineering at Hiroshima. This was in response to an invitation to introduce the content of a paper on bearing capacity which Toshihiro Noda, Shotaro Yamada and others had published in the journal *Soils and Foundations*, and which the Geotechnical Engineers had distinguished with their Outstanding Paper Prize. The gist of the paper was that bearing capacity problems in general were a subclass of progressive failure problems, which previous limit analyses for rigid plasticity had been unable to handle; that being so, the eyes of the conference audience were riveted to the moving calculation graphics which showed the progressive collapse of an embankment on a soft soil foundation following the shock from an earthquake.

Many fundamental research problems still remain to be solved, including further refinement of the constitutive equation, the enhanced practicability of the 3-dimensional calculation and the shortening of the computation time, and a fuller use of the Pre-Post processor. The fulfillment of the educational program leading to ***GEOASIA*** MASTER also poses a considerable challenge. This year, congratulations to society member Hidekatsu Takeuchi of Fudo Tetra Co. Ltd. on being chosen for the second ***GEOASIA*** MASTER award. However, ***GEOASIA*** will not be able to claim that it is meeting its originally announced social and international responsibilities until a total of something closer to 30 ***GEOASIA*** MASTER awards can be earned in Japan and overseas. It is expected that there will be more ***GEOASIA*** MASTERs next year, and all of the team under directors Nakano and Noda are making exertions to bring that about. As President, I would add my earnest hope that all members of the Research Society will lend their cooperation and support to this effort. My warmest greetings to all,

Akira Asaoka, Professor, Nagoya University Graduate School

Summary of Award-winning Academic Paper based on *GEOASIA*

～2007 Outstanding Paper Prize, The Japanese Geotechnical Society～

A paper containing ***GEOASIA*** analysis results published in *Soils and Foundations* (Noda T., Asaoka A. and Yamada S. (2007): "Some bearing capacity characteristics of a structured naturally deposited clay soil", Vol. 47, No. 2, pp. 285-301) was awarded the 2007 Outstanding Paper Prize by the Japanese Geotechnical Society. The paper's contents are summarized below.

Departing from the classical approach, the paper set out to tackle a bearing capacity problem through the use of a soil-water coupled finite deformation analysis (***GEOASIA***) incorporating the latest type of elasto-plastic constitutive equation (the SYS Cam-clay model). As opposed to a rigid plasticity analysis which (all in one move) would seek to find the equilibrium of forces in a foundation at a stage of total plasticity and the location of a plastic flow in one part of it, the paper graphically reproduced the phenomena accompanying a stage of deformation in the displacement control load of a part of the foundation: the obvious occurrence of a circular slip line accompanied by a decrease in load (i.e., softening in the load soil). For many researchers seeking to represent a foundation failure within a deformation analysis, that is to say, as an extension of the deformation phenomenon, not as a distinct event, classic bearing capacity problems have regularly been used as a perfect analysis target. But almost all analyses of this sort appear to have relied on expedients such as manipulative softening in the constitutive equation, the introduction of elements to permit discontinuous deformation, the use of gradient theory, or some other special technical tool for the replication of localized deformation or load softening. The authors of this paper also chose a bearing capacity problem as their object for analysis, but where their work differed greatly from previous ones was in the fact that it did not require any importation of special technical tools or theories for its private purpose of solving the bearing capacity problem. In other words, it employed a soil skeleton-water coupled deformation analysis based on a perfectly general theory of finite deformation (***GEOASIA***) and incorporating a constitutive equation for naturally deposited soils also based on a perfectly general theory of elasto-plasticity (the SYS Cam-clay model) to solve a bearing capacity problem without having to make extra allowances for localized deformation, load softening etc. as one-off concomitants of progressive failure. And this was the first point about this paper that made it so special.

The paper also offered discussions of a large number of geotechnical issues for which no firm views yet exist regarding bearing capacity problems; for example, if only the initial conditions of a problem are varied, what sort of influence does the soil state, i.e., the degree of development of the soil skeleton structure (structure, overconsolidation, anisotropy), have on the limit load and the failure form? More particularly, the paper was able to show analytically, among other things, that ① deformation phenomena such as localization and load softening occur not in reconstituted clays of the sort remolded in laboratories, but in naturally deposited clay soils in advanced states of development; ② in soils with anisotropy, the influence of this is all the more apparent as the region of failure becomes more confined; ③ where the initial state of a soil has imperfections, the higher structured the soil, the greater the likelihood of asymmetric deformation and the greater the risk that this will lead to a large fall in load; ④ within the soil-water coupling framework, a partial draining effect can be obtained naturally in a bearing capacity problem simply by changing the loading rate; and ⑤ at a certain rate of loading which allows a steady exchange of pore water through a highly structured soil, the shear band in the soil will show an alternation of "compaction bands" marked by draining and softening and "swelling bands" marked by adsorption and softening. This series of findings was the second thing that made the paper special.

Readers who would like to see for themselves the moving graphics belonging to Fig. 2 below can access them through the Japanese Geotechnical Society homepage (http://www.jiban.or.jp/topic/prize/2007/noda.pdf).

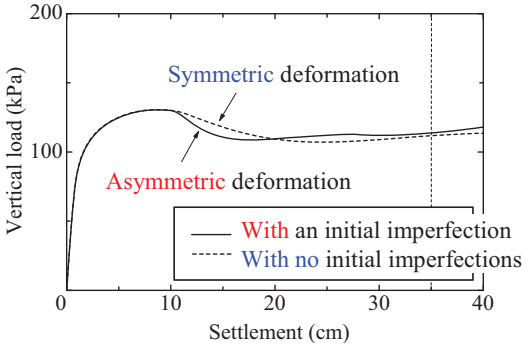

Fig. 1 Foundation settlement - vertical load

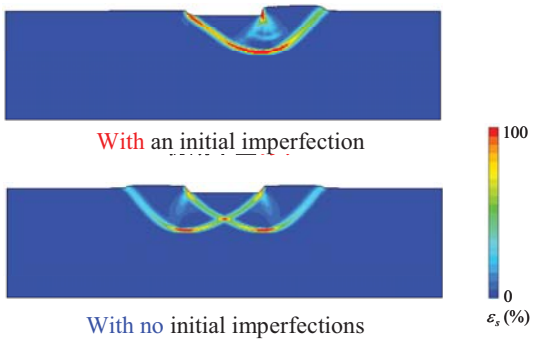

Fig. 2 Differences in the form of circular slip

① Analysis of the behavior of a foundation-embankment coupled system, based on an experiment using a centrifugal loading model

An experiment was performed using 40g field-centrifugal loading model tests to quantitatively verify the seismic and post-seismic behavior of an embankment and its clayey/sandy foundation; the equivalent behaviors were also analyzed for the altered case of an ultra-soft clay foundation. During the earthquake, almost no damage could be seen either in the embankment or in the foundation, but around 8 hours after the end of the quake, a circular slip occurred (on the right side) passing through the foundation. After a further delay, another circular slip occurred (this time, on the left side).

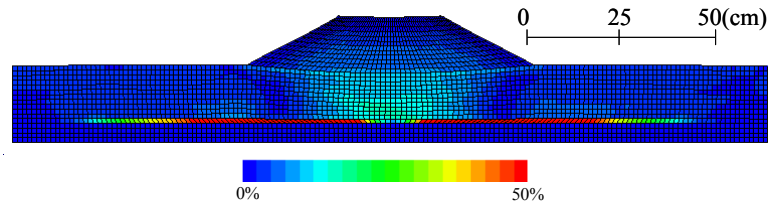

Fig. 3 Distribution of shear strains immediately after the end of the earthquake (analysis performed on a scale of 1/40)

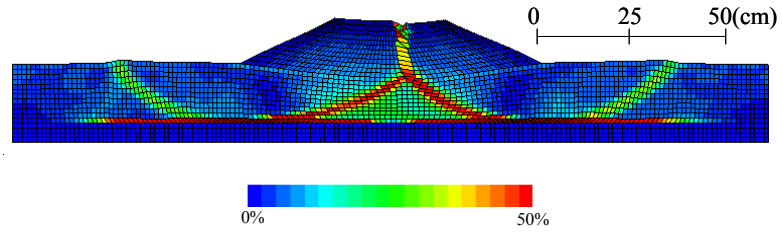

Fig. 4 Distribution of shear strains around 8 hours after the earthquake (analysis performed on a scale of 1/40)

② Analysis of the destruction of an embankment in the 2007 Noto Peninsula Earthquake

The Noto Peninsula Earthquake inflicted great damage on earth structures, with failures especially frequent in embankments on sloping foundations. A comparative analysis was carried out of the seismic behaviors of embankments on horizontal and sloping foundations. Depending on variations in the magnitude of the earth tremors, differences appeared in the patterns of collapse during the quake and of delayed failure following it.

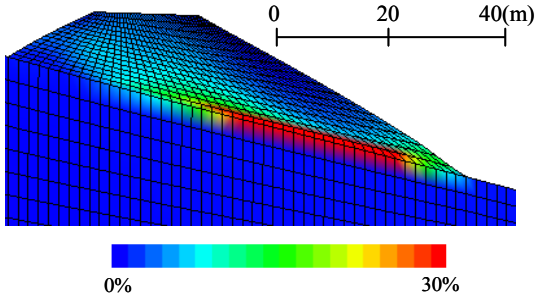

Fig. 5 Distribution of shear strains 50 seconds after the occurrence (immediately after the end) of the earthquake (breadth of analysis 1km, embankment portion enlarged)

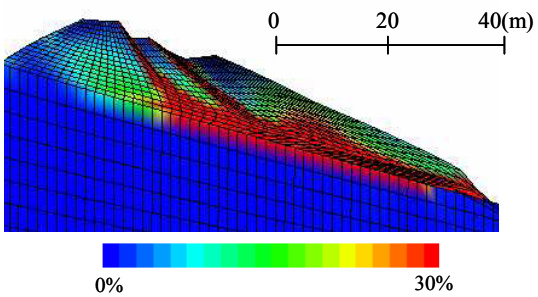

Fig. 6 Distribution of shear strains several days after the occurrence of the earthquake (breadth of analysis 1km, embankment portion enlarged)

③ Analysis of the seismic response of a foundation ground improved by the sand compaction pile (SCP)

A comparative analysis was performed of the seismic behaviors of two intermediate foundations, one unimproved and the other improved with sand compaction piles. This is a plane strain analysis, but the effectiveness of the improvement is obvious. The red lines in Fig. 8 coincide with the sand piles.

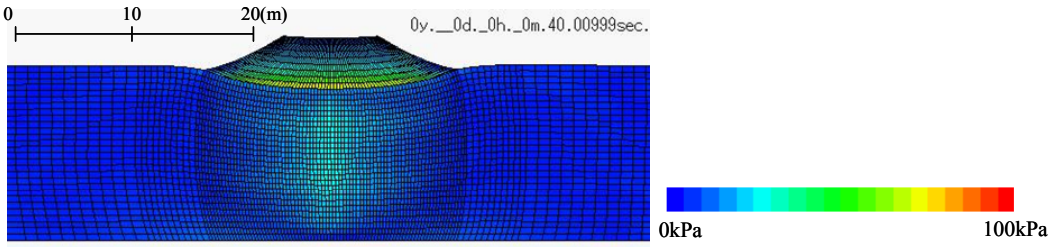

Fig. 7 Distribution of average effective stresses immediately after the end of the earthquake (ground unimproved by SCP method)

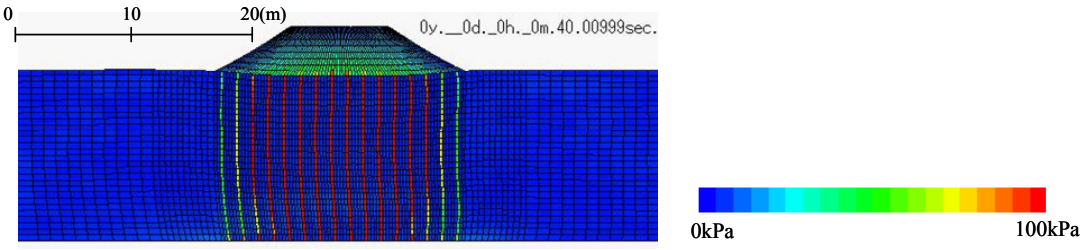

Fig. 8 Distribution of average effective stresses immediately after the end of the earthquake (ground improved by SCP method)

④ Deformation analysis of a fill dam during an earthquake

An analysis was performed of the seismic behavior of a fill dam which had been built in a manner that left the original relatively permeable ground in place. A considerable amount of water pressure arose in this ground, and the load from this deep ground water caused deformation in the dam wall in the rightward direction as shown in the figures, with a concentration of shear strain in the relatively weak original ground.

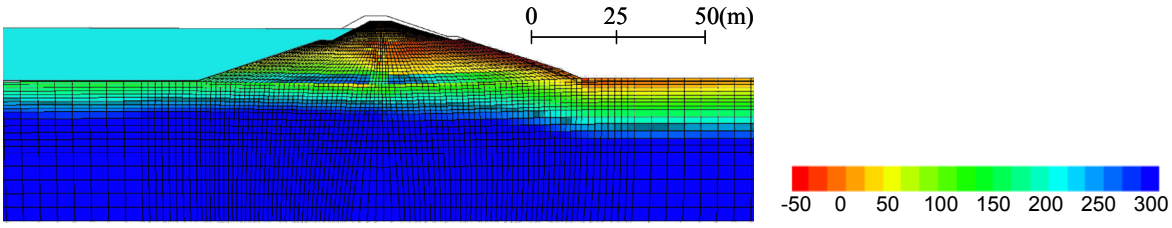

Fig. 9 Distribution of pore water pressures immediately after the end of the earthquake

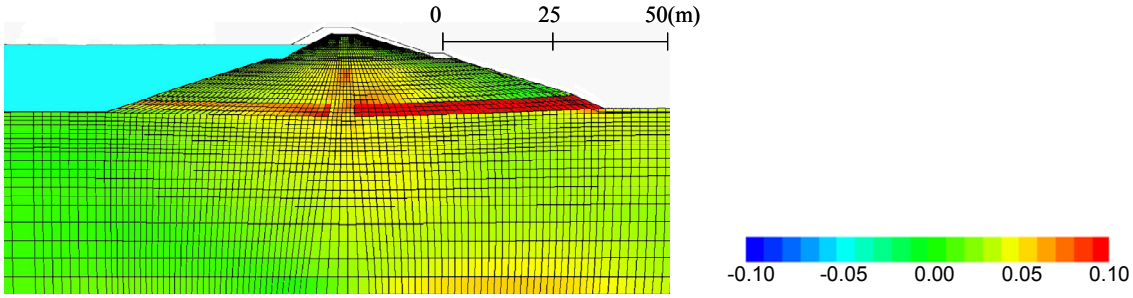

Fig. 10 Distribution of shear strains (τ_{xy}) immediately after the earthquake

⑤ 3-dimensional analysis of liquefiable ground installed with improvement devices

A 3-dimensional analysis was performed of the seismic and post-seismic behavior of a sandy foundation installed at dispersed intervals with circle-enclosed ground improvement piles. In places where piles were installed, the rise in excess pore water pressure could be better controlled during the quake and more quickly dissipated after it. The method therefore has a controlling effect on ground settlement.

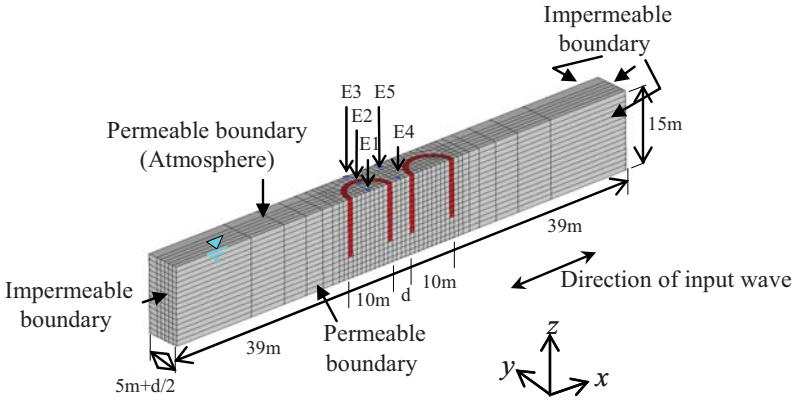

Fig. 11 3-dimensional mesh used in the analysis

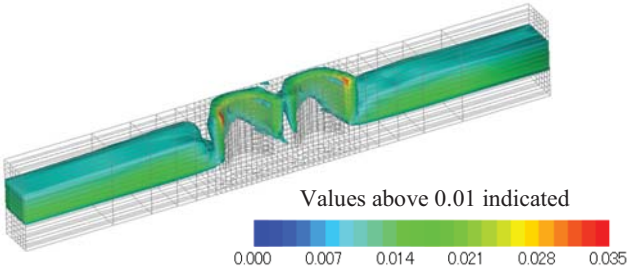

Fig. 12 Distribution of shear strains after consolidation due to seismic loading

Principal publications etc. in Academic Year 2007 (including the first half of AY 2008)

Academic papers:

【*Soils and Foundations*】

① Ground improvement of intermediate reclaimed land by compaction through cavity expansion of sand piles, Vol.48, No.5, pp.653-671, 2008.

② Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating the SYS Cam-clay model, Vol.48, No.6, pp.771-790, 2008.

International conferences:

【*3rd Sino-Japan Geotechnical Symposium* (Chongqing, China, Nov. 4-7, 2007) 】

Seismic/post-seismic response of a natural soil in delayed settlement, pp. 73-86.

【*APCOM '07* (Kyoto, Japan, Dec. 3-6, 2007) 】

Soil-water coupled finite deformation analysis applied to bearing capacity problems of structured clayey soils, Paper no. MS29-1-2.

【*Earthquake Hazard and Mitigation* (Guwahati, India, Dec. 7-8, 2007) 】

Effects of embankment rigidity on behavior of naturally deposited soils during/after earthquakes, pp. 249-256.

【*13th Asian Regional Conference on SMGE* (Kolkata, India, Dec. 10-14, 2007) 】

① Structural upgradation in clay and sand accompanying plastic swelling, pp. 23-26.

② Soil classification for occurrence of in-situ delayed consolidation, pp. 415-418.

③ Liquefaction-induced consolidation settlement of soil after earthquake, pp. 602-605.

④ Improvement of manmade island filled with intermediate soils by SCP method, pp. 787-790.

【*2nd US-Japan Workshop on Ground Improvement* (Sacramento, California, May 16 and 17, 2008) 】

Coseismic and postseismic deformations of reinforced/improved soil structure-ground systems.

Domestic Conferences:

【*62nd Japan Society of Civil Engineers 2007 Annual Meeting* (Hiroshima, Sep. 2007) 】3 papers.

【*43rd Japan National conference on Geotechnical Engineering* (Hiroshima, Jun. 2008) 】8 papers.

【*57th National Congress of Theoretical and Applied Mechanics* (Tokyo, Jun. 2008) 】

① Consolidation in clay and compaction/liquefaction in sand: Focusing on the concept of structure (Special address), pp. 1-10; also:

② Soil skeleton-water coupled analysis of post-seismic delayed failure in a clay foundation-embankment system.

【*13th Conference of the Japan Society for Computational Engineering and Science* (Sendai, May 2008) 】

Computation of the seismic liquefaction/compaction behavior of a sandy foundation, paying consideration to the compressibility of pore water, Vol. 13, No. 1, pp. 227-230.

【*TC34 Domestic Committee "Symposium on Prediction and Simulation Methods for Major Deformations in Foundation Mechanics"* (Tokyo, Oct. 2007) 】

① Analysis of progressive failure in a soft foundation soil accompanying the loading of a multi-phased test embankment, pp. 69-72.

② Seismic/post-seismic behavior of a reinforced embankment-alternate sand/clay layered soil system, pp. 73-80.

Principal forthcoming activities in 2008

In the coming year, in addition to submissions of research results to journals such as *Soils and Foundations*, presentations are planned to international conferences including the International Symposium on Prediction and Simulation Methods for Geohazard Mitigation (IS-Kyoto, May 25-27, 2009), the International Conference for Performance-Based Design in Earthquake Geotechnical Engineering - from case history to practice - (IS-Tokyo, Jun 15-18, 2009), and the (quadrennial) 17th International Conference on Soil Mechanics and Geotechnical Engineering (2009 ICSMGE, Egypt, Oct. 2009).

For the further enhancement of ***GEOASIA***, accelerated performance is now being sought through parallelized processing. As an educational program, we intend to hold a study and workshop event for Research Society members; details will be announced, and we hope many will take part. On the publicity side, as an addition to setting up the Society homepage, we are also considering stands at company exhibition fairs.

Editorial afterword

Professor Asaoka, the President of our Research Society, has now been named President of the Japan Society of Geotechnical Engineers. We need to aim for a program of activities that will bring no embarrassment to him, and with that in mind we ask all our readers for their continuing support. The Inaugural Issue of the Bulletin has now also come out in English, and we invite you to take a look at that, too.

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