GEOASIA Bulletin No.1 Inaugural issue

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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Edited by *GEOASIA* Research Society Office TEL: +81-(0)52-789-3833 & +81-(0)52-201-7850

E-mail: geoasia@soil.civil.nagoya-u.ac.jp

Message from the Society President

Specialization may be an unavoidable accompaniment to development in science, but specialization that runs to excess can actually hinder development. It seems to me that foundation engineering is no exception to the rule. I am not just talking about the separate versions of mechanics that exist for sand and for clay, or the fact that dynamics and statics engage different specialists. When it reaches the point that we take it for granted that a model purpose-designed to find undrained responses in loose sand will have no power to handle compaction in the same loose sand, or that dense sand presents quite separate problems again, or that a program devised for compressive deformation is unable to calculate the bearing capacity of a foundation, or that one that is capable of computing liquefaction in a soil cannot be expected to compute compaction, and so on and so forth, all that we have left of geotechnology in the end is an assemblage of miscellaneous specialist tools. And if that is the case, it means that when an external force comes to act on a foundation there is no system in place in geomechanics to allow consistent answers to questions such as: 'Will the ground fail or only be deformed?", "Will liquefaction occur or compaction?", or, more generally, "After an event like an earthquake, what is going to happen to that ground, and how?" Can we be satisfied with that? Questions like these gave the departure point from which the ***GEOASIA*** Research Society first set out.

It was at the end of August a year ago that the Society, with the aid of numerous public and private supporters, held its inaugural General Conference and affirmed its articles of association. Now, just a year later on August 24, we have been able to open our long awaited second General Conference, at which reports can be presented of the Society's first year of activities. I sincerely wish to thank all those who have given their support in this year, both those in public and private positions who have collaborated administratively by entrusting the Society with research requests, and also the many foundation engineers among our membership who have contributed to the growth of the ***GEOASIA*** integrated geo-analysis technology by responding to these requests.

One of the grand objectives of the Society affirmed in the articles of association, along with the regular aim of assuring steady progress for the ***GEOASIA*** analysis tool, was to support the personal research efforts of Society members. This year I am pleased to announce that Toshihiro Takaine, of the Asanuma Corporation Technical Research Center, has been chosen to receive the first official ***GEOASIA MASTER*** award. For the moment, the operations of this calculation program are still restricted to the ***GEOASIA*** Research Promotion Center housed in Nagoya University, but with growth in the ***GEOASIA MASTER*** project, we expect quite soon to see the work made publicly accessible.

Akira Asaoka, Professor, Nagoya University Graduate School

What's special about *GEOASIA*? (What can *GEOASIA* do?)

Describing ***GEOASIA*** as if it were a car, we can say that it is a calculating tool based on a soil-skeleton and water coupled finite deformation theory, which has for its engine the SYS Cam-clay model, a constitutive equation of soil skeleton, mounted on a chassis of continuum mechanics and mixture theory. The SYS Cam-clay model is an elastoplastic constitutive equation based on the ordinary Cam-clay model, but including a description of the soil skeleton structure mechanisms (structure, overconsolidation, anisotropy) which enables it to express mechanical behaviors of all kinds of soil, from clay, with its pronouncedly non-linear material characteristics, through intermediate soil types, to sand, all within the same one logical framework. Finite deformation theory is a theory which takes account of geometrical non-linear deformation from the primitive equation stage on in order to be able to trace the geometrical shape deformation of foundations and structures. Consequently, unlike all the specialized tools that constantly call for divisions of application depending on the tool user's varying perception of whether the foundation soil in question is clay or sand, whether the event being studied is one of deformation or failure, or whether the external state of forces is dynamic or static, ***GEOASIA*** is a single tool that will tell you "what will happen to this ground" if you simply put in the data from the "soil test" with what seems to be the external state of forces.

The components of the *GEOASIA* foundation analysis program

"Chassis" components

Mathematics (continuum mechanics, geometry, differential equations, numerical analysis)
Soil-water coupled analysis (finite deformation, inertial response)

"Engine" components

Soil mechanics (elastoplastic constitutive equation)
SYS Cam-clay Model (mudstone, clay, intermediate soils, sand)

The limits of conventional soil analysis technology

◆Previous research in soil mechanics (Engine)

Separate mechanics for clay and for sand
Research into sand centered on undrained conditions (especially liquefaction); the state of the soil after liquefaction was left out of account, as too was compaction.

◆Previous soil analysis left to depend on specialized tools (Chassis)

Specialized calculation tools for consolidation, bearing force, liquefaction (giving no insight into what will happen to the soil foundation)

GEOASIA breaks through conventional technology

- With an elastoplastic constitutive equation that is capable of explaining the whole range of soil types, from naturally deposited clay through intermediate soils to sand (Engine)
- With a soil-water coupled finite deformation theory that is not specific to one sort of calculation but can be applied across a range of problems including consolidation deformation, slip failure, compaction of sand, liquefaction, consolidation of sand after liquefaction, etc. (Chassis)

In other words, *GEOASIA* is an analysis technique that actually tells you what is going on in the soil foundation.

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

Report of Activities in Academic Year 2006

① Ground survey and seismic assessment of ground and embankment prior to planning of an embankment widening scheme

Consolidation behavior of soft horizontally deposited ground during construction of an embankment, and coupled behavior of ground-embankment system during and after a subsequent earthquake. With the successive occurrence of structural decay in the sand and clay layers, liquefaction in the sand layer will be followed by consolidation settlement in the clay.

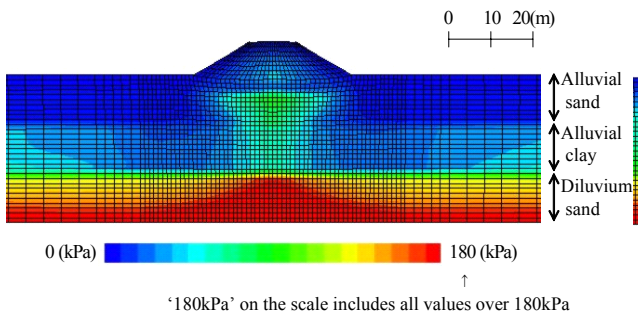


Fig. 1. Distribution of mean effective responses about 50sec after the occurrence of an earthquake

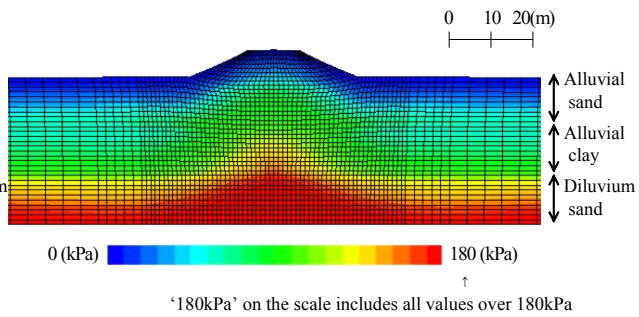


Fig. 2. Distribution of mean effective responses about 30yr after the occurrence of an earthquake (consolidation complete)

② Seismic stability assessment of a temporary structure on a soft embankment

Seismic stability of a temporary structure on a foundation consisting of sand, clay, or alternating layers of sand and clay. Where the top layer is sand, there is an increased risk of the structure collapsing with soil liquefaction, but this can be effectively prevented by the laying of plates.

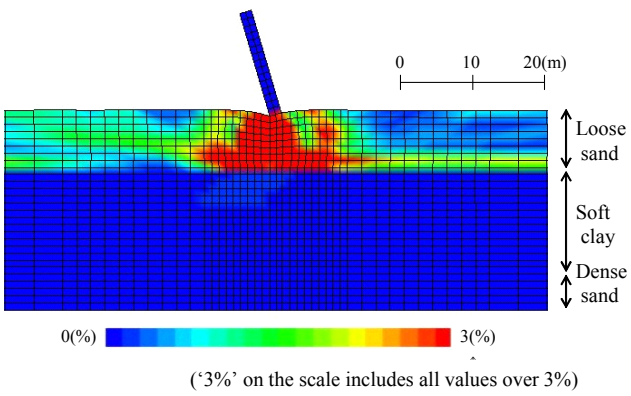


Fig. 3. Distribution of shear strains about 50sec after the occurrence of an earthquake (in a case where the top layer of soil is sand)

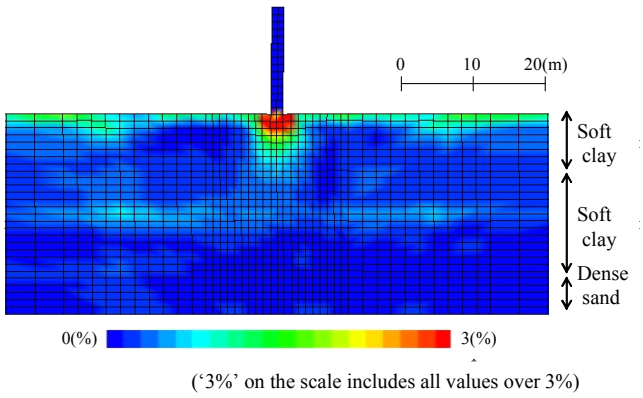


Fig. 4. Distribution of shear strains about 50sec after the occurrence of an earthquake (in a case where the top layer of soil is clay)

③ Seismic resistance assessment of a prepared-base system comprising a reclaimed ground, a pile foundation, and a heavy construction

Example of a case for which seismic stability can be assured, provided there is an adequate pile foundation.

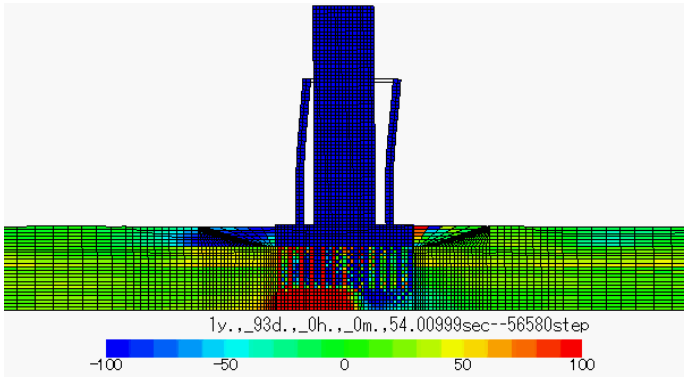


Fig. 5. Distribution of excess pore water pressures during an earthquake

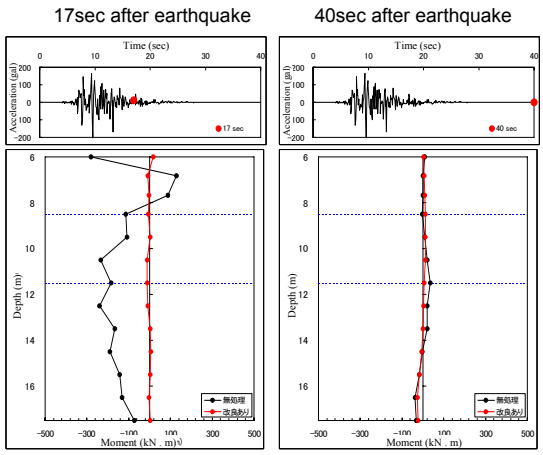


Fig. 6. Bending moments in a pile during an earthquake

④ Effectiveness evaluation for the use of tie rods to tighten the fit of a sheet pile

When a sheet pile is driven into a hard layer of soil and sufficiently well set at the base, effective results can be expected for the stability of an embankment in the event of an earthquake and for a minimization of any knock-on effects to the adjoining environment. However, where the base of the pile remains set in a soft clay layer, this layer will be disturbed after the earthquake leaving the risk of delayed settlement.

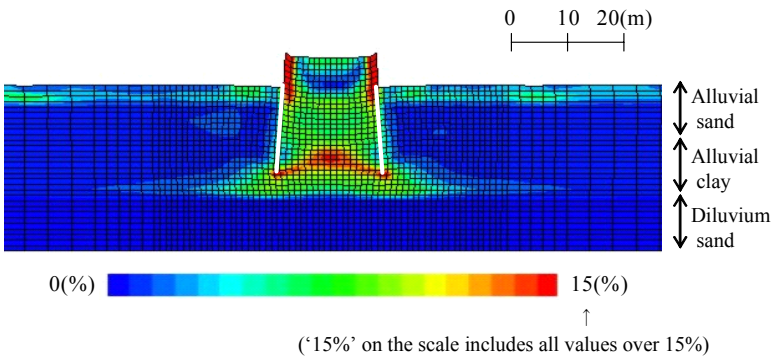


Fig. 7. Distribution of mean effective responses about 30yr after the occurrence of an earthquake (when consolidation is complete) (Height of embankment 6m, depth to base of sheet pile 15m)

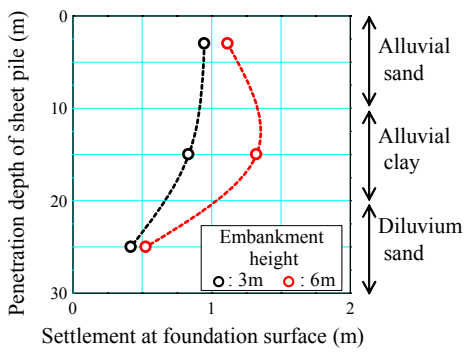


Fig. 8. The penetration depth of the sheet pile base, the height of the embankment, and the effect of these two factors on surface settlement

⑤ Serial analysis through deformation to failure in a system comprising a mixed peat and calcareous ground and an embankment

Predictive simulation of a process of failure in a multi-staged test embankment on a soft ground containing a peat and calcareous soil. The simulation was prepared as an entry for a “blind test” analysis competition at the Kyoto University Earth Forum held in November 2006 in memory of Professor Toru Shibata.

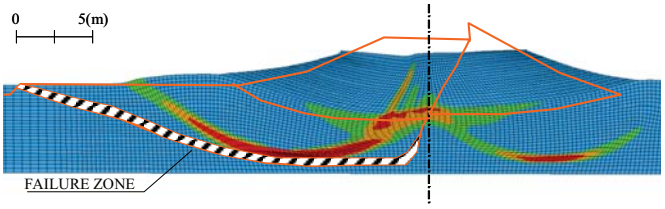


Fig. 9. Distribution of shear strains at the time of failure(Solid red line: actual shape of failure)

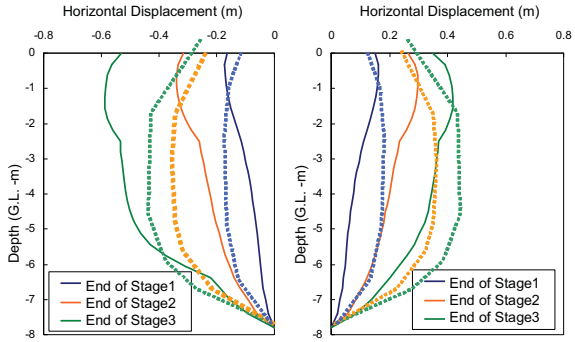


Fig. 10. Distribution of lateral displacement in the toe on either side of the embankment

⑥ Analysis relating to deformation / failure state observed in an embankment – foundation system at the time of the 2004 Chuetsu Earthquake

(Like number ⑤, not a requested project, but) an attempt was made to analyze the deformation and failure observed in an embankment – foundation system at the time of the Chuetsu Earthquake, with three patterns depending on the hardness and slope of the ground. The figures here show the case of a stiff sloping ground, on which the adsorption of water into the boundary area between the embankment and the foundation led over time to soil softening with the result that, several hours after the earthquake, the embankment began to slip down the line of the slope.

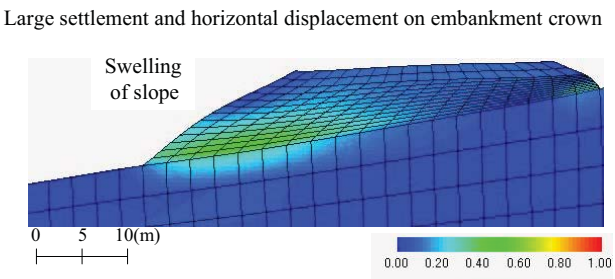


Fig. 11. Distribution of shear strains about 40sec after the occurrence of an earthquake (with embankment magnified in scale)

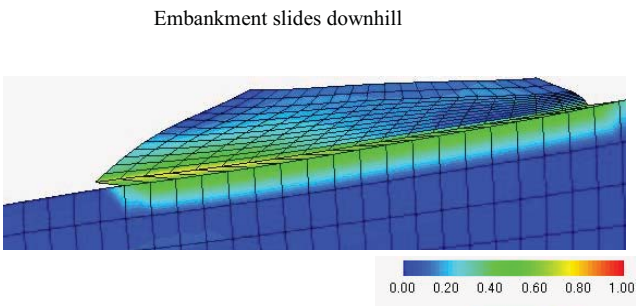
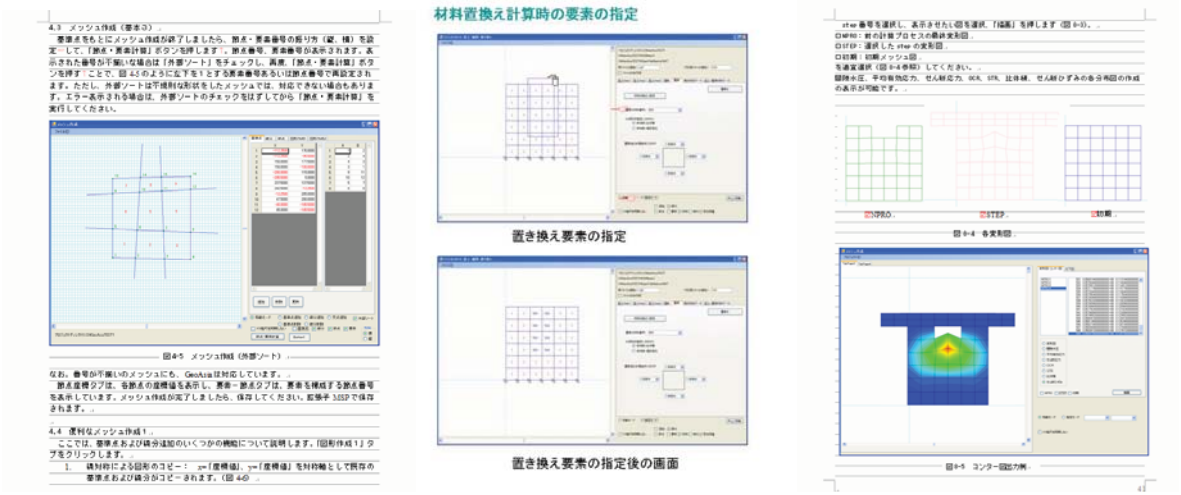


Fig. 12. Distribution of shear strains about 0.5 days after the occurrence of an earthquake (with embankment magnified in scale)

⑦ Creation of a pre / post program and manual

Following the creation of a pre / post program thanks to a grant obtained under the 2005 Construction Technology Research Development Support system (Fundamental Research category) of the Ministry of Land, Infrastructure and Transportation, a manual was produced for it using another grant from the same source in 2006.



(a) Mesh specifications section (b) Material permutations section (c) Contour generation section

Fig. 13. Examples of manual pages

Forthcoming activities in 2007

The results of the research have already been reported at the 42nd Japan National Conference on Geotechnical Engineering (Nagoya), but further presentations are planned at the 62nd Japan Society of Civil Engineers 2007 Annual Meeting (Hiroshima), the 3rd Sino-Japan Geotechnical Symposium (Chongqing, China), and the 13th Asian Regional Conference of Soil Mechanics and Geotechnical Engineering (Kolkata, India).

Under the educational program that has been set up for Research Society members, two mature doctor candidates are already engaged in learning the analysis technology, and this October a third member is due to matriculate, again as a mature student, in the Nagoya University Soil Mechanics Group.

Finally, research request topics expected for the coming academic year are due to include a number of problems in the Chubu area (Central Japan) involving such matters as reclaimed land shore protection, the seismic assessment of construction foundations, and the stability of embankments on sloping grounds.

Editorial afterword

This is the inaugural issue of the ***GEOASIA*** Bulletin, and an issue to remember. In future, we aim to publish once a year to keep members abreast of Research Society's activities. We also intend to set up a Society homepage. Our logo mark is ***GEOASIA***, as on the first page of this issue, but we plan shortly to create a symbol mark too.

Bulletin No. 1 Issued August 24, 2007 Edited by *GEOASIA* Research Society Office TEL: +81-(0)52-789-3833 & +81-(0)52-201-7850