GEOASIA Bulletin No.13

ALL SOILS ALL STATES ALL ROUND
GEO-*A*NALYS*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

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Message from the Society President

In the area of earthquake disaster prevention or risk reduction in recent years, there is no escape from the feeling that there has been a growing move away from hardware. There may be a slight bias behind what I say, but I would be glad to sound out people's opinion.

At the end of August, 2012, a year or so after the Great East Japan Earthquake of March 11, 2011, the government's Central Disaster Management Council (CDMC) published a damage estimate for the coming Nankai Trough Earthquake that predicted (a maximum of) 323,000 persons dead or missing, total damage of ¥ 220 trillion, and an effect on the lives of 60 million people. Not even the government can wholly ignore figures like these, and in 2014 a target was set to "reduce this by 80% by the year 2023." As the first stage towards this goal, on May 31, 2019, I found it reported in a newspaper that, in gist, "the predicted number of deaths had been reduced to 231,000". This already amounts to a 30 percent drop, so I read through the article to see what had changed. The drop was said to be due to a raised awareness of tsunami evacuation, building repairs, and a more widespread installation of breakers to guard against electrical fires. It was not the result of drastic preventive measures involving hardware. This called back to mind the various things written by members of the CDMC Working Committee in their "Conclusion" of March, 2013. "It is important to conserve the right kind of fear of largescale earthquakes and tsunamis …", "As we have learned from the March 11 disaster, we should not depend excessively on prevention through hardware …", "softer preventive measures such as evacuation drills, disaster training instruction, and the lessons handed down from past disasters …", "Even a strong force 7 tremor ... may not always require special prevention measures". Alongside that stark figure of 323,000 dead, why this unbroken string of remarks that can be taken as virtual dismissals of preventive hardware? If there is a reason, I still fail to see it. The last thing I would want to suspect is that this could all be a show of deference to help a hard-up government through its housekeeping pinch.

Quite apart from the pros or cons of "prevention through hardware", it has to be said as a fact that among so-called scholars of disaster risk reduction there has always been a stance of "dismissiveness towards hardware research" and that this is what forms the perennial thread of these people' s claims. Allow me to quote a few parts from a text authored in 2007 by the first well-known scholar to have used the Japanese term "gensai" (減災), generally translated as "disaster (risk) reduction". "Seismologists are researchers into disasters, not into disaster prevention. Seismologists pursue their research out of an interest in how earthquakes occur, but unfortunately there are none of them whose aim is to reduce the direct human or economic damage caused by earthquakes. What is meant here of course is that there are none engaged in first-order research. Look anywhere in the world, they are not to be found." .... "Researchers who specialise in seismology as a science, or in seismic engineering as technology, are all ham-handed." .... "Even after the increase in research funding, the practical achievements can then only be described as meagre, when the costs and the benefits are reckoned up together." .... "The clarification of mechanisms and the development of technical prevention hardware, while no doubt necessary for the prevention or reduction of disasters, is not sufficient." .... "Unless research into seismology and seismic engineering can be clearly placed in an overall framework of disaster prevention and reduction strategies [not left outside on grounds that these are scientific research fields] and better managed with a keen eye on cost effectiveness, no amount of time will suffice [relying on this research alone] to attain the intended objectives of predictive capability and a practical reduction in damage." (Parts in [square parentheses] are explicatory notes added by myself.)

In response to a request in October 2018 from the Education Ministry's Headquarters for Earthquake Research Promotion, I had the opportunity of working with Professor Noda and Professor Otani, president of the Japanese Geotechnical Society, on a report on the state of progress of recent geomechanics research concerning changes of state in grounds with soft surface layers due to strong seismic tremors. Adducing various research findings since March 2011, we were able to show that "changes of state in a ground go back to plastic deformations in the ground itself, meaning that the plastic deformation mechanism lies outside the logical framework of elastic (wave motion) theory." This means that joint cooperation is important in this area between earthquake research on the one hand and geomechanics on the other. In a presentation time limited to just thirty minutes, there was no way of arriving at a report that could be anywhere near complete. But preparing for the report provided a welcome chance of seeing once again what an outstanding state of progress there has been in these years since March 11.

The act of withholding fund provisions and in effect killing off research on grounds of cost effectiveness is a once off measure. But as any researcher knows, once a line of research has gone under, it is virtually impossible to revive it again. Underlying all the sustainment and improvement of disaster prevention hardware and all the training of personnel with requisite skills for maintaining it, is a supporting foundation of day-by-day progress in ongoing research activity. From our scholars of disaster prevention and disaster risk reduction, I would wish for a little more seemliness in their choices of language and argument.

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

Research Results in 2018

(1) Development of a soil-water coupled analysis method based on full formulation (***u-w-p*** formulation)

For its formalized analyses of soil-water coupled conditions in saturated soils, ***GEOASIA*** makes use of a ***u***–*p* formulation method that takes account of forces of inertia. This way of eliminating unknowns from the equation is equivalent to a "solution through approximation" grounded on an assumption that the rate of permeation of pore water through the soil remains sufficiently static. This has made it difficult for the same formulation to be applied to problems of coupled analysis in highly-permeable soils where more dynamic rates of pore water permeation are encountered. The analysis method has therefore recently been redeveloped into a "full formulation" version no longer involving approximations. First uses of this modified method have made it possible (i) to verify that problems in highly-permeable soils that were unsolvable with the ***u***–*p* formulation are now amenable to solution (extending the application scope of the ***GEOASIA***) and, at the same time, (ii) to undertake an investigation of the various phenomena involved in a dynamic response of pore water, opened up for the first time through this assumption of pore water inertia. Figure 1 shows examples of solutions for a rapid loading problem in highly-permeable test pieces (hydraulic conductivity = 10 cm/sec) obtained through full formulation analysis, revealing features of dynamic pore water flow phenomena associated with continuous deformations in the soil skeleton. Complicated whorls are generated and transformed as the process unfolds. It goes without saying that a problem of this type would be unamenable to ***u***–*p* formulation analysis. Looking to the future, we can expect to see the full formulation method applied to various gravelly soil problems such as the dynamic responses of gravel drains, as well as to erosion problems such as scouring in which pore water inertia plays a role that cannot be overlooked.

(2) Conspicuous shakedown settlement behavior appearing in a soft clayey soil directly under a river dike at the time of an L2 earthquake

In an analysis of the seismic response of a river dike of thick-piled soft clayey soil to a simulated pair of L1 and L2 earthquake tremors, the structure was initially found to retain its stability through the L1 tremor, but then, as shown in Figure 2 (b), as the longer-period L2 wave brought a strong tremor that went on for a greater length of time, the clayey soil became disturbed at a point exposed to unbalanced loading directly below the dike, which resulted in shakedown settlement while the earthquake was still in motion.

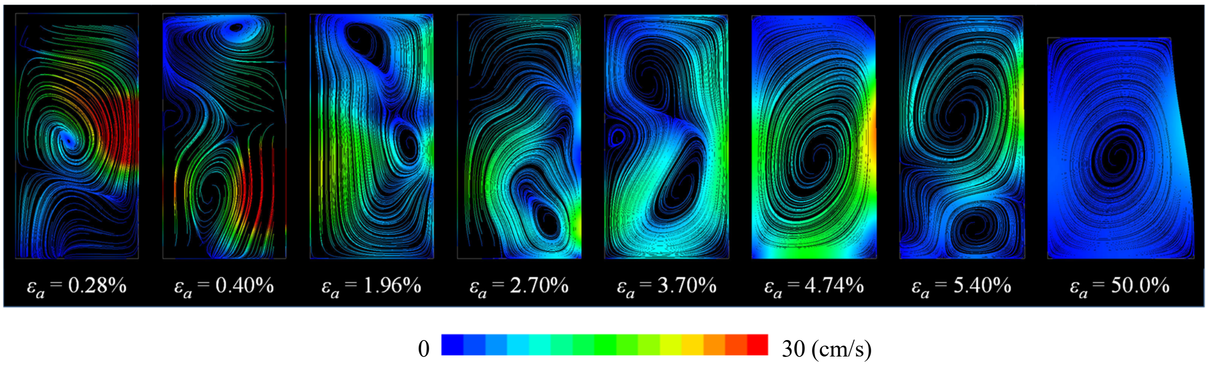
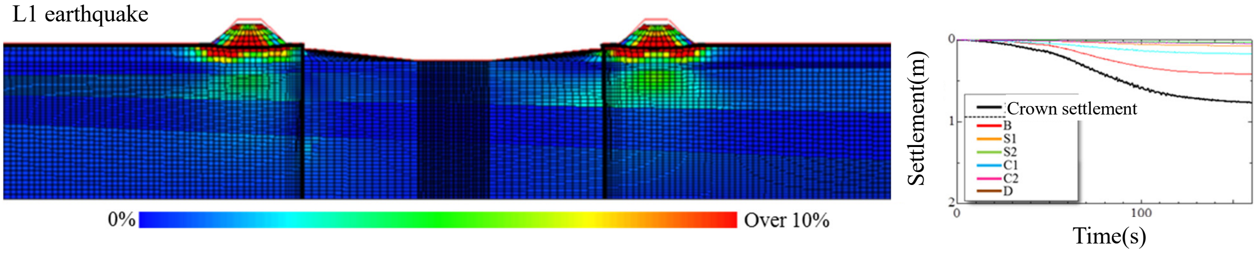
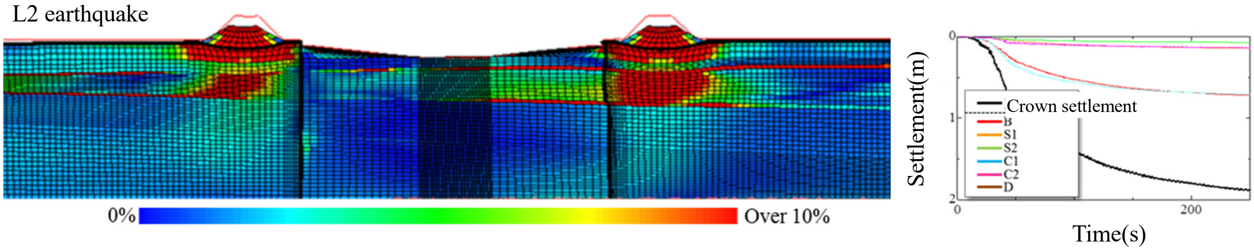


Figure 1 Variation in the flow lines of pore water in test pieces



(a) L1 earthquake

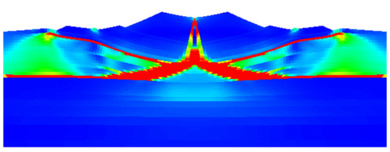


(b) L2 earthquake

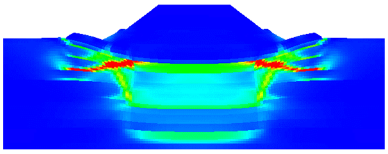
Figure 2 Distribution of strains after an earthquake, using input data from L1 and L2 tremors

(3) Simulation of a vacuum consolidation method with air/water separation

The vacuum consolidation method of ground improvement is prone to the problem of a buildup of water pressure below the airtight sheet which can result from soil settlement. One solution developed to keep this in check is known as air/water separation. In the case of the macro-element method which combines functions of water collection and drainage, it is easily possible to simulate this by means of a simple switch in the boundary conditions at the drain top. In a study carried out on the simulated application of this vacuum consolidation method with air/water separation to a site of peaty ground (Figures 3 and 4), the method was shown to work effectively as a measure against lateral displacement and also as a means of preventing settlement after the shutting off of the vacuum pump.



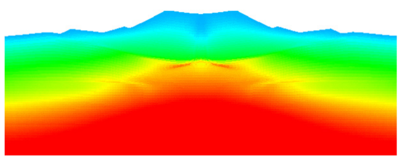
(a) With no ground improvement



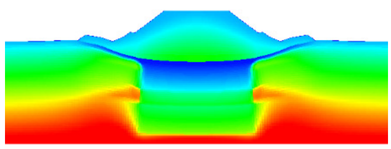
(b) Vacuum consolidation

0 50 (%)

Figure 3 Distribution of shear strains



(a) With no ground improvement



(b) Vacuum consolidation

−90 400 (kPa)

Figure 4 Distribution of pore water pressures

(4) Clarification of mechanisms leading to subsidence damage in the Mt. Aso caldera following the Kumamoto earthquake (2016)

After the Kumamoto earthquake of 2016, intermittent subsidence cracks appeared in the northwestern part of the Mt. Aso caldera (Kyushu) over a distance of 10 km. A seismic response analysis was conducted paying particular attention to the irregularly shaped bedrock structures sinking toward the center in the caldera and to thick accumulations of soft volcanic ash clay. Two main findings were that: (i) Complex interferences among surface waves generated at the edge of bedrock and body waves were a conspicuous cause for the localized and protracted long-frequency tremors inside the caldera. (ii) Even in clayey soils like these, the long-frequency shaking was sufficient to result in a drastic decline in strength. Taken together, the findings suggest that stratification irregularity may have greatly contributed to local surface subsidence damage in the caldera.

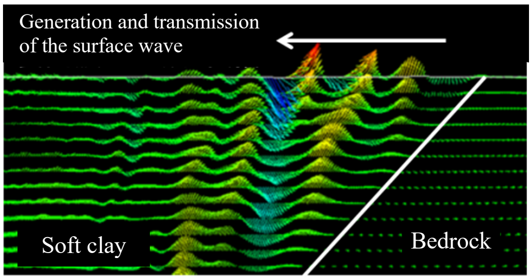
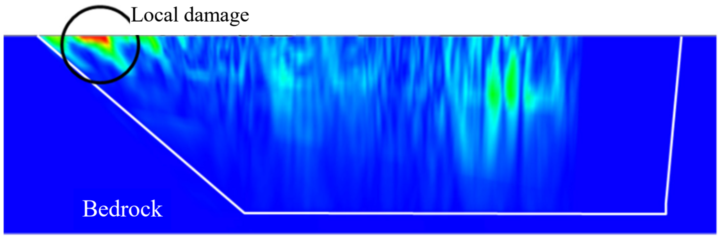


Figure 5 Velocity vector
immediately after the earthquake



(This figure expands to 8 times this size in the vertical direction)

Figure 6 Distribution of shear strains
40 seconds after the earthquake

Principal publications etc. in Academic Year 2018 (April 2018 – March 2019)

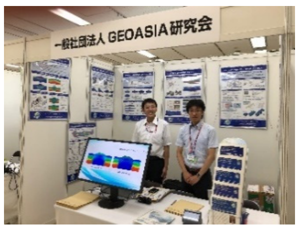
Academic papers:

1) Proposal of new countermeasure method and analytical study on the prevention of liquefied ground flow behind the quay with sheet-pile, Journal of Japan Society of Civil Engineers A2, Vol. 74, No. 2, pp.I_615–I_625, 2018.
2) 3D seismic response analysis of a spherical gas holder on a sandy ground considering a serious scenario by the greatest possible earthquake, Journal of Japan Society of Civil Engineers A2, Vol. 74, No. 2, pp.I_693–I_703, 2018.
3) Study on the influence of vulnerability due to strong motion for a structure body on tsunami inundation analysis, Journal of Japan Society of Civil Engineers B2, Vol. 74, No. 2, p.I_247–I_252, 2018.

Presentations within Japan:

【23rd Lecture Event of the Japan Society of Computational Engineers (Saitama, May 2018)】2 papers. 【Japan Geoscience Union Meeting 2018 (Makuhari, May 2018)】2 papers. 【53rd Conference of The Japan Geotechnical Society (Takamatsu, July 2018)】11 papers. 【30th Chubu Geotechnical Symposium (Nagoya, August 2018)】4 papers. 【Research Symposium on the phenomenon of strong nonlinearity in a surface ground layer at the time of an extremely large earthquake and matters relating to its influence, (Tokyo, August 2018)】4 papers. 【73rd Academic Lecture Event of the Japan Society of Civil Engineers, (Sapporo, September 2018】8 papers. 【6th Conference of River Dike Technology (Tokyo, December 2018)】1 paper. 【15th Japan Earthquake Engineering Symposium (Sendai, December 2018)】1 paper.【21st Applied Mechanics Symposium (Nagoya, May 2019)】2 papers.

Editorial Afterword



In July, 2019, the Society took part for the first time in a technical exhibition attached to the Conference of the Japan Geotechnical Society held in Saitama city. The photograph on the right shows the ***GEOASIA*** Society booth, and the picture of our president Professor Asaoka on the first page of this issue was also taken on this occasion. Most of the enquiries received during the event were connected with purchase interests. Our answer for the moment has to be: Preparations are taking a while, but slowly and surely, we are moving toward the point where ***GEOASIA*** will be available for sale. So please wait just a little longer. A final thing to note in this issue is that the ***GEOASIA*** Research Society has now marked its tenth year of existence as a general incorporated association. All of our thanks go to the precious help we have received over these years from our generous members. Calling to mind the three aims set out in the Society's founding articles, we remain more committed than ever to our efforts for training up top quality engineers, working for the general furtherment of science and technology in areas relating to time history response analysis in geomechanics, and for contribute in these ways to the advancement of society. We humbly rely on our readers' guidance and corrective responses as we continue in these pursuits.

(Toshihiro Takaine)