Proceedings of the 20th International Conference on Soil Mechanics and Geotechnical Engineering– Rahman and Jaksa (Eds)
© 2022 Australian Geomechanics Society, Sydney, Australia, ISBN 978-0-9946261-4-1

Towards improved image of geotechnical profession

Vers l'amélioration de l'image de la profession géotechnique

Ikuo Towhata
Department of Civil Engineering, Kanto Gakuin University, Japan, towhata.ikuo.ikuo@gmail.com

Keigo Azuno
Chuo Kaihatsu Corporation, Japan

Hajime Imanishi
Executive Director, WAGOKAN Culture Crossing Center of Engineering, Japan

Shunichi Sawada
OYO Corporation, Japan

Tatsuya Nojima
Chiyoda Corporation, Japan

ABSTRACT: The activity of the Public Image Committee of ISSMGE is reported in this paper. While the aim of the committee is to improve the status of geotechnical engineering, the committee decided that the improvement of income of the geotechnical profession is the essential issue. In this regard, this paper investigates the problems of georisk that were encountered in construction projects. The study revealed that more ground investigation can mitigate the georisk-related financial loss. Furthermore, open-access data base of ground conditions and knowledge transfer over generations are recommended for improved efficiency of underground investigation.

RÉSUMÉ : L'activité de «Public Image Committee» de SIMSG est rapportée dans ce papier. Dans le but de mieux situation de l'ingénieur géotechnique, le comité a décidé que l'amélioration de revenus de la profession géotechnique est une question essentielle. À cet égard, ce papier investigue le problème du risque géotechnique rencontrée dans le projet de construction. L'étude a révélé que l'investigation de sol peut atténuer la perte financière liée aux risques géotechnique. Par ailleurs une base de données en libre accès aux conditions du sol et le transfert de connaissances au fil des générations est conseillé pour l'efficacité des études de sol.

KEYWORDS: subsurface investigation, risk engineering, sustainability.

1 INTRODUCTION

One of the long-term burdens of geotechnical engineering community in the world has been the effort to improve its image among the general public. In contrast to the images of other disciplines of science and technology, our image has not been reasonably appreciated. The recent term of the Board of ISSMGE established a special committee called PIC (Public or Professional Image Committee) aiming to accomplish this difficult mission. The first author of this paper, as the Chair of this committee, has been taking initiatives since 2017. While there are a good number of international members in this committee, past experiences strongly suggested to form a special task force to push activities by means of regular meeting and discussion. In this regard, the Japanese Geotechnical Society (JGS) organized a national committee in which a variety of activities has been carried out under the initiatives of the first author as its Chair. After three years of its activities, this task force summarizes herein the outputs up to now and encourages the international community to join free discussions.

2 CURRENT UNFAVORABLE SITUATION

There are many reasons why the image of geotechnical engineering is not favorable among the public. Some people imagine that geotechnical engineering is "dirty" because it touches "dirt". Other people suppose that the level of this engineering is not advanced because no sophisticated technology is involved. They compare our discipline with other engineering such as semi-conductor, biological and aerospace technologies. In the past, much effort was made in order to promote the importance and fascination of geotechnical engineering to the public. Nevertheless, those efforts were not satisfactory. This unfortunate situation is presumably related with the people's first impression (without reasoning) towards geotechnical engineering. Thus, new attempt is needed.

3 IMPORTANCE OF GEOTECHNICAL ENGINEERING

Obviously, it is vital to express the importance of geotechnical engineering to people. However, one should not forget that other fields of technology have been making similar approach to maintain their favorable image and that their efforts appear more successful than ours. Hence, something new must be done. Stable foundations, convenient transportation facilities, and disaster mitigation are clearly the great contributions of geotechnical engineering. Hence, the present paper briefly introduces a few and possibly new points in this respect. The first example is protection of public health of urban residents from plagues. In the past, mega cities suffered from bad sanitary conditions and deaths by outbreak of plagues which were not uncommon until the middle of the 19th Century. This situation was drastically improved by construction of modern water supply and sewage systems (Figure 1). The contribution of such geotechnical engineering to the public hygiene is presumably greater than that of modern medicine.

Figure 1. First modern sewage system in Paris.

The second example is the ongoing attempt to solve the problem of the nuclear incidence of power station after the 2011 Tohoku earthquake, Japan. JGS organized a special committee to support efforts coordinated with nuclear-engineering specialists (Komine et al., 2019). Confinement of radioactive water inside the site by frozen underground walls, collection of radioactive wastes from the damaged reactors, and final repository of the wastes are obviously geotechnical engineering contributions. In addition to these views, the present paper calls upon the attention of the public to the issue of income of geotechnical engineers. Reasonable income is essential to attract bright young people to geotechnical engineering profession. It is believed that clients should allocate more budget to subsurface investigation in order to avoid “georisk”.

4 WHAT IS GEORISK?

Georisk stands for unexpected expenditures and elongation of construction period caused by adverse subsurface conditions that are recognized only after resuming a project. It is not universally perceived as a problem by the public and ignored.

One of the reasons for the negative image of geotechnical engineering is the georisk incidences and troubles that occur under ground. People see the geotechnical troubles, compare them with the good appearance of other disciplines, and get convinced of our inferiority. The cave-in of street caused by subway tunneling in Fukuoka (2016) was investigated by an official committee. This committee concluded that insufficient subsurface investigation in non-uniform troublesome condition was the main cause (Special Committee and PWRI, 2016). Many years ago, one of the authors, an expert in this area, had noticed heterogeneous subsurface condition and tried to transfer this knowledge to future generations. Unfortunately, this knowledge was lost after decades and resulted in this serious cave-in about 30m by 27m in plane and 15m in depth, cutting off utilities and lifelines.

A leaning building in the center of a mega city (Figure 2) is situated on a reclaimed land where the bearing layer is so deep that the building is supported by friction piles. As of September 2019, it had sunk 46 cm and tilted 36 cm since its completion in 2008, substantially damaging the property value of this luxurious residential building. Although soil sounding data can help assess the bearing capacity at pile tips, it is difficult for it alone to precisely assess the pre-failure settlement of foundations. More detailed information about soil properties could have helped avoid this problem.

The importance of subsurface investigation in control of unexpected expenditure was recognized many years ago. MacDonald (1994) assembled data from many construction projects and demonstrated that the unexpected expenditure can be reduced by allocating more budget to investigation. Later, this point was stressed by Clayton (2001). However, no significant progress occurred further in this field of study.

Figure 2. Leaning of a skyscraper in the center of a mega city.

5 CASE STUDIES ON GEORISK MANAGEMENT

The Georisk Society organizes annual symposia to collect information on importance of subsurface investigation for avoidance of geotechnical troubles (Watanabe et al., 2009). The most remarkable achievement of this society is the report on design of bridge foundation for the Kita-Kyushu Airport Island (Tagami et al., 2010). Because the subsoil condition was heterogeneous (Figure 3), the subsurface investigation budget was increased from the original approximately one million to 3 million US Dollars and the detailed subsoil data enabled to design much shorter friction piles. Accordingly, the construction cost was reduced by 100 million USD. With sincere appreciation of the Georisk Society’s achievements, the JGS committee initiated joint activity by using the collected information.

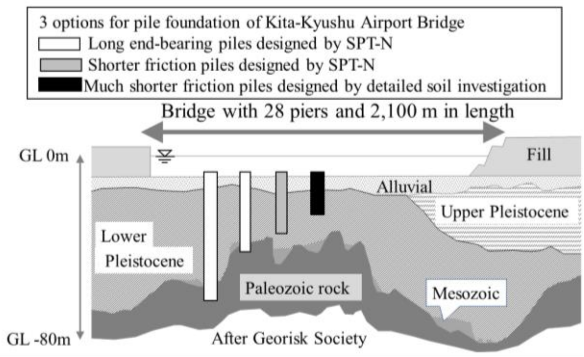

Figure 3. Heterogeneous cross section of subsoil under Kita-Kyushu Airport Bridge (drawn after Tagami et al., 2010).

The Georisk Society collected more than 140 geotechnical case histories including foundation, slope stabilization, soil pollution, and many others. Therein, the aim was to demonstrate the important roles of subsurface investigation that can detect georisk and promote mitigation measures to be taken so that the unexpected financial loss may be avoided and the total construction cost may be controlled. The research interest was focused on the cost for additional investigation that was conducted when risk was recognized. It was compared with the consequent cost reduction (called profit hereinafter). Figure 4 illustrates the overall view of the profit from soil investigation which is mostly greater than the additional investigation cost (points above 1:1 line in the figure), exhibiting that georisk management deserves efforts. Even some of cases below the 1:1 line were considered successful because the involved engineers were happy to have avoided delay and cumbersome situation.

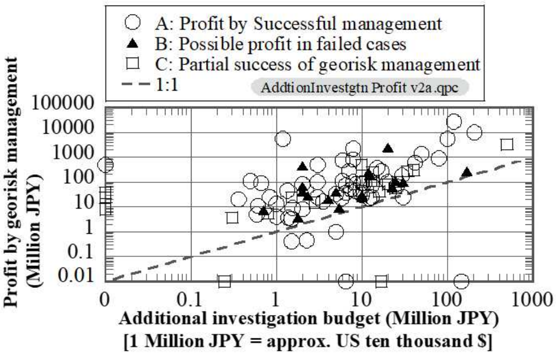

Figure 4. Overall summary on profit of georisk management changing with cost for additional subsurface investigation (Groups A-C).

Georisk Society classified the studied cases into three categories which are Group A (additional investigation prior to construction helped save the cost or avoid incidence), Group B (insufficient investigation resulted in increased construction cost or disaster) and Group C (partial success where risk was detected during construction, investigation and mitigation were taken, and catastrophe was avoided). Note that this classification represents what involved engineers personally felt. The authors interpreted all the data and re-classified them into the 3 groups again. What follows is the summary of the authors' interpretation. There is no substantial difference between the Georisk Society's interpretation and the authors' view.

5.1 *Discussion on Group A of successful georisk management*

Figure 5 addresses successful cases in which additional investigation helped save cost or avoid disaster. The real construction cost with successful risk management (subsoil investigation, design revisal etc.) and the hypothetical cost without risk management (i.e., affected by incidence cost) are compared. The difference between these two stands for the "profit" from risk management. This figure demonstrates that it is possible to save cost by conducting more subsurface investigation than usually practiced.

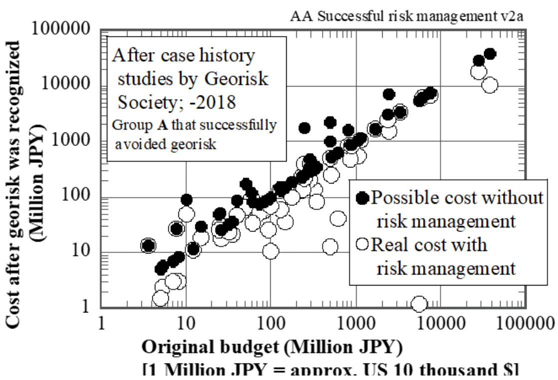

Figure 5. Comparison of cost with and without successful risk management (Group A).

The ratio of profit over the original construction budget is plotted in Figure 6. It is very possible to achieve good ratio of profit. The ratio >1 occurs when, for example, a significant disaster, such as slope failure, is avoided.

Figure 7 demonstrates the ratio of the cost for risk management over the original construction budget, plotted against the same original construction budget (size of the project). Although the range of variation is substantial, relatively bigger projects are focused here and then it is found that the additional risk response of 2-5 % or less is predominant in the successful risk management (Group A).

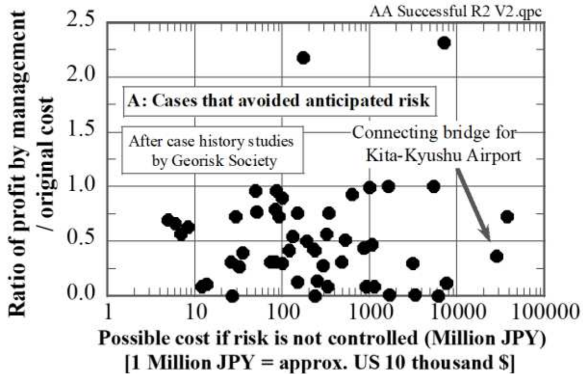

Figure 6. Ratio of profit and original project budget plotted against total cost after possible risk manifestation (Group A).

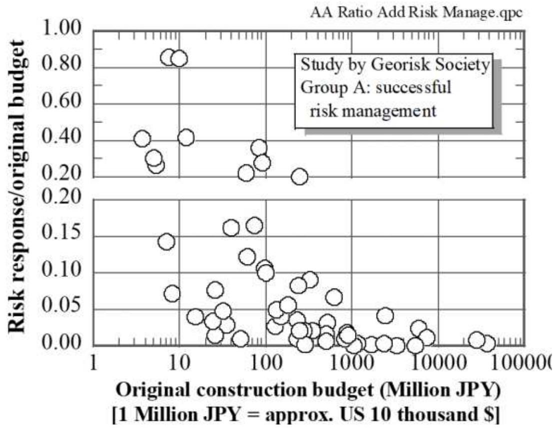

Figure 7. Ratio of risk management cost and the original budget of the entire construction (Group A).

5.2 *Discussion on Group B of failed georisk management*

Although unexpected trouble occurred in cases of Group B, it is still possible to assess the hypothetical situation in which good georisk management had been conducted and the worst situation would have been avoided. Figure 8 compares the real cost affected by disaster and the hypothetical cost with successful georisk management. It would have been possible to save cost even when the in-situ condition was adverse. In line with Figure 7 for Group A, Figure 9 illustrates the ratio of the hypothetical georisk management cost over the original construction budget. It is again shown for bigger projects that 2-5% is the hypothetical but desired ratio of the risk management budget that could have been allocated to additional soil investigation to control the risk.

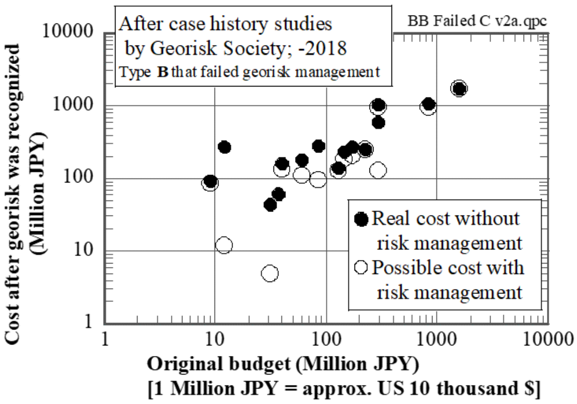

Figure 8. Comparison of real cost increased by georisk and possible cost reduced hypothetically by missed risk management (Group B).

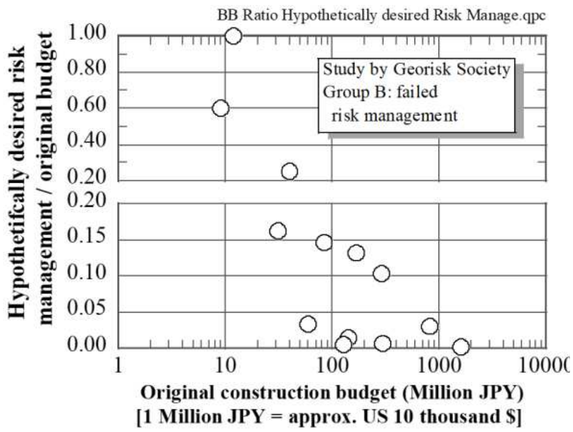

Figure 9. Ratio of risk management cost within the original construction budget (Group B).

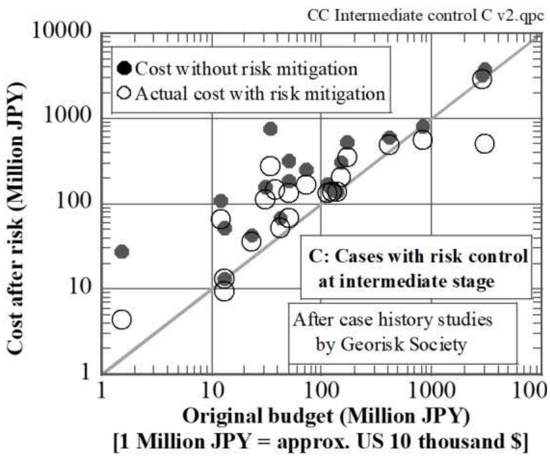

Figure 10. Relationship between costs with and without georisk management and the original construction budget (Group C).

5.3 *Discussion on Group C of partial success*

Figure 10 compares the real cost with partial success/partial loss against the hypothetical cost without risk management (no additional subsurface investigation). The cost reduction by risk management is evident. Figure 11 illustrates the ratio of georisk management cost that was spent on additional soil investigation etc. Although variable, the ratio of georisk management cost for bigger projects lies approximately in the range of 2-5% or less.

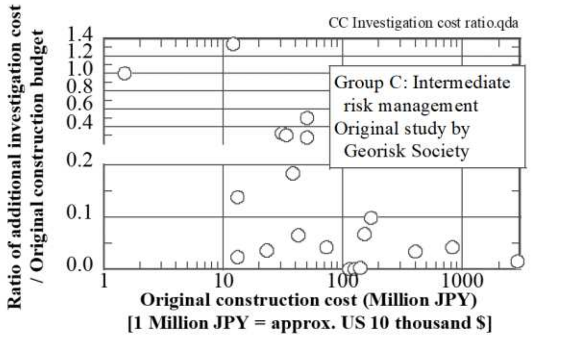

Figure 11. Percentage of risk response cost within the original budget of the entire construction budget (Group C).

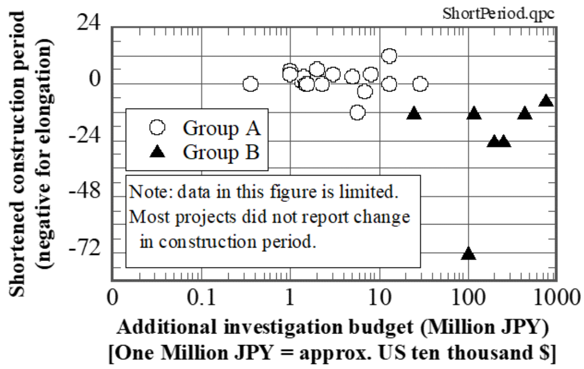

Figure 12. Change in construction period by days after georisk management (Groups A and B).

Table 1. Similarity in played roles by geotechnical investigators and medical doctors.

Geotechnical	Medical
Local geology & geomorphology	Health/medical history
Soil sampling and tests	Sample incubation
Sounding & boring	Camera, X-ray etc.
Design	Treatment planning
Construction	Surgery
Trouble and georisk	Unsuccessful treatment
High pressure to save cost	Low pressure; accuracy is important
Controlled by clients and project managers	**Authorized to make his/her own decision**
Efforts to improve skill	**More efforts than geotechnical people**
Public image not good	Respected by people

5.4 *Overall view on georisk management*

This study promotes the importance of and profit from elaborate subsurface investigation. The former sections suggested that additional subsoil investigation in response to risk manifestation should be 2-5% of the total construction cost in order to avoid the catastrophic situation. This percentage of budget should be added to the budget of conventionally practiced investigation. Although there is no established idea on this conventional expenditure, the authors talked to several international experts to get the value of 0.5-1%. This % is added to the aforementioned 2-5% and then a reasonably low but not too low number is recommended. Thus, recommendation is 3% of the total construction budget to be allocated to subsurface investigation.

When the present study was started, it was expected that good risk management could shorten the construction period because unnecessary troubles is avoided and projects proceed smoothly. The results of case studies, for which data is available, are illustrated in Figure 12 in which the change of construction projects of Groups A (successful) and B (failure) are plotted. The positive number of the vertical axis means shortening of the period. It is interesting that shortening for the successful Group A is not remarkable. Probably, the engineers are satisfied with on-time completion of projects. Possible time shortening is spent on more elaborate construction details.

6 DISCUSSION

The former section focused on financial aspects of subsurface investigation. One of the incentives of that study was to improve the public image of the geotechnical profession. Furthermore, because of the lack of financial background, the appearance of geotechnical engineering is not beautiful and people do not consider it an attractive discipline. People do not respect poor occupation and, hence, young bright people are not attracted to geotechnical job. Nevertheless, it is not very easy to earn more money from the clients by just insisting on georisk issue.

The authors point out the resemblance of geotechnical investigators with medical doctors (Table 1). Both investigate the target (subsoil or human body) and carry out action (construction or medical treatment). The essential difference is that medical doctors make more efforts on investigation (health inspection) prior to surgery. More budget can be spent by them. They are authorized to decide and conduct many necessary things than geotechnical engineers do. Obviously, medical doctors are highly respected by people. In this regard, geotechnical engineers need to do more efforts to achieve good quality of works and get people's respect similar to medical doctors.

Figure 13. Example of poorly maintained device for geotechnical subsurface investigation (shoe of standard penetration device).

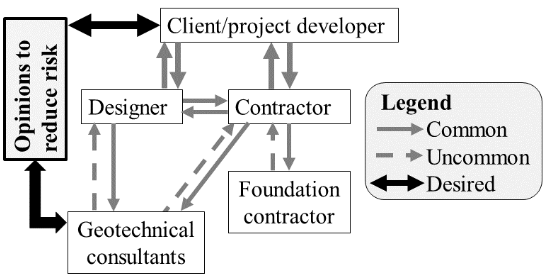

Figure 14. Communication channels among stake holders; existing and desired.

One of the targets of required effort is the quality of geotechnical works. Clients agree to pay more only when the achievement is improved. It is unfortunate to date that some investigation firms do not pay sufficient attention to the maintenance of equipment and device (Figure 13). Consequently, the obtained subsoil data is not reliable, which the clients do not like. In other words, geotechnical community should try to establish qualification of investigation firms (like ISO9001). This is a special requirement to company managers because individual engineers cannot change the budget allocation of the firm to good quality of subsurface investigation.

The other effort target is the establishment of direct communication between geotechnical engineers and clients, which is uncommon to date. Figure 14 illustrates the structure of communication channels. Although some channels are well established, geotechnical consultants can hardly talk with the client who controls the financial management. To achieve the desired direct communication, a general perception is important that georisk, beyond "baseline", should be borne by the client who is then driven to precisely capture the extent of georisk hidden under soil and decide to spend more money on additional investigation. There is an opinion among the authors that the georisk communication should not be via contractor for whom georisk is not an essential business issue.

To improve the quality of subsurface investigation, two more issues have to be sought for. The one is establishment of "Open-Access Database of Geotechnical Information" in which investigation data is collected from both public and private sectors and is made use of freely by people who conduct preliminary study on soil conditions prior to design. This preliminary study allows the planned projects to carry out subsoil investigations in a more efficient and systematic manner. The second issue is knowledge transfer over generations, as was pointed out already in relation to the cave-in upon tunnel construction. One may imagine that electronic database on adverse soil condition is promising but it is noteworthy that the time span of geotechnical knowledge transfer is as long as many decades. During this long time, electronic media may disappear and the recorded knowledge may become unavailable, just exemplified by data storage by (paper) punch cards for mainframe computers that were common in 1970s but no punch card reader is available today. In this regard, carving of information in stone or concrete deserves attention as has been practiced to transfer memory of natural disasters over generations (Figure 15).

Figure 15. Stone statue with carving of the memory of flood disaster in 1938 (near the Ochiai Bridge of Sumiyoshi River).

7 EXPOSURE TO THE PUBLIC

Noteworthy is that Figure 14 did not refer to the public. Most geotechnical engineers would not find anything strange in this figure but this lack of public means that geotechnical engineering in the past did not seriously take care of its public image. The geotechnical business world was closed within the range of

Figure 14 and people's perception was overlooked. Geotechnical engineering has been satisfied with customer satisfaction. Because geotechnical engineering does not care people, people does not care geotechnical engineering.

In contrast, some other fields of science and technology are profoundly more anxious about their exposure to the public. For example, automobile industries demonstrate EVs and FCVs in public stage and successfully convince people that automobile is a symbol of advanced technology. The idea of flying cars appeals people although its energy efficiency is of big question. The successful public exposure of smart phone industries is obvious. Oil and gas industries are recognized by people as a symbol of advanced engineering geology and earth science despite that people are not the direct client of their business. It should be emphasized here that geotechnical engineering should seek for something beyond "customer satisfaction".

What is "beyond"? Management of disaster mitigation is one of the answers. Note that the conventional disaster mitigation "technology" is not the answer. What is meant here is the policy making and technological/scientific management on the basis of mitigation technologies such as field investigation devices, design formulae, numerical methods and many others that conventional geotechnical engineering has achieved. Other disciplines cannot imitate it.

Furthermore, geotechnical engineering should focus on the ongoing global crisis that is of universal concern. Because of climate change, water shortage in arid populated countries (often population exploding there) is going to be a serious problem. Energy resource is now shifting towards renewable energy. It is therefore promising for geotechnical engineering to provide new water resources for drinking, irrigation, food production and "energy generation". More in detail, ground water is flowing across coast lines into the sea all over the world. In the present state, this fresh water resource is simply lost without use. Fortunately, geotechnical engineering has a skill to construct underground dams and extract this ownerless water without disturbing the land use at the surface (Åke, 1988) as illustrated in Figure 16. This new water resource can be combined with solar power generation in order to produce hydrogen resource by means of electrolysis in arid countries where climate favors solar power generation. The produced H_2 gas is condensed for export, and local economic development is achieved. Geotechnical engineering should demonstrate people that it can contribute substantially to the better future of the world.

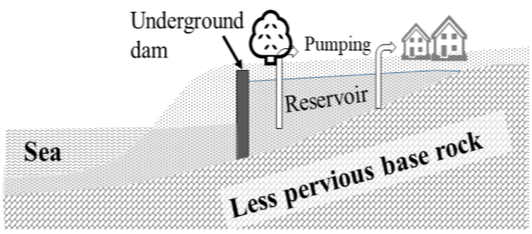

Figure 16. Conceptual sketch of underground dam.

8 CONCLUSION

This paper addresses the activity report of the Professional Image Committee of ISSMGE in conjunction with a domestic task force organized by JGS (Towhata et al., 2021). The major conclusions drawn from the study are as what follows:

(1) The image of our discipline among people is not very good. We need to disseminate the value of geotechnical engineering among people. Unfortunately, the previous efforts of this type were not very successful.
(2) People do not respect poor discipline. It is therefore essential to bring more income to geotechnical profession.
(3) Budget for subsurface investigation should be increased so that georisk is reduced and geotechnical appearance is improved.
(4) Case history studies of many past projects provide good reasons why clients should allocate more budget to subsurface investigation.
(5) At the same time, geotechnical engineering should achieve and maintain better quality of works. Good firms should be officially qualified and entitled to charge more than unqualified firms.
(6) Open-access database of geotechnical investigation output and knowledge transfer over generations are two more important issues in order to efficiently achieve good quality of subsurface investigation and reduce georisk.
(7) Geotechnical engineering should seek for dreams of future earth beyond "customer satisfaction".

9 ACKNOWLEDGEMENTS

The authors express special appreciation to the JGS committee members as well as the Georisk Society and Japan Geotechnical Consultants Association with whom many parts of this research were carried out.

10 REFERENCES

Åke, N. 1988. Ground Water Dams, Intermediate Technology Publications Ltd., ITDG Publishers, ISBN 1 85339 050 X.

Clayton, C.R.I. 2001. Managing geotechnical risk: time for change?, *Proceedings of the Institution of Civil Engineers - Geotechnical Engineering*, 149(1): 3-11.

Komine, H., Goto, S. et al. 2019. Geotechnical engineering for decommissioning and prototype education curriculum, *Proc. JSCE H*, 75(1): 10-19 (in Japanese).

MacDonald, M. 1994. Study of the efficiency of site investigation practices, Transport Research Laboratory, Crowthorne, Berkshire, *Project Report*, 60.

Special Committee & PWRI 2016. Report on ground depression at the site of subway tunnel construction, Fukuoka, https://www.pwri.go.jp/jpn/kentou-iinkai/pdf/houkokusyo.pdf retrieved on May 31, 2021 (in Japanese).

Tagami, H., Ochiai, H. et al. 2010. Importance of subsurface investigation with consideration on local characteristics, *Proc. 1st Conference on Georisk Management,* Georisk Society, Tokyo, 29-34 (in Japanese).

Towhata, I., Watanabe, T. et al. 2021. Promotion of ground investigation for avoidance of geo-risk and better construction management, 6*th International Conference on Geotechnical and Geophysical Site Characterization*, September, Budapest,

Watanabe, T., Sabase, Y. et al. 2009. Current situations and direction of change of geological risk management in public works in Japan, *Proc. JSCE on Construction Management*, F16: 215-230 (in Japanese).