Administrative report of TC29 – Stress-strain testing of geomaterials in the laboratory

Compte rendu technique de la No. CT 29 – Essais méchaniques des géomateriaux en laboratoire

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1 INTRODUCTION

The technical committee No. 29 (TC-29) on "Stress-Strain Testing of Geomaterials in the Laboratory" of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) was launched immediately after the 13th International Conference on SMFE, which was held January 1994 in New Delhi, India. The establishment of TC-29 was proposed by the Japanese Geotechnical Society and approved very positively by the president at that time, Prof. Jamiolkowski, M. With such a background as that a technical committee of the ISSMGE had not been established in this field despite its high engineering need, TC-29 has been very active since its establishment. Based on very fruitful activities of the first term, the extension of TC29 was approved by the present president, Prof. Ishihara, K., who was elected on the occasion of the 14th International Conference on SMGE, which was held in 16-12 September 1997 in Hamburg, Germany. For the first and second terms, the chairman and the secretary have been, respectively, Tatsuoka, F. and Shibuya, S. The members of TC-29 for the second term are listed in Table 1 on the back.

Immediately after the launching of TC-29, the domestic committee was established in the Japanese Geotechnical Society (JGS), which is the host country of TC-29, in order to support the activities of TC-29. The members of the JGS domestic committee are listed in Table 2 on the back.

In this report, the important outcomes, the present situation and the future perspective of TC-29 are summarised.

2 TERMS OF REFERENCES

TC-29 has been given with the following three terms of reference (T-O-R);

1. To promote co-operation and exchange of information about the recent developments in laboratory equipment and data acquisition systems;
2. To develop the recommendation for procedures referred to triaxial and torsional shear tests dealing with;

a) laboratory reconsolidation technique for cohesive soils, and

b) methods for measuring accurately, and in a reliable manner, stresses and strains of laboratory specimens for a strain range from 10-5 to 10-2;

3. To work out a uniform framework for comparison of stiffnesses measured by means of different laboratory techniques with emphasis on their relevance for the solution of problems of practical interest;

These terms of reference reflect such a situation as follows in 1994:

(i) It had been one of important geotechnical engineering needs to accurately predict ground deformation and structural displacements, in particular those at working loads (n.b., it is still the case at the present time).

(ii) It had been often considered that, compared with field loading tests, laboratory stress-strain tests be less direct (so less useful) for this engineering need. Stiffness values obtained from conventional type laboratory stress-strain tests were often too low to explain actual field full-scale behaviour, and it had been often considered that this discrepancy was due to serious effects of sample disturbance. Corresponding to the above, a link among stiffness values from laboratory stress-strain tests, field loading tests and field full-scale behaviour was rather missing, in particular among practising engineers.

(iii) In addition, the laboratory stress-strain testing method relevant to this objective while accepted widely had not been established.

For these reasons, in the activities of TC29 for the first and second terms, the pre-failure stress-strain behaviour of geomaterials, from elastic behaviour at strains for a range form less than about 0.0001 % to that at the peak strength, was focused. The concerned types of geomaterials are mainly; soft and stiff clay, sand, gravel and soft rock.

3 ACTIVITIES INITIATED, COMPLETED AND REPORTED

Following the terms of reference listed above, the following activities were initiated and the following achievement was made.

T-O-R 1: For this purpose, TC-29 sponsored two international conferences and one symposium (with publication of proceedings) and one workshop (only with preprint but without publication of proceedings) and will sponsor another international conference to be held in 2003 in Lyon, as listed in Table 3 on the back. In addition, a survey was made into the status quo of the relevant laboratory facilities in different countries and national reports on this issue were prepared. A book summarising the activities of TC-29 will include the result from this survey. This book will be published by the end of second term at the 15th ICSMGE due for a period of 27-31 August 2001 (see Table 3). The book will also include the outcomes of the activities related to the other two terms of reference.

Part of the activities of the first term was summarized also in the keynote lecture for Session No. 1 on "Soil Testing and Ground Property Characterisation" of the 15th ICSMFE in Hamburg; Tatsuoka,F., Jardine,R.J., Lo Presti,D., Di Benedetto,H. and Kodaka,T. (1999), "Characterising the Pre-Failure Deformation Properties of Geomaterials", Theme Lecture for the Plenary Session No.1, Proc. of XIV IC on SMFE, Hamburg, September 1997, Volume 4, pp.2129-2164. The first four authors of this keynote lecture are the members of TC29, while Dr. Kotake was a member of the JGS domestic committee. Panel discussions at this main session were made by some of the members of TC-29 (Jardine,R.J., Di Benedetto,H. and Shibuya,S).

T-O-R 2: Several laboratory stress-strain testing methods that are relevant to the present objective (i.e., to provide necessary information for predicting ground deformation and structural displacements) have been developed in some leading laboratories and have been widely acknowledged in some member societies of ISSMGE. To confirm the applicability of these testing meth-

ods to general use, a series of international round robin (IRR) tests was started in 1997 under the initiative of the JGS domestic committee. The materials used in this IRR tests are; a) reconstituted clay (Fujinomori clay); b) reconstituted sand (Toyoura sand); and c) undisturbed sedimentary soft mudstone (Kazusa group). The testing methods employed include; monotonic loading triaxial compression test, cyclic triaxial test, monotonic torsional test, cyclic torsional test, torsional resonant-column test and bender element test. Many volunteer members of TC-29 reviewed the standard test procedures that were suggested by the domestic committee in Japan. The test materials, together with the standard procedures for the testing, were distributed to a number of volunteer laboratories in the world. The members of TC29 examined the test results and evaluated the relevance of the proposed test procedures. As a result, the recommendation for the methods for stress-strain testing in the laboratory will be proposed in the book cited above. Some of the main conclusions obtained from this activity are;

(i) Rather consistent and reproducible results can be obtained in different laboratories by following the test procedures provided.

(ii) Local axial strain measurement is imperative to obtain accurate stiffness values of relatively stiff geomaterials, such as sedimentary soft mudstone, while it may be not the case with soft clay that exhibits a relatively large compression during consolidation, such as reconstituted Fujinomori clay.

(iii) When measured at equally small strains under the same stress conditions, essentially the same elastic or quasi-elastic deformation characteristics can be obtained from static and dynamical loading tests.

T-O-R 3: To achieve this, information of related case histories was collected by the members of TC-29. Based on this information, a file of case histories was made. In each case history, the full-scale behaviour of ground, geo-structures and superstructures is predicted or back-analysed based on the stiffnesses from in-situ loading tests and/or laboratory stress-strain tests. A summary of the case histories will be included in the book cited above. Some of the conclusions that can be derived from these case histories are:

(i) Relevant laboratory stress-strain test can provide information of non-linear stress-strain property of concerned geomaterials that is useful or essential in predicting accurately ground deformation and structural displacements.

(ii) Elastic deformation characteristics obtained from field wave velocity measurement can be used in such a prediction as described above after correcting for effects of relevant factors, including strain- and pressure-nonlinearity.

4 ACTIVITIES IN HAND

A summary book is now being edited, which will be published by the coming 15th ICSMFE, Istanbul. The present members of TC-29 (as listed in Table 1) are considering that although the activities of TC-29 for the first and second terms have been extremely successful, the terms of reference have not been fully realised and they will be still important issues to be solved for geotechnical engineering for the next coming term. So, the present members wish to continue TC-29 for the next coming term, starting from September 2001, after the 15th International Conference, Istanbul, changing the host member society and the chairman. The following was decided by the present members of TC-29:

(i) When the extension of TC-29 to the next term starting 2001 is approved by the incoming president of the ISSMGE, the chairman of the next term of TC-29 will be Prof. Jardine, R.J. of Imperial College, the United Kingdoms and the secretary will be Dr. Shibuya, S. So, the host member society will be the British Geotechnical Society.

(ii) The third international conference will be held in 2003 in Lyon, France, hosted by Prof. Di Benedetto,H., ENTPE. The main themes of the Conference, which concern soils and soft rocks, are:

- experimental investigations into deformation properties - from very small strains to beyond failure;
- the interpretation of laboratory, in-situ and field observations of deformation behaviour;
- characterising and modelling the behaviour; and
- case histories.

Emphasis will be placed on exploring recent investigations into anisotropy and non-linearity, the effects of stress-strain-time history, ageing and time effects, yielding, failure and flow, cyclic and dynamic behaviour. However, equal weight will be given to reporting the application of advanced geotechnical testing to real engineering problems, and to ways of synthesising information from a range of different sources when engaging in practical site characterisation studies.

5 CONCLUSIONS

The activities for the last two terms of TC-29, as listed in Table 3, include the following:

1) Recent developments in the characterisation of geomaterial prefailure deformation properties were reviewed and summarised.

2) The data required to predict ground deformations and structural displacements at working loads are focused.

3) The deformation characteristics developed at very small to intermediate strains, of a variety of geomaterials, in testing using modern laboratory and field techniques were summarised.

4) Several practical methods of local strain measurements in the triaxial tests and the dynamic methods the BE method and the resonant tests) were reviewed.

5) The relationships between static and dynamic experiments, between laboratory and field techniques, and between testing and field full-scale behaviour were discussed and a framework for the above was given. In particular, it was shown that for fine-grained geomaterials, the elastic deformation characteristics are defined at strains less than about 0.001 % and the values obtained by static and dynamic experiments performed under otherwise the same test conditions are essentially the same.

6) Important features of stress-strain properties of geomaterials were highlighted, including: kinematic yielding, effects of recent stress-time history, anisotropy, structuration and destructuration, non-linearity by strain and pressure and effects of cyclic loading. Careful distinctions were made between elastic, plastic and viscous properties.

Through the activities of TC29, the following conclusions were obtained.

1) Accurate prediction of ground deformation and structural displacements has been, is and will be one of the important geotechnical engineering issues.

2) Laboratory stress-strain tests of geomaterial can provide useful and essential information for this engineering need if the tests are performed adequately on high quality undisturbed samples while taking into account the effects of controlling factors. In particular, accurate measurements of strain for a range from about 0.001 % to that at the peak, for example, by local axial strain measurements in the triaxial test, and due considerations on the non-linearity of stress-strain behaviour by strain and pressure are important factors, among others.

3) The stiffness values from different laboratory stress-strain tests, different field loading tests and field wave velocity measurements and field full-scale behaviour can be linked to each other only when taking into account the effects of controlling factors, including non-linearity of stress-strain behaviour by strain and pressure, effects of recent stress history and so on. In particular, under otherwise the same conditions at very small strains, dynamically and statically measured values could be essentially the same at least fine-particle soils.

Table 3 International conferences, symposium, workshop and publications sponsored by TC29

Year	Venue	Conference or symposium	Proceedings; Editors; Publisher
September 1994	Sapporo, Hokkaido, Japan	International Conference on Pre-Failure Deformation of Geomaterials (IS Hokkaido '94)	Vol. 1 (1994) & Vol 2 (1995); Shibuya,S. et al.; Balkema
4th, September, 1997	London, UK	Géotechnique Symposium in Print (SIP) on Pre-failure Deformation Behaviour of Geomaterials	Pre-failure deformation behaviour of geomaterials (1998); Jardine,R.J., Davies,M.C.R., Hight,D.W., Smith,A.K.C. nd Stallebrass,S.E.; Thomas Telford
26th September 1999	Torino, Italy	International Workshop on Recent Advances Related to Terms of Reference of TC29 of ISSMGE"	Preprint
27-29, September, 1999	Torino, Italy	Second International Conference on Pre-Failure Deformation Characteristics of Geomaterials (IS Torino '99)	Vol. 1 (1999) and Vol. 2 (2001); Jamiolkowski,M., Lancelotta,R. and Lo Presti, D.; Balkema
August, 2001	-	-	Advanced stress-strain testing of geomaterials (2001); Tatsuoka,F. and Shibuya,S. : Balkema
22nd to 24th September, 2003	Lyon, France	3rd International Symposium on the Geformation Characteristics of Geomaterials (DCG LYON03)	*Proceedings; Di Benedetto, H. et al. and Soils and Foundations (JGS)*

4) Standard testing methods for laboratory stress-strain tests that are relevant to the engineering need described above were investigated and the details of the above were suggested.

Despite such significant outcomes of the activities of TC29 as described in this report, compared to wider requirements to laboratory stress-strain tests on geomaterial, the scope of the present terms of reference is rather narrow, and therefore, TC-29 should be continued while exploring new fields.

Table 1 List of TC29 members for the second term (1997-2000)

Chairman
Prof. F. Tatsuoka (JPN)
Secretary
Dr S. Shibuya (JPN)
Core members
Prof. E flavigny (France)
Prof. D. Lo Presti (ITALY)
Prof. R.J. Jardine (UK)
Prof. K.H. Stokoe (USA)
Members
Dr D. Airey (Australia)
Prof. A. Bolle (Belgium)
Prof. C.S. Pinto (Brazil)
Prof. O.M. Villar (Brazil)
Prof. Y. Vaid (Canada)
Dr J. Kurta (Cz/Slovakia)
Dr R.L. Verdugo (Chile)
Dr Lars Bo Ibsen (DMK)
Prof. Di Benedetto (FR)
Dr V. Georgiannou (Greece)
Dr A.V. Shroff (India)
Dr. M. Telesnick (Israel)
Dr V. Fioravante (Italy)
Dr F. Silvestri (Italy)
Prof. Won-pyo Hong (Korea Republic)
Prof. E.J. Den Haan (NL)
Dr S. Nordal (Norway)
Dr M. Lipinski (Poland)
Prof. A. Correia (Portugal)
Dr V. Cueller (Spain)
Prof. Mehmet Berilgen (Turkey)
Prof. D.W. Hight (UK)
Prof. Germain (USA)
Prof. P. Lade (USA)

Table 2 List of members in Japanese domestic committee

Chairman
Prof. F. Tatsuoka
Secretary
Dr S. Shibuya
Core members
Dr J. Kuwano
Dr S. Yamashita
Dr Y. Kohata
Dr J. Koseki
Members
Dr K. Kita
Dr M. Nakano
Dr T. Kodaka
Mr. F. Fujiwara
Mr. H. Uehara
Dr K. Oda
Prof. K. Uchida
Dr T. Moriwaki
Dr N. Yasufuku
Dr M. Hatanaka
Mr. I. Furuta
Mr. M.Nakajima
Mr. K. Hayano
Dr M.Yoshimine
Dr M.Katagiri
Dr T.Tsuchida
Dr Y.Tanaka
Dr R.Kuwano
Mr. T.Kawaguchi