

# Administrative Report of TC28 – Underground construction in soft ground

## Compte rendu d'activité de la CT 28 – Constructions souterraines dans les sols meubles

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### ABSTRACT

In 1994, under the leadership of the then Chairman, Prof K. Fujita, a one-day International Symposium was held in New Delhi – just before the 13th ICSMGE. Following the success of this, it was decided to initiate under the Chairmanship of Prof R. Mair a series of two-day International Symposia on Geotechnical Aspects of Underground Construction in Soft Ground, with a third day devoted to technical site visits to underground construction projects. These International Symposia have been held every three years over the past 10 years as follows: 1996 London, 1999 Tokyo, 2002 Toulouse, 2005 Amsterdam, and 2008 Shanghai. These symposia, for all of which comprehensive proceedings have been produced containing the written papers, selected and reviewed by members of TC28, along with general reports and special lectures, thus provide a regular means of presenting information about the latest construction projects and research linked to the theme of Underground Construction in Soft Ground.

The 2005-2008 period has been very active, TC28 having organised a major symposium in Shanghai (2008), two regional workshops, in Perth (2007) and Budapest (2008). The 2008 symposium in Shanghai was attended by 182 registered delegates from 27 countries, and the proceedings contain four invited lectures, six general reports and 112 papers. Three working groups have been created during this period for constructing a database about underground construction projects, establishing “Guidelines for comparing field or physical model observations with numerical simulations”, and launching a survey on design practice in the field of soft ground tunnelling. The main outcomes and other activities of TC28 will be presented at a workshop organised during the next ICSMGE, Alexandria 2009. Plans are already in place for continuing TC28's activities for the period 2009-2013: completing the work initiated by the 3 working groups and organising an International Symposium (continuing in the series) in Roma (Italy) in 2008.

### RÉSUMÉ

En 1994, sous la présidence du Pr K. Fujita, un symposium d'une journée a été tenu la veille de la 13e CIMSCE sur le thème « Constructions souterraines dans les sols meubles ». Suite au succès de ce symposium, il a été décidé d'organiser sous la présidence du Pr R.J. Mair des symposiums internationaux de 2 jours, avec une 3e journée de visites techniques de sites de travaux souterrains. Ces symposiums ont été tenus régulièrement tous les trois ans, en 1996 à London, 1999 à Tokyo, 2002 à Toulouse, 2005 à Amsterdam, 2008 à Shanghai. Chacun de ces symposiums a été l'occasion de faire un bilan sur les derniers projets et chantiers de travaux souterrains et de faire le point sur les recherches en cours dans le domaine des travaux souterrains. Ils ont fait l'objet de comptes rendus contenant les communications écrites, sélectionnées et revues par des membres de TC28, des rapports généraux et des lectures invitées.

La période 2005-2008 a été très active : TC28 a organisé un symposium international à Shanghai en 2008, deux ateliers régionaux, à Perth en 2007 et à Budapest en 2008. 182 participants inscrits de 27 pays ont participé au symposium de Shanghai et les comptes rendus comprennent 112 communications, 6 rapports généraux et 4 lectures invitées. Trois groupes de travail ont été créés pendant cette période, le premier pour constituer une base de données sur les projets de constructions souterraines en sol meuble, le deuxième pour établir des recommandations pour comparer les résultats des modèles physiques et des mesures in situ avec les modèles numériques, et pour lancer une enquête sur les pratiques de conception des tunnels en sols meubles. Les principaux résultats et les diverses activités de TC28 seront présentés durant une réunion organisée dans le cadre de la prochaine CIMSCE à Alexandrie en 2009. Pour la période 2009-2013 sont déjà programmées les activités suivantes : conclure les travaux initiés par les trois groupes de travail, et organiser dans la continuité un nouveau symposium international à Rome (Italie) en 2008.

### 1 INTRODUCTION

In recent decades there has been a massive development of large cities throughout the world. Due to the lack of surface space and the need for extensive transport infrastructure systems there is an increasing rapid growth in underground construction in these urban environments with significant tunnelling and excavation works.

Technical Committee TC 28 has a major commitment towards consolidating and sharing technical knowledge and experience in the investigation, design, analysis and construction of underground works in the urban environment,

including tunnels, caverns and deep excavations. The main topics addressed by the committee are:

- *Tunnelling in soft ground;*
- *Deep excavations;*
- *Monitoring the effects of underground works;*
- *Numerical analysis of tunnels and deep excavations, assessing both stability and induced movements and deformations;*
- *Protective measures -ground treatment, control of groundwater inflow and deformations (e.g. by compensation grouting);*
- *Safety, risk and hazard management.*

The primary activity of TC28 is the organising of an international conference every three years. Since the first symposium at New Delhi in 1994, six symposia have been organised every 3 years.

During the 2005-2009 period, the Technical Committee organized a major International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground In Shanghai in April 2008. Details of this very successful Symposium are given later in this report.

Two regional workshops have also been organised by TC28 members, in Sydney (September 2007) and Budapest (September 2008).

Several new activities have recently been launched by TC28 following the committee meeting held during the Amsterdam conference in 2005. The first concerns the creation of a database relating to tunnelling and deep excavation works and the second the preparation of guidelines for the provision of data for comparing field or physical model observations with numerical simulations. And finally, during the Shanghai TC28 meeting, it was decided that a survey on design practice in the field of soft ground tunneling should be prepared.

## 2 TERMS OF REFERENCE

The Terms of Reference for TC28 are as follows:

1. To continue providing a forum for interchange of ideas and discussion using representatives from many countries with an active interest in tunnelling and deep excavations.
2. To continue providing a source of data and information concerning the design, construction and analysis of deep excavations and tunnels with particular emphasis on the development, effects and control of ground movements and mitigation measures.
3. To encourage the publication of well documented case histories and reports on the design and monitoring of deep excavations and tunnels by ISSMGE Member Societies; and to disseminate and discuss these matters at international symposia on Geotechnical Aspects of Underground Construction in Soft Ground.
4. To make contact with other Technical Committees and encourage the participation in TC28 of members of these TCs such as TC37 (Interactive geotechnical design), TC2 (Physical modelling).
5. To continue the interaction with societies promoting trenchless technology and encourage their participation in the TC28 events
6. To report on the outcomes and other activities at the International Conference on Soil Mechanics and Geotechnical Engineering, Alexandria 2009

## 3 INTERNATIONAL SYMPOSIUM IN SHANGHAI 2008

The Sixth International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground (IS-Shanghai 2008) was held successfully at the Sino-French Centre of Tongji University, Shanghai, China, from 10th to 12th April, 2008. This very successful Symposium was attended by 182 registered delegates from 27 countries.

The symposium was organized by Tongji University under the auspices of Technical Committee 28 (TC28) of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE). It was supported by the Chinese Society of Civil Engineering, the Chinese Society for Rock

Mechanics and Engineering, Geotechnical Division of the Hong Kong Institution of Engineers, Hong Kong Geotechnical Society, Hong Kong University of Science and Technology, Shanghai Yangzi Tunnels and Bridge Development Co. Ltd and Shanghai Society of Civil Engineering.

The themes of the Symposium, in line with the Terms of Reference for TC28, were addressed in technical sessions as follows:

1. Analysis and numerical modelling of deep excavations;
2. Construction method, ground treatment, and conditioning for tunnelling;
3. Case histories;
4. Safety issues, risk analysis, hazard management and control;
5. Physical and numerical modelling;
6. Calculation and design methods and predictive tools.

The first two days of the symposium were devoted to technical sessions, with four invited lectures, six general reports addressing the corresponding technical sessions, and a special session on the Shanghai Yangtze River Tunnel.

The third day was dedicated to a technical site visit of the Shanghai Yangtze River Tunnel project under construction which is one of the biggest shield tunnels in the world, 15m in diameter and nearly 9km long.

The Proceedings of the Symposium, containing four invited lectures, six general reports and 112 papers, selected and reviewed by members of TC28, have now been published (Ng et al, 2009).

These symposia, for all of which comprehensive proceedings have been produced containing the written papers, , along with general reports and special lectures,

## 4 WORKSHOPS AND SEMINARS

### i) Perth seminar

Mr Eric Hudson-Smith, TC28 core member representing Australia co-organised a one-day seminar held in Perth on 12th September 2007. The event was a great success with about 120 people attending to hear Professor Mair's Rankine lecture and various other presentations during the day. Proceedings with papers and discussion from the seminar have been produced along with a CD.

### ii) Budapest Workshop

A very successful workshop was held at the Budapest University of Technology and Economics (BME), Hungary on 12th and 13th September 2008. It was organised by Professor József Mecsí under the aegis of TC28 in collaboration with the Hungarian Tunnelling Association, Budapest and Pest County, the Chamber of Engineers, Municipality of Budapest, BME and Pollack Mihály Faculty of Engineering, University of Pécs. The workshop, held in conjunction with the construction works of the new Budapest Metro Line 4 had two main components: a day of lectures and discussion followed by a day of site visits (written up in the ISSMGE Bulletin, Volume 2, Issue 4, December 2008, Page 16).

## 5 COMMITTEE MEETINGS OF TC28

Committee meetings of TC28 were held in Madrid in September 2007 and Shanghai in April 2008. The following points should be noted,

- i) At the Madrid committee meeting, it was agreed to launch two working groups,
  - the first one concerning the creation of a database to store information about underground construction projects
  - the second one for proposing "Guidelines for comparing field or physical model observations with numerical simulations"

- Prof Akagi handed out copies of a CD-ROM presenting a comprehensive textbook on geotechnical aspects of underground construction edited by Profs Akagi and Komiya and also Dr Standing and Mr Finlay Jardine.
- ii) At the Shanghai meeting, It was decided
  - that the next TC28 International Symposium should be held in Rome in 2011
  - to launch a questionnaire on design practice in the field of soft ground tunnelling. The results of this survey will be synthesized and presented during the next international symposium in Roma.

## 6 NEW ACTIVITIES OF TC28

As decided during the Madrid and Shanghai TC28 meetings, 3 main new projects have been launched by TC28:

- i) the creation of a specific database to store information about underground construction projects and particularly to make available to the geotechnical community interesting observation and monitoring data obtained during major tunnelling and excavation projects;
- ii) establishing "Guidelines for comparing field or physical model observations with numerical simulations"
- iii) launching a survey on design practice in the field of soft ground tunnelling

Details concerning these new activities undertaken by TC 28 are given in an appendix to this report.

## 7 FUTURE WORKSHOPS AND SYMPOSIA

A workshop will be organised by TC28 during the Alexandria International Conference

Together with TC 32, TC38 & TC42, TC28 is involved in the International Conference "Geotechnical Challenges in Megacities", organised in June 2010 in Moscow by Profs Petrukhin and Ulistky.

The next TC28 International Symposium will be held in Rome in 2011, in conjunction with the construction of a new metro line in a very sensitive environment with many major old monuments.

## 8 PUBLICATIONS ARISING FROM THE WORK OF TC28

***Proceedings of International Symposium at Shanghai, 2008:*** Geotechnical Aspects of Underground Construction in Soft Ground, Ng; Huang & Liu (eds) © 2008 CRC Press/Balkema. (112 papers, 4 invited lectures & 6 general reports). ISBN 978-0-415-48475-6 (Hardback); ISBN 978-0-203-87998-6 (eBook)

***F. Emeriault, R. Kastner, R. Louis-Sidney, E. Egyed-Zsigmond (2008).*** A new international database on case histories of monitored construction of tunnels and deep excavations, *6th Int. Conf. Case Histories in Geotech. Eng.*, Arlington VA, Aug. 2008. Proceedings on CD-Rom, 8 pages.

***Perth New MetroRail Project "Seminar on tunnelling and underground structures"***, 12 September 2007, Perth. Proceedings & CD: Fiona Thorniley, Engineers Australia, WA Division, 712 Murray Street, West Perth, West Australia.

***ISSMGE TC28 workshop Hungary. CD available from Jozsef Mecsi; jmecsi@hotmail.com***

## 9 APPENDIX: WORKING GROUPS CREATED DURING THE 2005-2009 PERIOD

### 9.1 Database for underground works

The idea of creating a database to store information about underground construction projects was raised at the Amsterdam TC28 meeting in 2005. The intention was to share comprehensive field and experimental data either (i) for cases where there is comprehensive monitoring data along with details of tunnelling/excavation techniques and parameters, ground conditions etc. or (ii) where there have been particular geotechnical problems (e.g. excessive settlements, failure, damage to nearby structures).

It was recognised that in many instances databases have been set up for projects but not maintained after completion of the works and also there were frequently difficulties with coping with various data input formats, organising the database to be effective etc...

INSA Lyon (Dr Fabrice Emeriault & Mr Rodolf Louis-Sidney) has taken the lead with this, initiating a project to develop a database for TC28 with a view to creating a system where members can input data that will be maintained on a permanent basis.

The basic requirements for this database have been established by the members of the Technical Committee TC28. A prototype of a new database for case histories of monitored construction of tunnels and deep excavations has been developed. It is based on the Content Management System (CMS) Typo3. The resulting structure is flexible, the data being mirrored on sites managed by each participant interested. It uses a web interface where the user can navigate and access to the data via an indexed search engine. Some very basic and brief standard forms describe the type of work, the geotechnical context and the data available. The other data (for example precise description of the construction works, results of monitoring, pictures and drawings...) are organized according to formats chosen by each of the participants. Guidelines and minimal rules have also been proposed in order to ensure that the data can be actually used. Nevertheless, the rules concerning availability/accessibility of the data outside the TC28 partners involved in the creation of the database are still under discussion.

More details can be found in the following paper presented in the 6th Int. Conf. Case Histories in Geotech. Eng, Arlington VA, Aug. 2008.

### 9.2 Survey on design practice in the field of soft ground tunnelling

TC28 decided during the Shanghai meeting, that instead of producing national reports, which present often tedious repetitions, it was more interesting to launch a survey on design practice in the field of soft ground tunnelling, based on the examples of national surveys previously carried out in Japan (K. Fujita) and in Brazil (A. Negro).

The general idea is to launch the questionnaire for discussion in advance of the next TC28 International Symposium in 2011.

The objective of the questionnaire is to assimilate, at an international level, the different practices adopted for the conception and design of these tunnels.

The intention is that the survey exclusively concerns tunnels:

- constructed in soft soils, cemented soils and weak rocks, and excludes tunnels driven in rock;
- of a diameter equal or greater than 1.5m in diameter (which excludes microtunnels), regardless of their use;
- bored either using a staged method (sometimes referred to as NATM or Sprayed Concrete Lining), or by tunnel boring

machine (TBM), or by jacking the lining pipes behind the TBM (excluding linings installed by directional drilling).

The main points addressed by the questionnaire are the following

- 1 - General description of the projects
- 2- Sequentially excavated tunnels (construction method, face stability, lining...)
- 3- Driven tunnels (TBM type, face stability, TBM parameters monitoring...)
- 4- Settlements and damage
- 5- Numerical approaches
- 6- Field monitoring
- 7- Research and Improvements

This questionnaire will be sent to all the TC28 members who will distribute it to at a national level to experienced engineers who supervise or are involved with the conception and design of tunnels.

The results from the various aspects considered in the survey will then be analysed by several specialists from the TC28 working group and a synthesis of the findings put forward during the next, sixth international TC28 symposium which is to be held in Rome in 2011. This synthesis will also be sent in advance to all those who responded to and provided information for the survey. It should allow all those involved in the field of tunnelling (from the geotechnical perspective) to consider their approaches in relation to those currently adopted and used by others working in different environments. It will then be possible for those involved in urban tunnelling to reflect on the various elements covered by the survey and to consider where and how to make improvements.

### 9.3 Guidelines for the evaluation of numerical simulation approaches

With the rapid development of numerical tools such as 2D or 3D finite element or finite difference codes, the validation of these tools or of simulation approaches using such tools has become a major concern for researchers and engineers. One can find more and more publications presenting comparisons between field measurements, or physical models, and predictions using various types of approach, ranging from empirical predictions to results obtained with sophisticated 3D models. Many examples can be found in the proceedings of the symposia held under the aegis of TC28.

Although these comparisons are obviously important, they are useful only if they take into account basic scientific rules and if they are clearly and completely described.

It is well-known that a simplistic calculation approach often allows, by adjusting some parameters, an acceptable match of value of one single measured parameter to be obtained. However, this does not guarantee that the results for other parameters will be acceptable. As an example, one can consider the design of retaining walls using the concept involving the hypothesis of subgrade reaction. Using this very simple concept, often with the help of some *a posteriori* adjustments, it is possible to reproduce the measured deformation of a flexible retaining wall. But it is often impossible, even after many *a posteriori* adjustments, to obtain simultaneously a good prediction of both the wall displacements and the forces in the strut system. This example shows the importance of considering various aspects of the behaviour of a construction works to investigate the suitability and performance of a modelling approach.

Likewise, comparing only calculated and measured surface settlements due to tunnel construction will generally be insufficient for evaluating the suitability of a simulation approach. The surface is usually at an appreciable distance from the tunnel so consequently the surface movements result from several actions linked with the tunnel construction, these actions can in some cases even have opposing effects on each other.

Similarly, because there is often uncertainty with the results from geotechnical investigations, the *a posteriori* adjustment of some soil parameters can be regarded as legitimate (e.g. with the principle of the observational method). Nonetheless, it would be advisable each time to specify the possible limits of these parameters starting from the geotechnical investigation, in order to check if these adjustments are legitimate. In the same way, the use of project design parameters is not generally a relevant approach, these data generally being modified by safety coefficients to limit the risks of damage or failure.

In this context, TC28 decided to launch under the leadership of Pr G. Viggiani, a working Group for proposing “Guidelines for the evaluation of numerical simulation approaches”, aimed at the main types of work relating to TC28. These guidelines should allow authors, when drafting their publications, to clarify the limits of their comparisons. These guidelines might even lead to better design of monitoring systems, for more comprehensive comparisons of field and experimental with computational data.