Workshop & Lectures on Eurocode 7 - A Model Code for All

Organised by: **Centre for Infrastructure Engineering and Management and School of Engineering, Griffith University Gold Coast Campus**

Trevor Orr, Dr. Director of the Graduate School of Professional Engineering Studies, Trinity College, Dublin, Ireland

Date: July 12-13, 2010

Venue: Griffith University Gold Coast Campus G30 1.09

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INTRODUCTION

Dr. Trevor Orr from Trinity College Dublin will give a series of lectures on July 12-13, 2010 on Eurocode. The objectives of the series of lectures on Eurocode 7 are to:

- **To explain the concepts and key features of Eurocode 7**
- **To provide an appreciation of the issues that arose in preparing Eurocode 7 and which have led to its final form**
- **To show how the following structures are designed to Eurocode 7:**
  - **A spread foundation**
  - **A pile foundation**
  - **A retaining structure**
  - **A slope.**
- **To provide practice in the design of a spread foundation and a retaining wall to Eurocode 7.**

Trevor Orr has been involved in the development of Eurocode from the very start and has participated on the committees that prepared the code drafts and is presently a member the Maintenance Group that is responsible for collecting the comments on Eurocode 7 and preparing the corrigenda and revisions. He is the co-author of two books on Eurocode 7 and has written many papers and given many invited lectures on Eurocode 7. He has chosen the *Eurocode 7 - A Code for All* as the title for his course of lectures because it is anticipated that Eurocode 7, as well as being the only code that will be used in Europe, will be adopted as the design standard for many non-European countries as well, particularly any countries that previously used European standards as these will no longer be supported by the European national standards organisations after 31st March 2010. In his 2-day course of lectures on Eurocode 7, Trevor Orr will explain the main concepts and features in Eurocode 7 and will show how these are applied in practice with examples of the design of shallow foundations, pile foundations, retaining structures and slopes and designs against hydraulic failure.
One of the objectives of the Eurocode programme is to harmonise designs across the different countries in Europe and hence remove the barriers to trade in the construction industry that occur due to the existence of different national design standards. Cross border projects are a particular area where harmonised standards are required; an example of a structure that has already been successfully designed to the Eurocodes is the Øresund Bridge between Sweden and Denmark. As well as harmonising design between different countries, the Eurocodes also harmonise design across different materials so that designs are based on the same design method and geotechnical and structural engineers speak the same design language. The Eurocodes are all based on the limit state design method, which is set out in the head Eurocode, EN 1990, with partial factors applied to characteristic parameter values and with designs aimed to achieve a certain target probability of failure or reliability. Implementing this design method in Eurocode 7 has caused particular challenges for geotechnical engineers as soil is a natural material rather than a manufactured material, like concrete or steel, and there has not been much experience in the use of limit state design method for geotechnical design in Europe. Work started on the preparation of Eurocode 7 in 1981 and after much discussion and debate and many revisions the challenges that arose were overcome and the final European standard version of Eurocode 7, EN 1997-1, was published in 2004.

Trevor Orr is chairman of the European Technical Committee 10 of the International Society for Soil Mechanics and Geotechnical Engineering. This committee is organising an important workshop on the Evaluation of Eurocode 7 in Pavia in April this year. Prior to this workshop a number of design examples were distributed to geotechnical engineers in Europe and the solutions to these examples will be reviewed and discussed at the workshop. In his lectures, Trevor Orr will present the results of the exercise and the outcome of the Pavia Workshop.

Technical Program

Day 1, Monday, July 12, 2010

08:30 – 09:00am	**Registration**
09:00 – 10:15am	**The Eurocode programme and key features of Eurocode 7**
10:15 – 10:45am	**Coffee break**
10:45 – 12:00pm	**Geotechnical data Characteristic values and related CEN standards**
12:00 – 01:00pm	**Lunch**
01:00 – 02:30pm	**Eurocode 7 Design Approaches and Calculation models**
02:30 – 03:00pm	**Coffee Break**
03:00 – 04:00pm	**Design of spread foundations with examples**
04: 00 – 05:00pm	**Practical design exercise: Design of a spread foundation**

Day 2, Tuesday , July 12, 2010

08:30 – 09:00am	**Registration**
09:00 – 10:15am	**Geotechnical complexity and Geotechnical Design Triangle**
10:15 – 10:45am	**Coffee break**
10:45 – 12:00pm	**Design of retaining structures with examples**
12:00 – 01:00pm	**Lunch**
01:00 – 02:30pm	**Design of pile foundations and design against hydraulic**

failure

02:30 – 03:00pm Coffee Break

03:00 – 04:00pm Practical design exercise – Design of an embedded retaining wall

04: 00 – 05:00pm Implementation of Eurocode 7, Report on Pavia Workshop and Future Development

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Synopses of lectures by Dr. Trevor Orr

1. The Eurocode programme and Key features of Eurocode 7

The concept of a suite of harmonised standards for structural and geotechnical design in Europe was an initiative, in 1974, from some European universities and the civil engineering profession. At that time, nine countries in Western Europe formed the European Economic Community (EEC), popularly called the Common Market, one of whose objectives was the expansion of trade through the removal of barriers and national regulations. Recognising the advantages of a suite of harmonised standards for structural and geotechnical design, the Commission of EEC decided in 1975 on an action programme called the Eurocodes. The Eurocode programme consists of 10 standards with 58 parts covering the design of buildings and civil engineering works. In 1991 the responsibility for preparing and publishing the Eurocodes was transferred the European Commission to CEN, the European Committee for Standardization. The Eurocodes are all based on the same limit state design method, which is set out in the head Eurocode, *EN 1990: Basis of Design*. The Eurocode for geotechnical design is Eurocode 7 or *EN 1997: Geotechnical Design*. Eurocode 7 has two parts: *Part 1 - General Rules*, published in 2004, and *Part 2: Ground investigation and testing*, published in 2007.

The key features of Eurocode 7 are that it shows how the limit state method is applied in geotechnical designs and it provides the principles and requirements for the entire geotechnical design process, which includes the following six stages:

- Assessing the complexity and risk of a geotechnical design situation
- Specifying ground investigations
- Determining and selecting geotechnical parameter values
- Carrying out the design calculations (verifying the design)
- Monitoring, i.e. checking, the ground conditions during construction
- Specifying the requirements for maintenance of the completed structure after construction

The limit state method involves checking that the occurrence of both an ultimate limit state and a serviceability limit state is sufficiently unlikely. This is achieved using calculations where partial factors are applied to characteristic loads and to characteristic material parameter values or resistances. The way in which Eurocode 7 provides the principles for geotechnical design is through checklists of items to be considered in each geotechnical design situation. These checklists are a key part of Eurocode 7. Since Eurocode 7 focuses on the principles for all the stages of geotechnical design, it only provides the equilibrium conditions to be satisfied and does not provide any calculation models in the code text, only some models are provided in informative annexes. By focusing on the principles for geotechnical design means that Eurocode 7 is a code that is relevant for all geotechnical engineers, not just European.

2. Geotechnical data, Characteristic values and related CEN standards

Geotechnical design differs from structural design in that soil is a natural material while the materials used for structural design are manufactured. The consequence of this is that, as part of the geotechnical design process, the soil parameter values must be selected, not specified, as in the case of structural design. Hence Eurocode

7 has a section in Part 1 on geotechnical data and has Part 2 which presents the requirements for geotechnical investigations, including the spacing and depths of boreholes, and for the selection of parameter values from field and laboratory test results. An innovative feature of Eurocode 7 is the definition of the characteristic value of a geotechnical parameter. The procedure for obtaining a characteristic soil parameter value from test results via derived parameter values is outlined. Examples are given of the selection of characteristic parameter values from laboratory test results and from pile load tests.

Related to Eurocode 7, which is a code for geotechnical design only, CEN is preparing 7 new standards, with 47 parts, for geotechnical investigation and testing, covering the most common field and laboratory tests, and 13 new standards for the execution, i.e. the carrying out, of special geotechnical works, e.g. bored piles and ground anchors. Most of these standards have already been published as full CEN standards. All the associated standards and other CEN standards related to geotechnical engineering are listed and their present status is explained.

3. Eurocode 7 Design Approaches and Calculation models

An issue which led to much debate during the development of Eurocode 7 was how to apply partial factors in geotechnical designs, i.e. whether they should be applied directly to characteristic soil parameter values or to resistances calculated using unfactored parameters, and how permanent loads should be factored. This issue was resolved by introducing three Design Approaches, with different sets of partial factors that are applied either to soil parameter values or to resistances. The main features of the three Design Approaches and the differences between them are explained, including how partial factors are applied to self weight and water pressures and when the single source principle is used. Examples are given of the use of the different Design Approaches in various design situations.

Since Eurocode 7 focuses on the design principles and since for most geotechnical design situations, there is no agreement on the calculation model to be used, only a few calculations models have been provided in informative (optional) annexes, not in the code text. The origin of the models that are provided in Eurocode 7 and their main features are explained. These models include models for earth pressure, both graphical and analytical, and for the bearing resistance of spread foundations.

4. Design of spread foundations with examples

The design of a spread foundation is probably the most fundamental geotechnical design situation. The requirements for the design of a spread foundation are given in the code text while some calculation models for the bearing resistance are provided in annexes. The use of these models in the ultimate limit state design of a spread foundation is demonstrated. Examples are given of the design of a foundation with a vertical central load and with an inclined eccentric load for all three Design Approaches. The serviceability limit design of spread foundations is also described, including the use of an indirect design method with the conditions for when a settlement calculation is required and what type of settlement calculation is required in the case of a foundation resting on fine-grained soil.

5. **Practical Design Exercise – Design of a Spread Foundation**

In this session, participants are asked to design a spread foundation subjected to an inclined and eccentric load using one of the Eurocode 7 Design Approaches.

6. **Geotechnical complexity and the Geotechnical Design Triangle**

Assessing the complexity of a geotechnical design situation is the first step in any design to Eurocode 7. The factors contributing to the complexity of a geotechnical design situation are the geotechnical hazards, including the ground and groundwater condition, and the vulnerability of the structure being designed and its impact on any neighbouring structures. The three Geotechnical Categories presented in Eurocode 7 to assess and treat the risks presented by the geotechnical complexity are discussed. A target reliability index value of $\beta = 3.8$ is set in EN 1990 for ultimate limit state designs and this values is compared with the calculated reliabilities of spread foundations designed to Eurocode 7 using the three different Design Approaches.

The challenges to be overcome by those drafting Eurocode 7 included preparing a code that:

- Harmonised geotechnical design with structural design and was consistent with EN 1990
- Took account of the special features of soil and geotechnical design, and
- Was acceptable to the European geotechnical community by taking account of existing national practices and experiences.

How these challenges were overcome, particularly how the special features of soil and geotechnical design affected the development of Eurocode 7, are explained. Then, just as Professor John Burland used a Soil Mechanics Triangle to explain how the four aspects of soil mechanics are linked, so also a Geotechnical Design Triangle is presented to show how the four components of a geotechnical design are related and where the safety elements are applied.

7. **Design of retaining structures, slopes and embankments with examples**

The design of retaining structures to Eurocode 7 using the three Design Approaches is demonstrated. When the earth pressure is treated as an action and when it is treated as a resistance is explained. Also it is explained when the total or net water pressure on a retaining wall is used in stability analyses. An important safety feature introduced in Eurocode 7 for the design of retaining walls is a geometric allowance in front of the wall to account for overdig or unplanned excavations. Examples are given of the design of an embedded retaining wall, including the determination of the maximum shear force and bending moment for the structural design of the wall, and the design of a cantilever gravity retaining wall.

There is no section in Eurocode 7 with the requirements for the design of slopes. Instead there is a section on overall stability and another section on embankments. The requirements in these sections are discussed and it is explained how the requirements in Eurocode 7 regarding the equilibrium checks required in slope stability analyses render certain slope stability analysis methods unacceptable. Examples are given of slope stability analyses.

8. **Design of pile foundations and Design against hydraulic failure with examples**

The design of pile foundations to Eurocode 7, another common geotechnical design situation, is explained. A particular feature of the design of pile foundations to Eurocode 7 is the importance given to static pile load tests for validating the different pile design methods and the emphasis given to factoring pile resistances rather than soil strength parameters in the design of piles. Another feature is the provision of correlation factors to obtain characteristic pile resistances directly from pile load test results. Examples are given of the design of pile foundations using the three Design Approaches.

Eurocode 7 considers two types of hydraulic failure, failure of a buried structure due to uplift from hydrostatic groundwater pressure and failure of soil due to heave caused by excessive seepage pressure. Since these design situations involve no, or very little, soil strength, Eurocode 7 provides separate sets of partial factors for these ultimate limit states. How hydraulic forces are treated in these situations and how designs are carried out to ensure that neither uplift or heave failure occur is explained.

9. **Practical Design Exercise – Design of an embedded retaining wall**

In this session, participants are asked to design an embedded retaining wall retaining a surcharge and subjected to earth and groundwater pressures.

10. **Implementation of Eurocode 7, Report on Pavia Workshop and Future Development**

In the final lecture, the implementation of Eurocode 7 in Europe is discussed. In order to use Eurocode 7 in a particular CEN country, that country has to prepare a national annex stating the Design Approach(es) to be used and giving the values of the partial factors for designs carried out in that country. The Design Approach(es) that each CEN country has decided to adopt are presented and discussed. On 31st March 2010 the Eurocode era begins in Europe and on that date the Eurocodes, including Eurocode 7, are to supersede the existing national standards for structural and geotechnical design. A Workshop on the Evaluation of Eurocode 7 is being held in Pavia in April 2010 shortly after its implementation. For this Workshop, six Eurocode 7 design examples were distributed to geotechnical engineers across Europe and the solutions received will be reviewed at this Workshop in Pavia. A report on the outcome of this Workshop will be presented. A report will also be presented on the plans for revisions to and for the future development of Eurocode 7.

Bio data : Dr. Trevor L. L. Orr

Trevor Orr is the Director of the Graduate School of Professional Engineering Studies at Trinity College Dublin. He received his PhD degree from Cambridge University in 1976 for research into the behaviour of tunnels in stiff clay. After first working as an engineer with Sir William Halcrow & Partners in London he has since been at Trinity College Dublin where his research interests include geotechnical design, the use of probabilistic methods in geotechnics and tunnelling. He has spent three half-year sabbatical periods away from Trinity College, one at Karlsruhe University, Germany, another at the Danish Geotechnical Institute, Copenhagen, and the third at the Charles University, Prague, Czech Republic.

He has been closely involved in the development of Eurocode 7, the new European standard for geotechnical design, since work started on this in 1981:
- 1981 – 1987: Member of the committee that produced the model code for Eurocode 7
- 1987 – 1994: Secretary of the drafting panel for the ENV (trial) version of Eurocode 7
- 1996: Reporter for the International Seminar, Eurocode 7 - Towards Implementation
- 1997 – 1998: Member of Working Group 1 established to convert the ENV into an EN
- 2006 – present: Member of the Maintenance Group for Eurocode 7.

He has been chairman of the European Technical Committee for the Evaluation of Eurocode 7 from 2003 to the present time and organised a Workshop on the Evaluation of Eurocode 7 in Dublin in 2005. He has written many papers and given many lectures on Eurocode 7, including invited lectures in Austria, Belgium, Croatia, Germany, Italy, Japan, Latvia, Macedonia, Poland, Taiwan and the UK.

Trevor Orr is the co-author of two books on Eurocode 7; the first book, with E. Farrell and entitled *Geotechnical Design to Eurocode 7*, was on the ENV version of Eurocode7 and was published by Springer in 1999. The second book, with six other co-authors and entitled *Designers' Guide to EN 1997-1*, was on the EN version of Eurocode 7 and was published by Thomas Telford in 2004. This book, which is one of a set of Designers' Guides to the Eurocodes, has proved to be extremely popular and a new, updated, edition is currently being planned

He was a founder member of the Geotechnical Society of Ireland and was secretary of the IX European Conference for Soil Mechanics and Foundation held in Dublin in 1987. He was chairman of the 15th European Young Geotechnical Engineers' Conference held in Dublin in 2002. He was a member of the Advisory panel for the journal *Geotechnique* from 2006 – 2009 and is currently a member of the Advisory panel for the journal Geotechnical Engineering.