THE DEVELOPMENT AND IMPLEMENTATION OF EUROCODE 7

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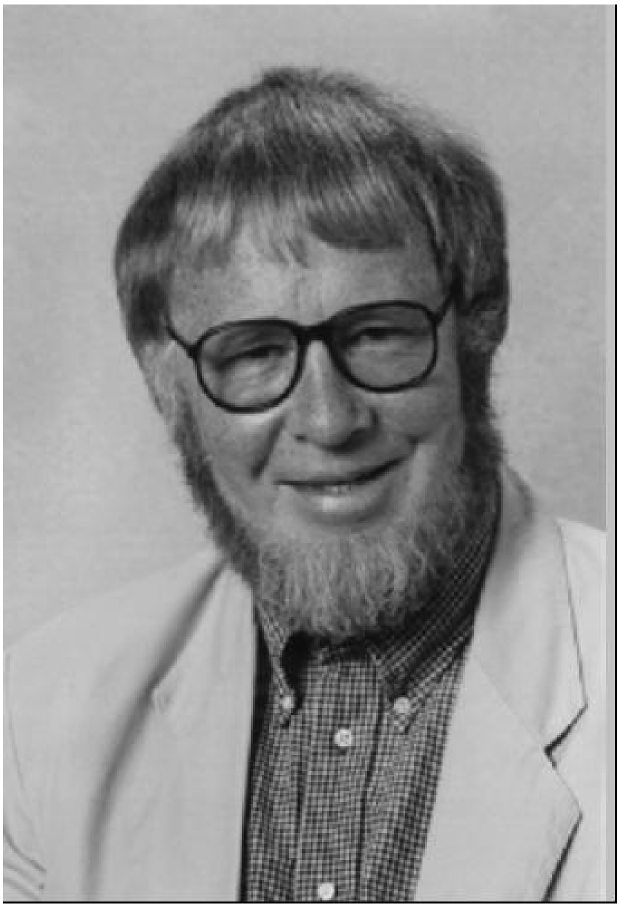
Paper presented to a meeting of the Geotechnical Society of Ireland Society at Engineers Ireland
6th November 2007



Niels Krebs Ovesen
Chairman/Convenor of Eurocode 7 1980 - 1998

ABSTRACT
The development of Eurocode 7, the new European standard for geotechnical design, is traced from the decision of the European Commission in 1975 to establish a set of harmonized technical rules for structural design, known as the Eurocodes, to remove the barriers to trade within the EEC. The stages involved in the development of Eurocode 7 from the first committee meeting in 1981 to the publication in 2004 of EN 1997-1, the European Standard version of Eurocode 7, are outlined. The challenges that had to be overcome in preparing a geotechnical design code that harmonized geotechnical design with structural design within the Eurocode framework are explained. The process of implementing Eurocode 7 as a national standard in each European country through the preparation of National Annexes is outlined. Details are given of Nationally Determined Parameters chosen for the Irish National Annex. The Irish National Annex with the text of EN 1997-1 was published in 2007 as I.S. EN 1997-1 and is the first Irish standard for geotechnical design. The significance of this is that Eurocode 7 can now be used for geotechnical design in Ireland and will be called up in public contracts from 31st March 2010, which is when the Eurocode Era is due to start.

1. Background: 1975-1980

Eurocode 7, the new European code for geotechnical design, is one of the set of 58 Eurocodes for structural, including geotechnical, design throughout Europe. The concept of the Eurocodes arose as a consequence of the European Commission deciding in 1975 on an action programme to remove the barriers to trade in construction within the member states of the European Community. Within this action programme the Commission took the initiative to establish a set of harmonised technical rules, known as the Eurocodes. It was intended that the Eurocodes would, at a first stage, serve as an alternative to the national standards and, ultimately, would replace them. It was also decided to base the Eurocodes on the limit state design method with characteristic values and partial factors.

A Eurocode Steering Committee to oversee the work on the Eurocodes was established by the section of the Directorate General for the Internal Market, DG3.1. In 1979 a geotechnical engineer on the Eurocode Steering Committee informed the International Society for Soil mechanics and Foundation Engineering (ISSMFE) of the proposal to prepare a Eurocode for geotechnical design. Professor Kevin Nash, Secretary General of the ISSMFE, wrote to the EC stating that the ISSMFE was *keenly interested to become involved in the work on EC 7 and to draft a proposal for Eurocode 7*.

This paper outlines the stages in the development of Eurocode 7, the challenges that had to be overcome, the process for its implementation in the CEN Member States and the main features of the Irish National Annex for Eurocode 7.

2. Model Code Stage: 1981 - 1987

Following the Professor Nash's letter to the EC, the ISSMFE sought to identify a suitable person to chair a sub-committee to prepare the draft Eurocode 7. Following consultations with geotechnical engineers in Europe, Professor Fukuoka, president of the ISSMFE, asked Professor Nash in 1980 to invite Professor Niels Krebs Ovesen of the Danish Engineering Academy to chair the sub-committee and produce a model code for Eurocode 7. In 1980, invitations were sent to each of the eight geotechnical societies within the nine EEC countries at that time to nominate a representative to this committee. These nine countries were Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands and the UK; Luxembourg does not have a separate geotechnical society. The first meeting of this committee took place in Brussels in March 1981, by which time Greece had joined the EEC and so was represented at the meeting. Trevor Orr was appointed as the representative of the Geotechnical Society of Ireland on this committee and attended its second meeting in Stockholm in June 1981 during the 11th International Conference on Soil Mechanics and Geotechnical Engineering.

The year 1981 was a time of change in the ISSMFE: Professor Nash died unexpectedly and Professor John Burland acted for a short period as Secretary General until Dr. R.H.G. Parry was appointed; Professor Fukuoka was succeeded by Professor Victor de Mello as President. The recently established Eurocode 7 sub-committee caused a problem for the new ISSMFE Steering Committee under Professor de Mello as it was a unique committee and was functioning without the status of a normal ISSMFE technical committee. Also, the members of the ISSMFE Steering Committee felt that the ISSMFE should not be engaged in drafting codes of practice. Hence, on 20th November 1981, Professor de Mello wrote to all the member societies stating that the status of the sub-committee on Eurocode 7 was under reconsideration. Subsequently, on 12th May 1982, John Burland, a member of the Steering Committee, wrote to Niels Krebs Ovesen, as requested by Professor de Mello, suggesting that the committee should be designated an ad-hoc committee consisting of representatives from the nine member societies of the ISSMFE. It was agreed with Krebs Ovesen that when the final draft had been produced it would go to the nine ISSMFE member societies who would express their views on the draft. The draft would then be sent to the European Commission with the views of the member societies. Also the following statement relating to the ad-hoc committee appears in the minutes of the ISSMFE Steering Committee meeting in May 1983: *Any publication of this committee should not imply responsibility of the ISSMFE*.

The withdrawal of ISSMFE sponsorship from the committee, while disappointing, did not in fact affect its work nor did it result in any members leaving the committee. The members were happy to continue working on the ad-hoc committee for their national societies under the leadership of Niels Krebs Ovesen. When Portugal and Spain joined the EEC in 1985, representatives from these countries also joined the ad-hoc committee. Meetings were held in the countries of the committee members so that, as well as drafting the model code, they learnt about the geotechnical practices in the different countries. The eighth meeting was held in Dublin at the Institution of Engineers of Ireland in January 1983. Figure 1 is a photograph of those who attended that meeting.

After 22 meetings held in the 6 years between 1981 and 1987, the ad-hoc committee completed its work and submitted the draft model code for Eurocode 7 shown in Figure 2 to the European Commission in December 1987. It is stated in this document that it had been prepared by representatives of the geotechnical societies within the European Communities so that, as agreed by Niels Krebs Ovesen, it is clear it was not an ISSMFE approved document.

3. First Draft Stage: 1988 - 1989

Once the model code for Eurocode 7 had been submitted, the European Commission then formed a smaller 7-member Drafting Panel to convert the model code into the standard Eurocode 7. Niels Krebs Ovesen was appointed Chairman of this Drafting Panel. Trevor Orr

Figure 1: Eurocode 7 Ad-hoc Committee members at Meeting in the IEI, Dublin, January 1983

Front row:
Trevor Orr Ireland), Demetrious Coumoulos (Greece), Niels Krebs Ovesen (Denmark), Wim Heijnen (Netherlands)

Middle row:
Willie Sadgorski (Germany), Terry Thorp (Germany – representing U. Smoltczyk), E. Farrell (Ireland)

Back row:
Brian Simpson (UK), Emanuel Lousberg (Belgium), Francois Baguelin (France), Rugiero Japelli (Italy), Henk Nelissen (Netherlands).

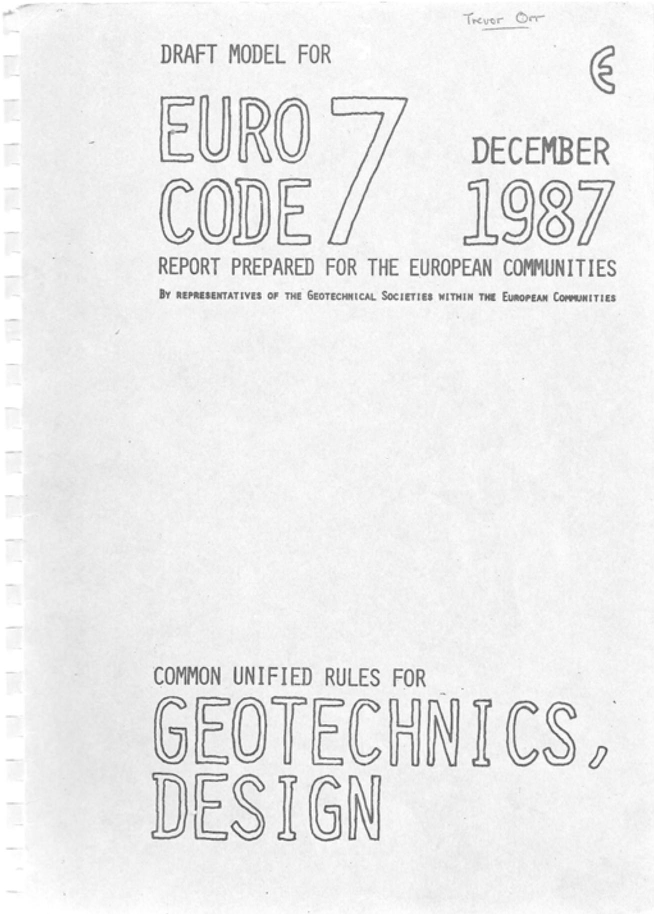

Trevor Orr
DRAFT MODEL FOR
EURO CODE 7
DECEMBER 1987
REPORT PREPARED FOR THE EUROPEAN COMMUNITIES
BY REPRESENTATIVES OF THE GEOTECHNICAL SOCIETIES WITHIN THE EUROPEAN COMMUNITIES
COMMON UNIFIED RULES FOR
GEOTECHNICS, DESIGN

Figure 2: Draft Model Code for Eurocode 7

was selected to be a member and acted as secretary. This Drafting Panel differed from the previous ad-hoc committee as the members were now working as independent experts for the European Commission, rather than as representatives of the national geotechnical societies.

Since the Drafting Panel was working under European Commission, it was obliged to have most of its meetings in Brussels organised by the Commission. However, as the scale of the work on the Eurocodes had expanded so much, the Commission was having difficulty managing it. There was a shortage of suitable committee rooms in Brussels and, as an example of the sort of problems that occurred, on one occasion the members of the Drafting Panel found themselves locked out of their meeting room when they returned from lunch.

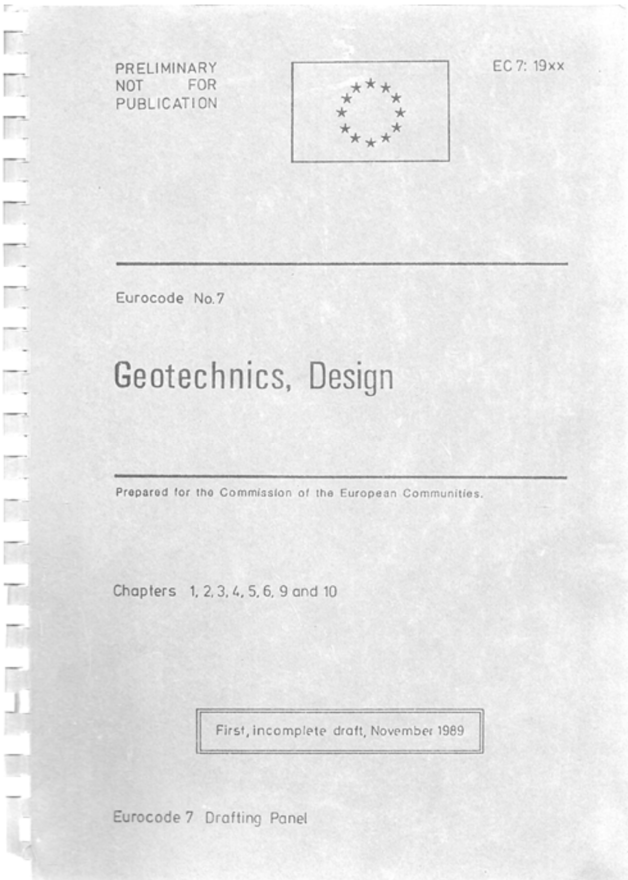
The problems that the Commission had in managing the work on the Eurocodes reflected the more fundamental problem that it was a civil service type of organisation established to serve the European Parliament, not an organisation to prepare codes of practice and standards. Consequently, in 1989, the European Commission decided to transfer the work on the Eurocodes to CEN, the European Committee for Strandardization. Before transfer of the Eurocode work from the Commission to CEN took place, the Drafting Panel submitted the first incomplete draft of Eurocode 7 shown in Figure 3 to the Commission in November 1989.

4. ENV Stage: 1990 - 1994

The transfer of the Eurocode work to CEN took place on 1 January 1990. CEN established the technical committee TC 250 Structural Eurocodes, consisting of representatives of the national standards organisations, to oversee this work. The current National Standards Authority of Ireland (NSAI) representative on TC 250 is Barry Smith.

A sub-committee of TC 250 was set up for each Eurocode; in the case of Eurocode 7, this sub-committee was called SC7: Geotechnical Design, and Niels Krebs Ovesen was appointed convenor in 1990 and held that position until 1998. His successor as convenor was Roger Frank (France) from 1998 to 2004 and Bernd Schuppener (Germany) has been convenor since June 2004. Eric Farrell was appointed the NSAI representative on SC7. The first SC7 meeting was held in Rotterdam in December 1990. Since then, there have been 22 SC7 meetings, one or two a year, usually in a different CEN member country. In July 2002, SC7 met in Trinity College, Dublin. The most recent meeting was in Bratislava in June 2007 and the next meeting will be in Warsaw in 2008.

When SC7 was established, the Drafting Panel was renamed as Project Team 1 of SC7 with Niels Krebs Ovesen as the convenor. Having produced the first incomplete draft of Eurocode 7 and then drafts of the remaining



PRELIMINARY
NOT FOR
PUBLICATION

EC 7: 19xx

Eurocode No. 7

Geotechnics, Design

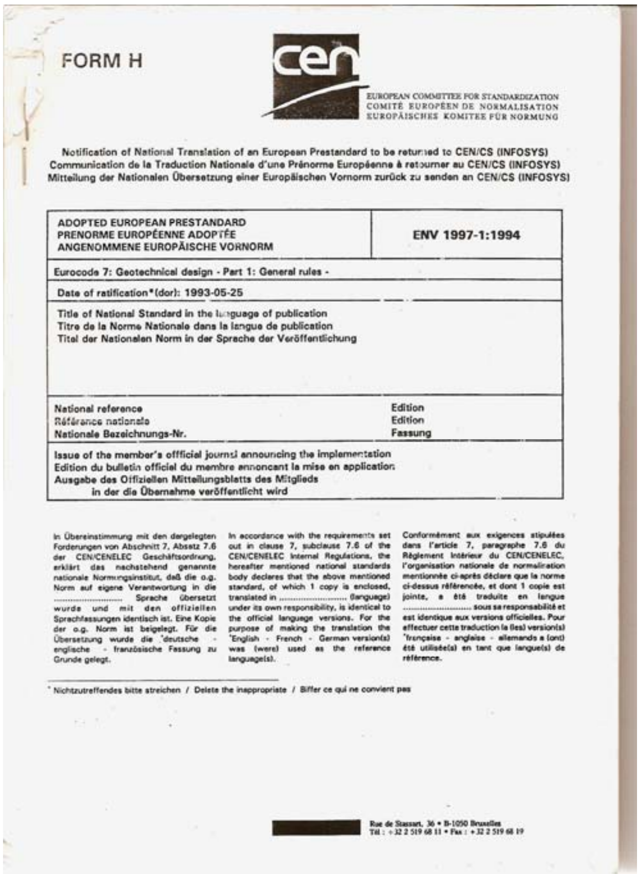
Prepared for the Commission of the European Communities.

Chapters 1, 2, 3, 4, 5, 6, 9 and 10

First, incomplete draft, November 1989

Eurocode 7 Drafting Panel

Figure 3: First Incomplete Draft of Eurocode 7



FORM H

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Notification of National Translation of an European Prestandard to be returned to CEN/CS (INFOSYS)
Communication de la Traduction Nationale d'une Prénorme Européenne à retourner au CEN/CS (INFOSYS)
Mitteilung der Nationalen Übersetzung einer Europäischen Vornorm zurück zu senden an CEN/CS (INFOSYS)

ADOPTED EUROPEAN PRESTANDARD PRENORME EUROPÉENNE ADOPTÉE ANGENOMMENE EUROPÄISCHE VORNORM	ENV 1997-1:1994
Eurocode 7: Geotechnical design - Part 1: General rules -	
Date of ratification*(dor): 1993-05-25	
Title of National Standard in the language of publication Titre de la Norme Nationale dans la langue de publication Titel der Nationalen Norm in der Sprache der Veröffentlichung	
National reference Référence nationale Nationale Bezeichnungs-Nr.	Edition Edition Fassung
Issue of the member's official journal announcing the implementation Edition du bulletin officiel du membre annoncant la mise en application Ausgabe des Offiziellen Mitteilungsblatts des Mitglieds in der die Übernahme veröffentlicht wird	

In Übereinstimmung mit den dargelegten Forderungen von Abschnitt 7, Absatz 7.6 der CEN/CENELEC Geschäftsordnung, erklärt das nachstehend genannte nationale Normungsinstitut, daß die o.g. Norm auf eigene Verantwortung in die .... Sprache übersetzt wurde und mit den offiziellen Sprachfassungen identisch ist. Eine Kopie der o.g. Norm ist beigelegt. Für die Übersetzung wurde die *deutsche - englische - französische Fassung zu Grunde gelegt.

In accordance with the requirements set out in clause 7, subclause 7.6 of the CEN/CENELEC Internal Regulations, the hereafter mentioned national standards body declares that the above mentioned standard, of which 1 copy is enclosed, translated in .... (language) under its own responsibility, is identical to the official language versions. For the purpose of making the translation the *English - French - German version(s) was (were) used as the reference language(s).

Conformément aux exigences stipulées dans l'article 7, paragraphe 7.6 du Règlement Intérieur du CEN/CENELEC, l'organisation nationale de normalisation mentionnée ci-après déclare que la norme ci-dessus référencée, et dont 1 copie est jointe, a été traduite en langue .... sous sa responsabilité et est identique aux versions officielles. Pour effectuer cette traduction la (les) version(s) *française - anglaise - allemande a (ont) été utilisée(s) en tant que langue(s) de référence.

* Nichtzutreffendes bitte streichen / Delete the inappropriate / Biffer ce qui ne convient pas

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Figure 4 ENV version of Eurocode 7

chapters, these were sent to the CEN member countries for comment.

A total of 1848 comments were received on the first draft of Eurocode 7. Project Team 1 considered and responded to each of these comments. To provide a technical link between Project Team 1 and the CEN members, each country appointed a National Technical Contact. In November 1992 Project Team 1 held a meeting with the National Technical Contacts. One of the main issues discussed at this meeting was how to introduce partial factors for geotechnical design into Eurocode 7. At this meeting, the concept of three combinations of partial factors, referred to as Cases A, B and C, was developed. The concept of the three cases was further developed by Project Team 1 and then, after 22 meetings, Project Team 1 completed the ENV or trial standard version of Eurocode 7, which was ratified by CEN in May 2003 and published in 1994.

5. ENV Trial Stage: 1995 - 1998

Following publication of the ENV version of Eurocode 7 in 1994, trial calculations were carried out using it. In addition two books were written on the ENV during this period; the first was "Eurocode 7 – A commentary" by Brian Simpson and Richard Driscoll (1998) and the second was "Geotechnical Design to Eurocode 7" by Trevor Orr and Eric Farrell (1999).

Following publication of the ENV, there was discussion and debate about Eurocode 7 in the geotechnical societies of the CEN member countries and in engineering journals. Some of this expressed concerns about the introduction of Eurocode 7 with the three Cases and the fact the Eurocode 7 was so radically different from the existing practice in many of the CEN countries.

To focus the discussion on Eurocode 7 an International Seminar *Eurocode 7 – Towards Implementation*, was organised at the Institution of Structural Engineers, London on 30 September and 1 October 1996. There was a lot of interest in this Seminar, with a full attendance of 90 engineers from 26 countries and some having to be turned away at the door as they could not be accommodated in the meeting room.

The discussions during the seminar covered a wide range of issues relating to EC7 and its implementation, including the philosophy in EC7 for geotechnical design, the difficulties in assessing characteristic values, problems with the use of partial factors in geotechnical design, problems with Cases B and C, experiences with the use of Eurocode 7 in practice, and the conversion of the ENV to an EN. An example of a speaker concerned about the introduction of Eurocode 7 was Alasdair Beal who said "On present evidence, it appears that the method proposed in EC7 needs considerably more development before it can be considered for use".

In summarizing the opinions expressed at the Seminar, Niels Krebs Ovesen, noted that the discussion at the seminar had concentrated on only about 5% of the text of Eurocode 7; the remaining 95% had not given rise to debate. He concluded, therefore, that this indicated there was general agreement on the validity of the basic philosophy for geotechnical design in Eurocode 7 which aimed to provide a system for geotechnical design within which judgement could be exercised and the discipline of geotechnical design could move away from the black box approach and become more transparent. At the end of the seminar, by a show of hands, the participants demonstrated their approval for the conversion of the ENV into an EN (Orr, 1996).

In 1997, SC7 voted positively to convert the ENV into an EN. However, in view of the concerns that some countries had about certain aspects of the ENV, for example Cases A, B and C, the SC7 members decided in 1997, to establish Working Group 1 (WG1) with Ulrich Smoltczyk as convenor to examine these aspects before establishing a project team to carry out the conversion work. WG1 was a large committee, with representatives from all of the CEN member countries; Trevor Orr was the Irish representative on WG1. This committee had detailed discussions on the technical aspects of Eurocode 7, which was not normally possible at the more administrative SC7 meetings. Thus establishment of WG1 enabled all the CEN members to become directly involved initially in the conversion process. WG1 met 6 times during 1997 and 1998 and produced a draft EN which included two new Cases D1 and D2 with partial resistance factors in addition to the existing Cases A, B, and C with partial material factors. Furthermore, WG1 developed new sections on hydraulic failure, anchorages and embankments that were not in the ENV version.

6. EN Stage: 1999 - 2004

Once Working Group 1 had completed its work and produced a draft EN in 1998, SC1 established a new 6-man Project Team 1 in 1999, with Ulrich Smoltczyk as convenor, to convert the ENV into an EN. PT1 carried out its work during the period 1999 to 2003.

The final draft of the EN for Eurocode 7 produced by Project Team 1 in October 2003 included three Design Approaches with partial factors on resistances as well as on material parameters and actions to replace the three Cases in the ENV version. Furthermore, there were additional sections on hydraulic failure, anchorages and embankments, as prepared by WG1. However, much of the text was identical or very similar to the text of the original model code demonstrating that the main and innovative geotechnical design principles set out in the model code by the ad-hoc committee under Niels Krebs Ovesen had been accepted and retained.

The formal (postal) vote for acceptance of the 2003 EN draft of Eurocode 7 was launched in January and closed in March 2004. This vote, 23 years after the first committee meeting to draft a Eurocode for geotechnical design, was unanimous in favour of accepting Eurocode 7 and hence it was ratified by CEN as the new European Standard for Geotechnical Design – Part 1: General Rules, EN 1997-1 on 23 April 2004. Work on Part 2 of Eurocode 7 on Geotechnical Investigations and Testing was being carried out in parallel with Part 1, but is not discussed in this paper. Following the ratification of EN 1997-1, CEN then prepared the French and German translations of EN 1997-1 before it was published by CEN on 24 November 2004. The date when CEN published EN 1997-1 is known as the Date of Availability (DAV).

Frank et al. (2004) published a handbook on Eurocode 7, entitled Designers Guide to Eurocode 7, which explained how to carry out geotechnical designs to EN 1997-1.

7. Implementation Stage: 2005 - 2010

In each CEN member country, Eurocode 7 is implemented as a National Standard with a National Annex providing values for partial factors and other parameters left for national choice – referred to as nationally determined parameters (NDPs). The National Annex also states which Design Approach or Approaches should be adopted in that country and may refer to complementary non-conflicting national standards. EN 1997-1 allows for national choice in:

- 29 sub-clauses of EN 1997-1
- 11 sub-clauses of Annex A
- regarding the application of the informative annexes.

According to the CEN programme, each member country should issue its national standard version of Eurocode 7 and its national annex within three years of the DAV, i.e. by December 2007. There is then a three-year coexistence period, during which either Eurocode 7 or a national standard may be used. At the end of the three year period or when all the other related Eurocode parts are available, CEN states that all existing conflicting and non-complementary standards shall be withdrawn and designs carried out using the Eurocodes. This date is known as the Date of Withdrawal (DAW) and has been set as 31 March 2010 in the case of both parts of Eurocode 7 and most of the other Eurocodes for structural design, for example Eurocodes 2 and 3 for concrete and steel. According to NSAI, the Eurocodes will be called up in all public contracts from this date. Thus this date will mark the beginning of a new period for design: the Eurocode Era.

While the CEN member countries have been preparing their national annexes, there have been discussions about the values to select for the partial factors and some comparative calculations have been carried out. Examples of this activity are the design examples that formed the basis for the International Workshop held in Dublin in 2005. These examples, together with worked solutions, have been published by Orr (2005).

8. Monitoring and Maintenance of Eurocode 7

Since the aim of Eurocodes is to achieve harmonisation of structural and geotechnical design in Europe, the European Joint Research Council at Ispra, Italy, has established a database of all the NDPs chosen by the member countries and is monitoring the

Table 1: Special features of soil and consequences for geotechnical design

Soil	Steel	Consequences for Geotechnical Design
1. Natural material	Manufactured	Properties are determined, not specified so ground investigation and testing part of design process
2. Two or three phases	Single phase	Need to consider water and water pressures as well as soil
3. Non-homogeneous	Homogeneous	Characteristic value is not 5% fractile of test results
4. High variability	Low variability	Need to use judgement when selecting characteristic values
5. Frictional	Non-frictional	Loads affect resistances so need care factoring permanent loads
6. Ductile	Not as ductile	Causes load redistribution in structures so lower partial factors may be appropriate for structural loads
7. Compressible	Non-compressible	Design often controlled by SLS, not by ULS
8. Non-linear and complex	Linear and simple	SLS calculations often difficult so design carried out using ULS calculation

implementation of the Eurocodes in Europe. If a country does not choose the recommended parameter values in a Eurocode, an explanation has to be provided giving the reason why. SC7, at its meeting in 2006, established a Eurocode 7 Maintenance Group to collect corrections to Eurocode 7 and advise on future revisions. Trevor Orr was elected a member of this group. This group has met once already and has collected a large number of comments on and minor corrections to Eurocode 7. Once the Eurocodes have been used for a few years, they will be subject to a review process. In the case of Eurocode 7, the review date is 24 November 2009, i.e. five years after its publication by CEN on the DAV in 2004.

9. Challenges in Developing Eurocode 7

Since Eurocode 7 was intended to be one of a series of harmonised standards for structural and geotechnical design in Europe, all those involved in the drafting of Eurocode 7 have had to face the following three challenges, which were to prepare a standard that:

a) Harmonised geotechnical design with structural design and was consistent with EN 1990
b) Took account of special features of soil that have resulted in the unique nature of geotechnical design, and
c) Was acceptable to the European geotechnical community.

a) Harmonisation with EN 1990

In facing the first challenge of preparing a geotechnical Eurocode that harmonised geotechnical design with structural design and was consistent with EN 1990, the drafters of Eurocode 7 had to produce a code that had the following features:

- Was based on the limit state design method
- Had partial factors applied to characteristic values
- Had characteristic values and partial factors chosen in accordance with EN 1990, which states that the values for partial factors can be determined either on the basis of calibration with long experience of construction, or on the basis of statistical evaluation of data when the partial factors should be calibrated such that the reliability levels for representative structures are as close as possible to a target reliability index
- Used the partial action factors given in EN 1990
- Provided partial material factors.

b) Special features of soil resulting in the particular nature of geotechnical design

In facing the second challenge concerning the special features of soil, the drafters of Eurocode 7 had to take account of the eight features that have resulted in geotechnical design being different from structural design using manufactured materials, such as steel, and hence Eurocode 7 being unique and different from the other Eurocodes. In Table 1, eight special features of soil are compared with those of steel and their consequences for Eurocode 7 are listed. These special features of soil are:

1. Soil is a natural material and hence its properties have to be determined, unlike the properties of manufactured materials, such as steel, which are specified. Thus geotechnical investigations and soil testing are part of the geotechnical design process, unlike structural design. Hence Eurocode 7 differs from the other Eurocodes through having a Part 2 on Geotechnical Investigations and Testing. None of the other Eurocodes have parts on the determination of parameter values from tests. The importance of soil testing is emphasised throughout Part 1 of Eurocode 7; for example Clause 2.4.1(2) states:

   "*It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant than is precision in the calculation models or the partial factors"*

   The importance of geotechnical investigations and testing in geotechnical design is further demonstrated by the fact that Eurocode 7 has sections on geotechnical data and on the supervision of construction (including checking ground conditions), monitoring and maintenance of geotechnical works both during and after construction

2. Soil is a two or three phase material consisting of soil particles, water and sometimes air, whereas steel is a single phase material. Since pore water pressures affect the effective stresses in the soil and hence the soil strength, the presence of water and its ability to drain must always be considered in geotechnical design.
3. Soil is non-homogeneous and in any geotechnical design situation the behaviour is determined by the mean behaviour over the relevant zone of soil. Hence the characteristic value is a cautious estimate of this mean value, not the 5% fractile of the test results which is appropriate for a homogeneous material such as steel.
4. Soil has a high variability and in order to take into account the variability, judgement is required when selecting the characteristic value of a soil parameter. Since steel has little variability, no judgement is required and the designer adopts the characteristic value provided by the manufacturer.
5. Since soil is frictional, its strength on any plane is related to the normal load acting on that plane. Thus soil strength is a function of the load and hence care is required when applying factors to loads in geotechnical design since a factor that increases the design load will also increase the design soil strength. For this reason in some geotechnical design situations, for example in slope stability design, the permanent loads due to the self weight of soil are not normally factored. Furthermore, in some geotechnical design situations, for example in retaining wall design, the loading on the wall is determined by the soil strength. These situations do not arise in steel design as it is not a frictional material and the loads and strengths are not related functions.
6. The ductility of soil, for example its ability to deform under loading, enables it to redistribute loading from weaker to stronger zones of soil. An example of this is a building resting on a series of pad foundations. If one foundation is resting on soft ground and if the building is redundant so that load transfer can occur within its members, then the building will settle so that the load carried by the foundation resting on the weaker soil reduces while the loads carried by the foundations resting on the stronger soil increase. Thus favourable redistribution of the loads on the foundations will occur due to this ductility of the soil. In the building, load redistribution will result in the loads increasing in those columns resting on the stronger ground and decreasing in the column on the weaker soil, even if all the columns have the same properties. Thus the structural members in a building have to be designed to accommodate this probably unfavourable increase in load in such a situation. The consequence of the favourable redistribution of loads in the ground and the unfavourable redistribution of loads in a redundant structure are that lower partial factors are appropriate on loads in geotechnical design than in structural design.
7. Soil is compressible, particularly cohesive soil, and this can lead to large settlements occurring over a long period. Thus geotechnical designs are often controlled by the allowable settlements, i.e. they are controlled by the serviceability limit state (SLS) design requirements than by the ultimate limit state (ULS) design requirements.
8. The stress-strain behaviour of soil is highly non-linear and complex, being dependent on many factors which include the soil composition, stress level, stress history and stress path. Also the geometry of the problem is not normally well defined in geotechnical design. As a consequence of these factors, there is usually not a unique generally accepted calculation model for each geotechnical design situation, as there normally is in structural design. Hence Eurocode 7, unlike the other Eurocodes, provides no calculation models, except some optional ones in the Annexes, for example for bearing resistance and earth pressure.

This particular feature of geotechnical design was demonstrated by Quentin Leiper, President of the Institution of Civil Engineers, in his Presidential Address to Engineers Ireland in Dublin on 16th October 2007 when he presented the following example to compare geotechnical and structural designs:

Give 30 structural engineers a structural design problem and they should all produce the same design. Give 30 geotechnical engineers a geotechnical design problem and they will produce at least 30 different designs, all of which may be valid.

A further consequence of the non-linear and complex behaviour of soil is that it is often very difficult to predict the settlements and ground movements for a geotechnical design. Hence geotechnical designs are often carried out using an ultimate limit state rather than serviceability limit state calculations.

c) <u>Acceptable to the European geotechnical community</u>

The third challenge involved preparing a Eurocode 7 that was acceptable to the European geotechnical engineering community by accommodating the different national geotechnical design practices in Europe. These different design practices involve different ground investigation and testing methods, design methods and calculation models and have developed due to different: ground conditions, climatic conditions, regulatory regimes and design traditions in Europe; for example in Germany the calculation methods are normally prescribed in the national standards, which are mandatory, while in the UK, the calculation methods are not

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PART 1: GENERAL RULES (INCLUDING IRISH

NATIONAL ANNEX 2007)

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Údarás um Chaighdeáin Náisiúnta na hÉireann

Figure 5: Cover of Irish National Standard I.S. EN 1997-1

NA to I.S. EN 1997-1: 2005

NA.2 Nationally Determined Parameters

NA.2.1 Subclause 2.1(8)P Design requirements

Part A of Irish Building Regulations establishes the minimum structural requirements for new buildings. The accompanying Technical Guidance Document to Part A (TGD A) [1]offers prescriptive guidance on meeting these requirements for certain small buildings in straightforward ground conditions.

NA.2.2 Subclause 2.4.6.1(4) P Design values of actions

The values of partial factors on actions (γ_F) are the recommended values as established in Table A.1 of EN 1997-1.

NA.2.3 Subclauses 2.4.6.2(2) P Design values of geotechnical parameters

The values of partial factors for soil parameters (γ_M) are the recommended values as established in Table A.2 of EN 1997-1.

NA.2.4 Subclause 2.4.7.1(2)P Ultimate Limit States, General

The values of partial factors for persistent and transient situations are the recommended values as established in Annex A of EN 1997-1 except in the case of those factors described in NA.2.8 and NA.2.10.

NA.2.5 Subclause 2.4.7.1 (3) Ultimate Limit States, General

The value of partial factors to be used in accidental situations should be 1,0.

NA.2.6 Subclause 2.4.7.2(2) P Verification of static equilibrium

The values of partial factors on actions (γ_F) and of partial factors for soil parameters (γ_M) are the recommended values as established in Table A.1 and Table A.2 respectively of EN 1997-1.

NA.2.7 Subclause 2.4.7.3.2(3) P Design effects of actions

The values of partial factors on actions (γ_F) or the effects of actions (γ_E) and partial factors for soil parameters (γ_M) are the recommended values as established in Table A.3 and Table A.4 respectively of EN 1997-1.

NA.2.8 Subclause 2.4.7.3.3(2) P Design resistances

The values of partial resistance factors (γ_R) are the recommended values established in Tables A.5, A.6, A.7, A.8, A.13 and A.14 respectively of EN 1997-1.The values of partial resistance factors for pre-stressed anchorages to be used in the Republic of Ireland are established in Table NA.1. This table replaces Table A.12 of EN 1997-1.

Figure 6: Page 2 of Irish National Annex for EN 1997-1

prescribed and the standards are not obligatory but codes of good practice.

Since the geotechnical design practices, including calculation models, vary from country to country and cannot be harmonised easily because ground conditions and climate are different, and since these practices have been used successfully for many years in Europe and hence encapsulate valuable local experience, the SC7 members did not want to lose this experience when changing from the existing geotechnical standards to Eurocode 7. However, within the Eurocode system, national practices and experience could not be accommodated and hence it was foreseen that a positive vote to convert the ENV version of Eurocode 7 to an EN could not be achieved unless this situation were resolved. As result of this, CEN/TC 250 accepted the fact that geotechnical design was unique and different from structural designs using the other materials, so in 1996 it passed the following important resolution:

> "*CEN/TC 250 accepts the principle that ENV 1997-1 might be devoted exclusively to the fundamental rules of geotechnical design and be supplemented by national standards*".

As a result of this resolution, it was accepted that Eurocode 7 could be supplemented by non-conflicting complementary standards. This resolution was an important factor in obtaining the positive vote to convert the ENV version of Eurocode 7 - Part 1 to an EN in 1997.

10. Geotechnical Standards in Ireland

Before 1996, the National Standards Authority of Ireland (NSAI) was a section within the Department of the Environment. Until recently NSAI had never produced any Irish Standards for geotechnical or structural design although it had produced standards for construction materials. Traditionally British Standards have normally been used for geotechnical and structural design in Ireland. In 1996, NSAI became an independent organisation preparing Irish standards. NSAI produces standards that are optional, not mandatory.

NSAI publishes the Eurocodes as Irish Standards with Irish National Annexes (INAs). The cover of the Irish Standard for Eurocode 7 - Part 1, I.S. EN 1997-1 is shown in Figure 5. The publication year on this standard is 2005 and it is stated that it comes into effect on 2 November 2005. However, since the Irish National Annex for Eurocode 7 - Part 1 was not available on that date, I.S. EN 1997-1 could only be used for educational/training purposes without the Irish National Annex and in fact was not issued by NSAI until the National Annex was published in 2007.

In 2002, a small Eurocode 7 Mirror Group was formed from members of the Geotechnical Society of Ireland (GSI), which is a member society of Engineers Ireland, to prepare the Irish National Annexes for the Irish

Table 2: Partial resistance factors (γ_a) for pre-stressed anchorages

Sets of Partial Factors	R1	R2	R3	R4
EN 1997-1:Table A.12				
Transient (temporary), $\gamma_{a;t}$	1.1	1.1	1.0	1.1
Permanent, $\gamma_{a;p}$	1.1	1.1	1.0	1.1
INA (Table NA.1)				
Transient (temporary), $\gamma_{a;t}$	1.35	1.35	1.0	1.35
Permanent, $\gamma_{a;p}$	1.35	1.35	1.0	1.35

Table 3: Partial resistance factors ($\gamma_{s,t}$) and (γ_R) for pile tensile resistance and anchorage resistance against uplift

Partial Factors for pile tensile resistance and anchorage resistance against uplift	$\gamma_{s;t}$	γ_a
EN 1997-1 (Table A.16)	1.4	1.4
INA (Table NA.2)	2.0	2.0

Table 4: Correlation factors (ξ) to derive characteristic values from ground test results (n = number of profiles of tests)

ξ for n =	1	2	3	4	5	7	10
EN 1997-1: Table A.9							
ξ_3	1.40	1.35	1.33	1.31	1.29	1.27	1.25
ξ_4	1.40	1.27	1.23	1.20	1.15	1.12	1.08
INA (Table NA.3)							
ξ_3	2.10	2.03	2.0	1.97	1.94	1.91	1.88
ξ_4	2.10	1.91	1.85	1.80	1.73	1.68	1.62

Table 5: Partial factors for compressive and tensile resistances of bored piled from ground test results

Sets of Partial Factors for bored piles	R1	R2	R3	R4
EN 1997-1: Table A.7				
Base, γ_b	1.25	1.1	1.0	1.6
Shaft (compression), γ_s	1.0	1.1	1.0	1.3
Total (compression), γ_t	1.15	1.1	1.0	1.5
Shaft in tension, $\gamma_{s,t}$	1.25	1.15	1.1	1.6
Increased by 1.75 model factor				
Base, γ_b	2.19	1.93	1.75	2.80
Shaft (compression), γ_s	1.75	1.93	1.75	2.28
Total (compression), γ_t	2.01	1.93	1.75	2.63
Shaft in tension, $\gamma_{s,t}$	2.19	2.01	1.93	2.8

Standard versions of Eurocode 7 - Parts 1 and 2. This Mirror Group, consisting of geotechnical consultants and academics, was chaired by Dr Eric Farrell, the NSAI representative on SC7. The Mirror Group examined EN 1997-1 and carried out many comparative design calculations over the five years from 2002 to 2007 and drafted the Irish National Annex for EN 1997-1. In May 2006 this was distributed by NSAI to geotechnical and structural engineers in Ireland for public enquiry. Taking into account the comments received, it was approved by the Irish geotechnical community and by NSAI and published on 2nd June 2007 so that since that date I.S. EN 1997-1 could be used in the Republic of Ireland as the first Irish Standard for geotechnical design.

11. Irish National Annex

The Irish National Annex for I.S. EN 1997-1 is a short document, the technical part being just six pages in length, giving the national choices that have been made regarding the Nationally Determined Parameters. As an example, Page 2 of the national Annex is shown in Figure 6. The national choices in the Irish National Annex have been made in ten sub-clauses and three tables in the Annexes of EN 1997-1 and may be summarized as follows:

- Reference is made to the Irish Building Regulations with regard to the minimum requirements for small buildings in straightforward ground conditions,
- While the recommended partial factor values established in EN 1997-1 have generally been accepted as the Nationally Determined Parameter values, the recommended partial factor values concerning piles and anchorages have been increased in three tables in Annex A as described below.
- When using the "alternative approach" for pile design, i.e. when calculating the design pile compressive or tensile resistance from soil characteristic parameter values, the Irish National Annex states that recommended partial resistance factors should be increased by a model factor of 1.75 as described below.
- For most design situations, any one of the three Design Approaches may be used. When using Design Approach 3 in situations where soil has a low shear strength, the Irish National Annex states that the following alternative combination of sets of partial factors A1 + M1 + R1 shall be considered as well as the given combination of A1 or A2 + M2 + R3. The reason provided for this is because *"situations can arise where there is insufficient margin of safety in relation to ground forces where the soil has very low shear strength."* The Irish National Annex also states that Design Approach 3 *"should only be used for design from soil parameters determined from laboratory or field tests."*
- The informative annexes are left open to choice and no alternatives are offered nor are there any references to non-conflicting complementary standards.

The national choices made in the Irish National Annex regarding parameter values for anchorages or piles are as follows:

- the partial resistance factors, $\gamma_{a;t}$

and $\gamma_{a;p}$, for the design of transient (i.e. temporary) and permanent pre-stressed ground anchorages for STR and GEO ultimate limit states, referred to in Clause 8.5.2(2) of EN 1997-1 and with recommended values of 1.1 given in Table A12, have been increased to 1.35 in Table NA.1 in the Irish National Annex; i.e. they have been increased by a factor of 1.23, as shown in Table 2. The reason given for this is "*to allow sufficient margin between proof test loads and ultimate limit load.*"

- the partial factors, $\gamma_{s;t}$ and γ_a, for pile tensile resistance and anchorage resistance in design against uplift (UPL limit state), referred to in Clause 2.4.7.4(3) of EN 1997-1 and with recommended values of 1.4 given in Table A.16, have been increased to 2.0 in Table NA.2 in the Irish National Annex, i.e. by a factor of 1.43, as shown in Table 3. The reason given for this increase is because it was considered the recommended $\gamma_{s;t}$ and γ_a values "*do not give sufficient margin of safety under certain uplift conditions.*"
- the correlation factors, ξ_3 and ξ_4, to derive the characteristic compressive and tensile resistance of a pile foundation from ground tests (number of profiles of tests), referred to in Clauses 7.6.2.3(5) and 7.6.3.3(4) of EN 1997-1 and with recommended values given in Table A9, have been increased by a factor of 1.5 in the Irish National Annex, as shown by the values in Table 4. The reason given for increasing the ξ values in Table A.10 is because they are considered necessary *"to allow for uncertainties in deriving the appropriate parameters from ground test results."*
- when using the "alternative procedure" for the design of piles, a model factor of 1.75 should be applied to the partial factors γ_b, γ_s and γ_t in Annexes A.6, A.7 and A.8, when calculating the design compressive resistance, and to the partial factor $\gamma_{s,t}$ when calculating the design tensile resistance. The recommended partial factor values for bored piles and values increased by the 1.75 model factor are shown in Table 5. The reason given for the use of this model factor value is that it "*is considered necessary to allow for uncertainties in deriving the characteristic parameters from ground test results."*

12. Conclusions

The background to Eurocode 7, the new European standard for geotechnical design, was the decision of the European Commission in 1975 to establish a set of harmonized technical rules for structural design, known as the Eurocodes, to remove the barriers to trade within the EEC. The development of Eurocode 7 began in 1980 with the appointment of Niels Krebs Ovesen as chairman of the first Eurocode 7 drafting committee, which had its first meeting in 1981. The development of Eurocode 7 has involved a number of stages with several important dates which include the publication of the Model Code for Eurocode 7 in 1987, the publication of the ENV version in 1997 and the publication of EN 1997-1, the European Standard version in 2004.

The challenges to be overcome in drafting Eurocode 7 included preparing a geotechnical design code that harmonized geotechnical design with structural design within the Eurocode framework, took account of the eight special features of soil and geotechnical design, and accommodated national geotechnical design practices.

The process of implementing Eurocode 7 as a national standard is a further stage that began in 2005 and involves each CEN member country preparing its National Annex. The main features of Irish National Annex are:

- For most design situations, any one of the 3 Design Approaches may be used
- National choices have been made in the case of pile and anchorage designs, providing larger partial and correlation factors or a model factor
- The Irish National Annex does not offer alternatives to any of the informative annexes and does not refer to any non-conflicting complementary standards.

In Ireland, Eurocode 7 has been published by NSAI as I.S. EN 1997-1:2005 with the Irish National Annex in 2007, and is the first Irish Standard for geotechnical design. Thus, 26 years after work first began on Eurocode 7, I.S. EN 1997-1 may now be used for geotechnical design in the Republic of Ireland. The implementation stage for Eurocode 7 and many of the other Eurocodes is due to be completed on 31st March 2010. This is the date when any conflicting national standards for geotechnical design must be withdrawn and when it will be called up in public contracts so that the Eurocode Era will begin.

Acknowledgements

The author wishes to thank all those who have provided information during the preparation of this paper or comments on the text including L. Buth, R. Frank, E. Farrell, S. McEoin, B. Schuppener, B. Smith and N. Taylor. The photograph of Niels Krebs Ovesen was kindly provided by J. Steenfeld.

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