**TC250/SC7/EG6: Seismic Design**

**(draft) Interim Report 2014**

# Active membership

|  |  |  |
| --- | --- | --- |
| Name | Position\* | Country |
| **Alberto Bernal** |  | Spain |
| **Raffaele di Laora** | Secretary | Italy |
| **Amir Kaynia** |  | Norway |
| **Ziggy Lubkowski** |  | UK |
| **Daniel Manoli** |  | Romania |
| **Baran Ozsoy** |  | Turkey |
| **Vincenzo Pane** |  | Italy |
| **Achilleas Papadimitriou** |  | Greece |
| **Panicos Papadopoulos** |  | Cyprus |
| **Onur Peckan** |  | Turkey |
| **Alain Pecker** |  | France |
| **Selman Saglam** |  | Turkey |
| **Giuseppe Scarpelli** | Convenor | Italy |

# Meetings

|  |  |
| --- | --- |
| Tele-meeting no. | Date |
| 1 | 18 July 2011 |
| 2 | 11 September |
| 3 | 30 November |
| 4 | 26 January 2012 |
| 5 | 21 May |
| 6 | 24 July |
| 7 | 11 October |
| 8 | 4 December |
| 9 | 21 January 2013 |
| 10 | 12 March |
| 11 | 26 April |
| 12 | 19 November |
| 13 | 25 March 2014 |
| 14 | 25 June |
| 15 | 2 July |
| 16 | 31 July |

# Agreed Scope of work

The purpose of EG6 is to advise TC250/SC7 on the **interplay between Eurocode 7 and Eurocode 8**, specifically of its part 5. The overall aim is :

- to explore the potential for greater compatibility/consistency between EN 1997 and EN 1998

- to examine geotechnical design as it results from the joint use of the two Eurocodes;

- to evaluate the efficiency and the sustainability of the resulting design in the whole.

This scope of work is in total alignment with the scopes stated for both EN 1997 EN 1998 in **CEN/TC 250 Programming Mandates.**

e.g. : CEN/TC250 Programming Mandate M/466, June 2011

**B.8 EN 1997, pg. 68, Justification and impact**:

“*The existing rules for the seismic design of foundations given in EN 1998-5 were developed largely in isolation from the development of EN 1997. Greater compatibility between the separate codes is intended*”

e.g. : CEN/TC250 Programming Mandate M/466, June 2011

**B.9.4 EN 1998-5, pg. 75, Scope of work**:

“*The potential for simplification of rules and better consistency with other Parts of EN 1998 (namely EN 1998-1) and EN 1997*”

# Some Specific Tasks of EG6

1. Identify the interplay and possible inconsistencies between Eurocodes 7 and 8: **by means of practical examples**
2. Prepare a list of clauses to be added to Eurocode 7 for both part1 and 2, referring the relevant sections of Eurocode 8
3. To identify, and possibly develop, specific sections of EN 1997 dealing with **dynamic loading** (e.g. : vibrations) and **ground investigation in seismic regions**
4. To collect and list national procedures for geotechnical design in regions of medium-high seismicity.
5. Compare levels of safety explicitly or implicitly adopted by the different countries both for static and seismic conditions.
6. To select and suggest design procedures to evaluate the **performance** under seismic actions of typical geotechnical structures initially designed for static loadings.

**A fruitful and continuous liason with the subcommittee TC250/SC8** is deemed to be necessary to accomplish the scope and the specific tasks.

# Practical Examples and comparisons (static vs. seismic)

Practical examples of seismic design of typical geotechnical structures have been discussed. Examples have been worked by different members of EG6 and comparison between solutions are made at the web conferences. Available examples are the following:

* Footing
* Gravity wall
* Cantilever and propped embedded walls

In preparation:

Pile design example

Available examples are published on the EG6 webpage.

# Which clauses in the current EN 1997-1 and -2 are relevant to your EG's topic of interest ?

Clauses concerning seismic geotechnical design are **very few in EN 1997, and only expressed in general terms.**

The word “seismic” is used :

in EN 1997 part 1

1.1.1 to make clear that special provisions for seismic geotechnical design are in EN 1998 only;

2.2 to include regional seismicity in design requirements;

3.1 to consider seismicity when planning site investigation;

3.4.2 to include information on seismicity when preparing the site investigation report;

7.3.2.4 to consider transverse loading on piles for seismic areas.

Also, the word “earthquake” is used in clauses 2.2; 2.4.2; 6.6.4; 7.3.2.1

in EN 1997 part 2

* + 1. (7) to make clear that special provisions for seismic geotechnical design are in EN 1998 only;

2.1.1 (3) to include seismicity between objectives of the ground investigation;

6.2 to include seismicity of the area in the ground investigation report.

# Which of those clauses should remain unchanged in the next edition of Eurocode 7 ?

The above clauses are far too general and do not appear particularly useful for geotechnical seismic design.

Instead, EG6 has indicated few **design principles** according to which the revision of EN 1997, jointly with the revision of the relevant parts of EN 1998, should be developed.

**DESIGN PRINCIPLES**

* The seismic design of a geotechnical structure should be conceived according to the principles of safety and economical sustainability;
* Design of foundations and of earth retaining structures is a unique process to be accomplished by considering all the possible boundary (e.g. loading) and environmental (e.g. seismicity) conditions **since the very beginning** of the design process;
* Recommended design procedures must ensure a **smooth transition** between static and seismic designs.

**SUGGESTIONS TO ACCOMPLISH THE ABOVE PRINCIPLES**

The transfer of action effects to the ground should consider the possibility of **permanent displacements** of foundations and retaining structures, and dissipation mechanism in the ground

More emphasis is needed in EN 1997\_EN 1998 to assess seismic-dynamic properties of the ground; **ground investigation and testing**, currently covered in EN 1997-2, must include seismic issues (e.g.: geo-physical methods of investigations, lab and field dynamic testing)

EN 1998-5 does not adopt explicitly, for seismic design, any of the Design Approaches given in EN1997. Nevertheless, partial factors on geotechnical parameters are suggested, apparently referring to **Material Factor Approach**, whereas most of the European countries are now orienting themselves towards **Load and Resistance Factor Approach**;

The use of Material Factor Approach for ULS verification with seismic loadings and pseudostatic analysis should be carefully discussed:

* + partial factors for material properties for seismic geotechnical design could well be lower than those for the static case; this possibility is never mentioned explicitly in EN 1998-5 and recommended **seismic values are equal to the static ones** (3.1 (3) NOTE)

For obvious reasons it will be difficult for a Country to adopt partial factors on material properties lower than those recommended, even if this possibility is not excluded by EN 1998-5; it would be better to eliminate the recommended values in EN 1998-5.

Suggest new design procedures for the seismic case based on the “**performance based design**” concept; such procedures aim at evaluating the seismic performance of geotechnical structures initially designed for static loadings (permanent displacements, structural capacity strictly needed); a Loads and Resistance Factor Approach in this case could be used to introduce safety.

T**HE FOLLOWING SUGGESTIONS ARE CONSIDERED FOR POSSIBLE IMPLEMENTATION IN EN 1997**:

**Clauses 2.1 Design requirements**

* The pseudo static calculation model should be included in the verification procedures by partial factors.
* The complete set of partial factors (model, actions, material or resistances) should be presented in appropriate tables; the same tables must also be included in EN 1998-5.

**Clauses 2.2 Design situations**

Geotechnical design considering earthquake would better use drained and undrained conditions instead of long term and short term as in 2.2 (1) of EN 1997.

**Clauses 2.4.8 Serviceability limit states and 2.4.9 Limiting values for movements of foundations**

EN 1997 and EN 1998 should provide guidance to select the limits of allowable/excessive permanent displacements both for static or seismic loading conditions.

**Section 3 Geotechnical data**

Guidance should be provided on:

* In situ and laboratory test to assess soil resistance to cyclic-dynamic loads
* Techniques to measure the shear wave velocity with possible limitations, accuracy etc.
* Laboratory tests to measure stiffness degradation and material damping, including information from well-established experience.

**Clause 6.2 Limit states** (for spread foundations but also for other geotechnical structures if applicable); add to the list of ULS:

* The occurrence of sand liquefaction under a footing or a slab (the appropriate calculation model should be presented in EN 1998)
* The occurrence of excessive displacements due to the earthquake shaking.

T**HE FOLLOWING SUGGESTIONS ARE GIVEN FOR POSSIBLE CONSIDERATION FOR EN 1998-5**

Soil characteristics:

(§3.1 and §5.4.1.1(9)) recommendations on how to measure the undrained shear strength of cohesive soils under rapid loading and also warning on the type of material sensitive to significant cyclic degradation; should be referred to appropriate clauses of EN 1997-2

(§3.2) laboratory tests to measure stiffness degradation and material damping: see EN 1997

Siting:

(§3.2) suggest acceptable techniques to measure the shear wave velocity referring to EN 1997;

(§4.1.2) Geological investigations to identify active faults: the subject may be out of the scope of the Code

Foundations:

* Guidance on acceptable values for permanent (absolute and differential) settlements following an earthquake (5.1(1)b)
* The complete set of partial factors (model, actions, material or resistances) should be presented in appropriate tables; the same tables must also be included in EN 1997
* Verification for piles under lateral loading (5.4.2(2) and 5.4.2(5))
* Indication of soils susceptible to significant degradation of resistance during the earthquake (nature, depth from the ground surface, etc..)

Earth retaining structures:

* Table 7.1 — Values of factor *r* for the calculation of the horizontal seismic coefficient must be reconsidered to allow for soil permanent displacements with high seismicity

Anchor system

* Strength hierarchy principles should be introduced to ensure that anchor foundation capacity is reached before the failure of the tendons and of the restrain system.