**TC250/SC7/EG10: Calculation Models**

**(draft) Interim Report 2014**

# Agreed Scope of work

* Critical review of existing calculations models in EN1997.
* Review of calculation models in supporting national standards for possible inclusion in next version of EC7.
* Review of the international literature in order to ensure that calculation models are the best currently available. Results from both theoretical analyses and experimental investigations should be considered.

# Key issues under discussion

* Bearing capacity assessment; bearing capacity factors.
* Assessment of serviceability; slope stability analyses; definition of actions and resistances in calculation models
* Earth pressure calculation models; review of methodologies
* Design procedures followed in geotechnical practice with respect to calculation methods in general
* Proposal of explicit equations for the Annexes of EC7

# Discussion/outcomes

* Each member was asked to summarize in short the practice followed in her/his country for the assessment of the **bearing capacity** of footings for central vertical loading and circulate this within the group, including a personal opinion on the quality/accuracy/reliability of bearing capacity factors, particularly Nγ factor. The exchange of information was made during the tele-meetings.
* Since most of the design equations for bearing capacity include modelling/adjustment factors based on in-situ tests, members were also invited to include information on large scale test results, if any. Such tests have been carried out in France and Germany and are described in publications or reports (partially not in English).
* Review of values of the inclination factors used in the respective country (without any eccentricity) showed that are not adequately documented in all countries.
* A crucial point in the proper application of the bearing capacity equations refers to the definition of the value of  that has to be used in the formulae (peak, constant volume or residual) and the way to obtain it (triaxial, direct shear tests…). Different procedures are followed in the various countries. Harmonization is needed.
* With respect to bearing capacity of footings the various equations available in the literature are presently compared and a review of large scale footing tests will be conducted. This is necessary because the equations included hidden calibration factors that are not evident at first sight.
* The review showed that the basic equations are correct and the definitions of actions and resistances are logical and consistent. There are rigorous solutions for the factors Nc and Nq and there are good numerical values for Nγ in the literature.
* The convenor collected reports by the Degebo on large scale field tests on footings that obviously constitute the basis for the values given in the respective DIN code and the last published version of the EC7. Comparisons are presently made between these test results and the formulae.
* Clarification is still needed on the equations for the shape and inclination factors. Available computational codes have been identified. Test results are presently being collected by the convenor.
* Members presented in concise form the practice followed in her/his country for calculation methods referring to **slope stability** analyses and calculation models for assessing serviceability of foundations under central vertical or moment loading.
* General calculation models have been discussed and agreed for ULS and SLS for shallow foundations with central vertical loading for both drained and undrained soil with water tables above and below the foundation.
* Great differences exist between the methodology followed in France and other countries for standard situations: In France pressuremeter data are used combined with available empirical relations. For complex situations FEM analyses are performed. Most countries use a decoupled two-step approach consisting of a combination of oedometer test data with stress calculation based on elasticity theory using the well-known Boussinesq/Steinbrenner equations.
* Members presented the state of practice for **settlement predictio**n in their counties.
* The convenor tried to collect information from other countries, not represented in the EG10, but this is still difficult.
* The selection of stiffness from observed non-linear soil behavior for use in simple SLS settlement calculation models has also been discussed in detail. Formulation of a straightforward, widely accepted procedure is still difficult.
* Still under discussion is the necessary extent of the specifications defined/suggested in the EN 1997 for such analyses. This refers both to the systems to be considered in the analysis of geotechnical structures as well as the analysis method itself.
* Several group members are favoring to consider within EG10 also the necessary input parameters for a certain calculation model (peak vs. residual strength is overall ULS stability analyses etc) as well as the relevant design approaches, the partial factors etc in order to provide comprehensive guidance through the EC7.
* Closely linked to the above is the definition of a “geotechnical structure” and that of actions and resistances. Since we are distinguishing between effective and total stresses the proper consideration of water effects is crucial. Examples could demonstrate the need for clarification.
* Clause 2.4.2 Actions need to be defined more specifically when actions arise from a single source
* Clause 2.4.5.2 referring to characteristic values needs clarification with respect to the appropriate shear strength to be used in analysis. Most members are using peak values. Exemptions should be defined based on the calculation model considered.
* Clause 11.5.1 Stability analysis of slopes: A calculation method such as Bishop simplified method of slices could be adopted as standard method. Clarification on the use of design/characteristic values is needed.
* 6.5.4 Loads with large eccentricities: Verification against overturning needs clarification in connection with definition of EQU under 2.4.7.1. Distinction between hard/soft soil.
* The transition of design methods for static and seismic actions should be continuous. Presently there are gaps that must be smoothened. An interaction with exchange of information with the respective Evolution Group is continuously taking place.
* A proposal for a definition of solution classes for calculation models has been made and is being presently discussed within the group. A decision has to be made within WG1 on the detail degree of the analysis models included in the new edition of EN 1997 and the extent of guidance to be given within the code.
* Members prepared summaries for the practice followed in their countries for calculation methods referring to **earth pressure**.
* Annexes C and D of EC-1997-1 as related to calculation models were reviewed. Note that Annex C has been modified in 2009.
* References to charts and formulae are missing in both annexes and it is recommended that they should appear in new versions of the Code. Some of the figures need clarification and detailed background information.
* Especially on earth pressure calculation additional information should be provided for other parameter combinations as well as for earth pressure due to compaction effects. On the other hand there is a wish for shortening the contents of the code.
* Presently available graphs and tables for earth pressure are collected and compared against each other. It is recommended to add approximating equations or/and tables with numerical values.
* There are calculation models (mostly empirical) in the part 2 of EC7. The group will examine these too.
* Assessment of compaction earth pressure will be considered by the group.
* The different procedures followed in the countries represented in the group with respect to the calculation of earth pressures in the design of retaining structures are apparent. In Germany the first choice in design are calculation methods as outlined in much detail in recommendations for excavations. The distribution of earth pressures is defined in dependency on the boundary conditions (number and position of supports, soil conditions). For the earth pressure calculation explicit formulae are available in a separate DIN code.
* The situation is quite different in the other countries: Commercial software is mostly used that incorporates earth pressure calculations in combination with Winkler beam theory. The underlying assumptions are described in the handbooks of these software suites. In some other countries FEM Codes are routinely used with built-in options for the selection of appropriate soil and interface models. Structural design of walls is then performed based on the numerical output of such analyses. Among these codes popular are PLAXIS and CESAR. The use of FEM-codes allows for the determination of deformations required for checks of serviceability.
* The need for improvement of the specifications for earth pressure in the EC7 is recognized.
* Surcharge effects are determined either on elasticity solutions, FEM calculations, or using some procedure based on wedge theory.
* For the minimum earth pressure some national codes (DIN, BS) provide some recommendation. This topic will be addressed in forthcoming meetings.
* Earth pressure due to compaction will also be treated next.
* As outlined above, in most countries design is carried out using commercial codes with built-in options. The need for checking such numerical computations by other explicit step-by-step methods is recognized.

# Meetings held during the reporting period

Tele-meetings took place at the following dates:

10. November 2011

16. January 2012

1. March 2102

12. March 2012

16. May 2012

21. February 2013

20. September 2013

26 February 2014

12. June 2014

10. July 2014

Meetings were held also during the TC250/SC7/WG1 Experts’ Meetings:

15./16. October 2012 in Brussels

17./18. October 2013 in Vienna

# Members during the reporting period

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| Name | Position | Country | Period |
| **John Atkinson** | Member | United Kingdom | 2011 to 2013 |
| **Liudvikas Furmonavicius** | Member | Lithuania | 2011 to date |
| **Jana Frankovska** | Member | Slovakia | 2011 to date |
| **Sergio Gobbi** | Member | Italy | 2012 to date |
| **Achim Hettler** | Member | Germany | 2011 to date |
| **David Nash** | Member | United Kingdom | 2014 to date |
| **Áurea Perucho** | Secretary | Spain | 2011 to date |
| **Tudor Saidel** | Member | Romania | 2013 to date |
| **Ivan Vanicek** | Member | Czech Republic | 2011 to date |
| **Jean-Paul Volcke** | Member | France | 2011 to date |
| **Christos Vrettos** | Convenor | Germany | 2011 to date |

# Report prepared by:

Christos Vrettos

09. September 2014