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The following topics were proposed for discussion:

(a) Is the limit state design concept an appropriate format for Geotechnical Codes?

(b) How to solve the problem of defining characteristic values of soil parameters in Codes of Practice?

(c) Are the advantages of harmonizing Geotechnical Codes between different countries substantially larger than the disadvantages?

Invited discussers were the following experts:

Dr R.T. Murray (UK)
Professor E.L. Matyas (USA)
Professor H.G. Poulos (Australia)
Professor Dr P. Anagnosti (Yugoslavia)
Professor Dr.-Ing. G. Gudehus (Germany)
Professor A. Verruijt (Netherlands)
The contribution that follows is concerned with the minimum requirements for reporting geotechnical data. These requirements are in accordance with the latest draft of Eurocode EC-7 Geotechnics-Design, which aims to the harmonization in the presentation of geotechnical reports.

A geotechnical report consists normally of the following parts:

- Presentation of the geotechnical information
- Evaluation of the geotechnical data
- Conclusions and recommendations

Presentation and evaluation of geotechnical data are the most important parts of a geotechnical report because they are the basis for the selection of geotechnical parameters.

It is of vital importance that the Geotechnical Engineer has a continuous close contact with all phases of work, i.e., the field reconnaissance, planning and follow-up of the field and laboratory work, and the compilation of the final report.

PRESENTATION OF GEOTECHNICAL INFORMATION

The presentation of geotechnical information will include a factual account of field and laboratory work and detailed description of methods used to carry out the field investigations and the laboratory testing.

This factual report should include, but not limited to, the following information:

(a) Purpose and scope of the geotechnical investigation.
(b) Authorization to carry out the geotechnical investigation.
(c) Brief description of the project for which the geotechnical report is being compiled, giving information about the location of the project, its size and geometry, anticipated loads, structural elements, materials of construction, etc.
(d) Dates between which field and laboratory work were performed.
(e) Types of field equipment used.
(f) Names of specialized field personnel responsible for the continuous follow-up of the field work, the visual description of the samples and their handling for storage and transportation to the testing laboratory.
(g) Detailed description of the methods used for the execution of the field and laboratory work with reference to widely accepted standards.
(h) Field reconnaissance of the general area of the project with particular emphasis to the following:
   - history of the site and its geology
   - surface observations that may be related to the project and information from aerial photography
   - local experience from the area including information on ground water table, behaviour of neighbouring structures, faults, sliding areas, difficulties during excavations, etc
   - information about quarries and borrow areas
   - seismicity of the area
(i) Tabulation of quantities of executed field and laboratory work.
(j) Presentation of field observations which were made by the supervising field personnel during the execution of the subsurface explorations.
(k) Data on fluctuations of ground water table with time in the boreholes during the performance of the field work and in piezometers after the completion of the field work.
(l) Compilation of boring logs with descriptions of subsurface formations based on field descriptions and on the results of the laboratory tests.
(m) Grouping and presentation of field and laboratory test results in appendices.

EVALUATION OF GEOTECHNICAL DATA

The evaluation of the geotechnical data is concerned with a thorough review of the field and the laboratory work by the Geotechnical Engineer. In cases where there are limited or partial data, the Geotechnical Engineer should state it. If, in the Geotechnical Engineer's opinion, the data are defective, irrelevant, insufficient, or inaccurate, he can and should point this out and qualify his comments accordingly. Any particularly adverse test results should be considered
carefully in order to determine whether they are misleading or represent a real phenomenon that must be accounted for in the design.

In addition to the above, the evaluation of the geotechnical data should include, but not limited to, the following:

(a) Tabulation and graphical presentation of the results of the field and laboratory work in relation to the requirements of the project and, if deemed necessary, histogram illustrating the range of variation of the most relevant data and their distribution.

(b) Determination of the depth of the ground water table and its seasonal fluctuations.

(c) Subsurface profile(s) showing the differentiation of the various strata. Detailed description of all formations including their physical properties and their compressibility and strength characteristics. Comments on irregularities such as pockets and cavities.

(d) Grouping and presentation of the range of variation of the geotechnical data for each stratum. This presentation must be in a comprehensible form which enables the most appropriate soil parameters to be selected for the design.

(e) Submission of proposal(s) for further field and laboratory work, if deemed necessary, with comments justifying the need of this extra work. This proposal should be accompanied by a detailed programme for the types of the extra investigations to be carried out with specific reference to the points which have to be answered.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of a geotechnical report will include the following:

(a) Identification of subsurface formations and selection of suitable geotechnical parameters for the computations required for the design.

(b) Recommendations for the most appropriate and economic method(s) of foundation to be applied. Presentation of basic geostatic computations to justify these proposal(s).

(c) Recommendations for problems which are anticipated to occur during construction, such as excavations, pumping operations, retaining structures, ground anchors, placement of fill.

Special computations for piles, retaining structures, ground anchors, slope stability, ground improvement, etc, are not part of this chapter on conclusions and recommendations. The same applies to special computations for other types of structures, such as dams, lining of tunnels and drainage.

FINAL COMMENT

It is believed that if the above requirements are agreed upon and adopted, it will be possible to contribute greatly towards harmonization in the presentation of the geotechnical reports.

REFERENCES


However, it is clear that the geotechnical profession in Australia, which has become accustomed to dealing with a single safety factor, will require a considerable amount of re-education before becoming comfortable with the partial factor approach to design.

AUSTRALIAN STANDARD PILING CODE
A revision of the Australian Standard Piling Code, AS2159 (1978), is currently being undertaken. A major feature of the new code is that it will be in limit state format following the current practice with new or revised Australian standards. The code will consist of two sections:

i) a mandatory section, written in rather general terms

ii) a commentary which will include recommended methods of design; however, alternative methods will be permitted provided that they can be justified.

PROBLEMS IN MODIFICATION OF EXISTING CODE
A number of problems have arisen in modifying the design section of the existing code, among these being:

i) the development of partial factors which will give compatibility with present practice using an overall factor of safety approach;

ii) a means of making allowance, in the selection of material factors, for the method of determining the design parameters, e.g. SPT, CPT, laboratory triaxial testing, etc;

iii) making allowance for the quantity and quality of geotechnical information, e.g. the number of boreholes, whether laboratory or insitu tests are carried out, whether pile loading tests are performed, etc;

iv) allowance for the method of calculation and design;

v) allowance for extreme loading events; it would seem appropriate to allow for lower load factors for such events than for more routine loadings;

vi) the method of application of the partial material factors, i.e. whether the factor should be applied directly to (say) the skin friction or end-bearing value (the "American method") or to the soil parameters from which the design values are derived (the "European method").

At the present time it appears that the American method will be adopted because of the diversity of approaches possible for deriving the design parameters. It is also likely that basic partial factors will be specified, with modifying factors to reflect the quantity, quality and type of geotechnical data available. It is generally agreed that, in principle, the limit state design concept is desirable as it forces the designer to consider carefully the components of uncertainty in the design process.
The discussion leader's questions can be answered as follows in the light of the present situation in West Germany.

1. The limit state design concept is more and more accepted as an appropriate format for geotechnical codes. However, the advantages of the conventional concept of global safety factors is not easily abandoned as it is practically well-established. Few constant partial safety factors are not easily fixed so that the present safety level is conserved. There is some confusion about the safety of structural elements as influenced by soil-structure-interaction; limit state equations are not generally well-established so that safety factors are rather guessed.

2. In order to avoid the rather non-realistic 5 % fractiles we prefer a definition of characteristic values as "cautious mean value" which is still inevitably partially subjective.

3. The attempts of harmonizing geotechnical codes have been helpful but sometimes also frustrating. The formulation of some generally accepted principles in Eurocode 7 - such as the Geotechnical Categories - is a remarkable progress. We are convinced that a further agreement of geotechnical engineers from different countries has to be achieved and will be of mutual benefit. However, a merely bureaucratic or political fixing of dates for codes - such as 1992 ± x - can be rather detrimental.
Limit States Design (LSD) methodology has been accepted and practiced in Canada by structural engineers for many years but it is only within approximately the past six years that geotechnical engineers have begun to make a concerted effort to incorporate LSD in design codes e.g. Ontario Highway Bridge Design Code (1983); Canadian Foundation Engineering Manual (1985); and Canadian Standards Association Code for the Design, Construction and Installation of Fixed Offshore Structures (in preparation).

Numerous technical committees are involved with the preparation of these codes and the members of these committees include a wide spectrum of structural and geotechnical engineers who represent academia, consultants and government institutions.

The Canadian Geotechnical Society (1989) organized a Symposium to bring the structural and geotechnical communities together to reach a common understanding of LSD. The broad Canadian representation of invited speakers included engineers associated with the preparation of the Canadian Codes noted above. In addition, K. Ovesen (Denmark) and M. Duncan (U.S.A.), were invited to present the status of LSD in Europe and U.S.A., respectively. It is planned to continue dialogue and studies on LSD in Canada through the auspices of the National Research Council Associate Committee on Geotechnical Research.

"Safety" and "Format" were the two topics suggested for this Discussion Session. The following discussion addresses these topics and is based primarily on CGS Symposium.

Safety:

The CFEM (1985) recognizes two limit states in geotechnical engineering: (a) The ultimate limit state (ULS) which relates to collapse or failure of the structure and/or soils, and (b) The serviceability limit state (SLS) which is defined as the onset of unacceptable deformations, cracking or vibrations.

Traditionally, geotechnical engineers use, or have used, working stress design methodology by applying an overall factor of safety in order to prevent failure and to minimize the associated deformations (ULS) e.g. bearing capacity, earth pressure and slope stability. For foundations, serviceability (SLS) is considered by estimating and limiting consolidation settlement (cohesive soils) and employing empirical methods or correlations to limit the settlement of structures founded on cohesionless soils (no factor of safety is considered). The acceptability of this approach may be attributed primarily to experience. From this experience, procedures have been established to select soil parameters, method of analysis, overall factor of safety and loads. This usually results in the satisfactory performance of the structure. Of course, there are exceptions!

From a structural engineer's point of view, working stress design methodology lacks rigor, it does not provide a consistent approach and is not compatible with the ultimate limit states methodology used by structural engineers. The structural engineer's preference is to quantify each step of the analysis/design by applying a factor to each resistance or load component and to quantify each uncertainty associated with these components. This practice may be applicable for structural materials such as concrete and steel but many geotechnical engineers question the applicability of this approach to soils. Nevertheless, through comparisons and calibrations with conventional working stress methods, partial factors have, and will be, introduced into geotechnical-based codes to promote compatibility, understanding and communication between structural and geotechnical engineers with the ultimate goal to provide safe and economical structures. The apparent success of the LSD method is already evident in Eurocode.

Engineering decisions involve uncertainties as a consequence of poor or insufficient information and the inherent randomness in the properties of the soil/structural materials and loading. Some of these uncertainties are being quantified through the application of probability theory. The usual assumption that analyses can only be made if a large site-specific data bank is available is being seriously challenged.

It is generally accepted that probability analyses can cope with most of the uncertainties that are encountered in geotechnical engineering. However, probability is associated with risk and therefore, the final design is a function of the level of risk that is considered and accepted. Accordingly, an acceptable margin of safety may be significantly influenced by public opinion.

Format:

There is a general consensus by geotechnical engineers that any Code should avoid elaborate and detailed procedures. Soils are typically heterogeneous in situ, their behavior is stress-path dependent, methods of analysis may differ, etc.; therefore, there is a genuine reluctance to reduce geotechnical engineering to a specific "cook book" format. Some provision must be retained for engineering judgment.

A Code is perceived as a mandatory regulation, law, manual, etc. that must be adopted, accepted and used by all practicing engineers. It is believed that detailed codes could lead to increased litigation.

There appear to be several options in the format of a Code e.g. specified partial factors on soil parameters combined with an unspecified method of analysis (Eurocode) vs. factored total resistance combined with a specified method of analysis (U.S.A.).

Many soil parameters are difficult to determine accurately. For example, soil strength is a function of soil type, geological history, methods of testing, time, field loading, inherent in situ variability, sample disturbance, lack of information and data, etc. If this variability is superimposed on the number and variety of methods of analysis, there is an obvious reluctance to specify partial factors to a set of soil parameters that are likely to be site-specific.
It is suggested that the Canadian Codes should follow the Eurocode system wherein several "geotechnical categories" are defined in order to establish minimum requirements for the extent and quality of the geotechnical investigations, calculations and construction control checks.

Reference: