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Session 8

Existing practice of limit state design and codes and standards

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Session 8: Existing practice of limit state design and codes and standards

By

Chairman: R. Green, University of Waterloo, Canada.
Rapporteur: C.S. Sørensen, Aalborg University, Denmark.

For the session 8 papers were allocated

1. "Development of limit states design for foundations in the national building code of Canada" by *Becker, D.E., Allen, D.E., Ho, K.S. & Law, K.T.*
2. "Limit state design of offshore foundations" by *Dahlberg, R. & Ronold, K.O.*
3. "Geotechnical dimensioning of footings using partial safety coefficients" by *Hartikainen, J. & Heinonen, J.*
4. "Role of construction control in pile foundations in limit state design" by *Kusakabe, O., Kakurai, M. & Sandanbata, I.*
5. "Towards limit state design standards for pile foundations" by *Kuwabara, F., Aoki, H. & Kishida, H.*
6. "25 years of utilization of the limit state concept in the Romanian Code for geotechnical design" by *Manoliu, I. & Marcu, A.*
7. "Limit state design application to railway foundation design standard" by *Nishimura, A., Haya, H. & Okumura, F.*
8. "Limit state design and geotechnical engineering in Ireland" by *Orr, T.L.L.*

INTRODUCTION

This final Session attempts to provide examples of the uses of Limit State Design in engineering practice. These examples are taken from several different national jurisdictions. Examples are given concerning the development of limit states design provisions, experiences with well-established provisions and quality assurance procedures. RG's experience with codes for bridge design indicates that as engineers we have a sound enough technological base. However, we need to improve the communication mechanisms between structural and geotechnical engineers if any transition between working stress design and limit states design is to be successful. In Ontario as part of the 1983 version of the bridge code, eccentrically loaded footings for foundation walls grew about 50 percent in width as a result of a misapplication of limit states design philosophy. The papers in this Session provide much useful data pertaining to the development of limit states design procedures.

PAPER NO 1

Mr. K. Been (KB) from Golder Associates presented the paper on behalf of the author.

From a Canadian point of view the main problems for building designs are:

- Inconsistency in the interaction between structural and geotechnical engineers.
- Misunderstanding or confusion related to limit states design methodology and terminology.

The main reasons for these problems are:

- The Limit States Design (LSD) methodology is the general state of practice used by structural engineers in Canada.
- The Working Stress Design (WSD) has been the basis for all foundation designs until the introduction of the Ontario Highway Bridge Design Code.

The geotechnical engineering profession in Canada is currently in the process of evaluating Limit States Design for its incorporation into codes of practice for bridges and buildings.

The following study approach is used:

- Factored resistance.
- Consistent with the other Canadian codes.

Before finalizing the evaluation the following tasks must be performed:

a. Develop database information for geotechnical parameters and resistance.

b. Investigate the uncertainty of various analytical methods for foundation design.

c. Investigate the uncertainty of various field test methods for the determination of geotechnical parameters. The category of geotechnical investigation should also be taken into account.

d. Study the variations of various loading test methods to establish geotechnical parameters for geotechnical analytical methods.

e. Use an appropriate reliability model to establish resistance factors based on the uncertainty parameters.

PAPER NO 2

Mr. Rune Dahlberg (RDA) presented the paper.

The paper highlighted the difficulties in determination of characteristic soil strength. The Norwegian code NPD (1984) prescribes that the characteristic shear strength has to be taken as a conservatively assessed mean value. RDA remarked that this is an ambiguous definition and highlighted the importance of an unambiguous definition of the characteristic soil strength. RDA recommended the use of statistical methods in the development of characteristic soil strength as a supplement to engineering judgment. RDA also pointed out the need for recalibration of the codes to ensure that the desired target safety is achieved with the specified partial safety coefficient and load factors.

PAPER NO 3

Mr. Jorma Hartikainen (JH) presented the paper. It contained a comparison study of the consequences of using different codes. Two examples were treated, a normal storage hall footing and a light tower foundation. The study was performed with fixed strength parameters. JH concluded that a geotechnical designer should perform a sensitivity analysis in design.

PAPER NO 4

Mr. Osamu Kusakabe (OK) presented the paper.

The paper described construction control as a part of limit state design for various pile construction methods currently used in Japan. The paper concluded that quantitative evaluation of the accuracy of construction is equally important for pile foundation design. OK concluded with the following remarks:

- The need for accumulating construction control data.
- The preferred way to incorporate construction control into Design Code.

PAPER NO 5

Mr. Fumio Kuwabara (FK) presented the paper.

The latest development of limit state design standards in Japan were introduced.

A number of design criteria specified in recently proposed codes were presented, which consider earthquake load. The seismic coefficient method is a common practice to consider earthquake effects. FK illustrated this method which takes allowable damage extent of structures by earthquake at each limit state into account.

Two major limit states will be introduced against earthquake in future new design codes. These are:

- Limit state I: Collapse of structures or loss of support for bridges due to large deformation of foundations during large single earthquake during the life time of the structure, and
- Limit state II: Yielding of structural members and/or ground against a middle size earthquake which may occur several times during the life time of a structure.

PAPER NO 6

Mr. Iacint Manoliu (IM) presented the paper. He started his lecture with the following general comments:

"There are just a few participants, a sort of "rare birds", coming from Central and Eastern European countries, former so-called socialistic countries, at this very interesting and successful Symposium. This is by no means an indication of the lack of interest in the theme of the Symposium but obviously the result of the great economic difficulties these countries are facing. We can only hope that the situation will improve in the future and the economy of this region will depart from its present *ultimate state* and reach a state of, so to speak, *normal serviceability*, thus enabling a greater number of members of the geotechnical community, including the young ones, to attend such meetings".

The lecture presented features of the Romanian Code which have been used for more than 25 years. The code is based on the limit state concept. Experience has made it possible to work out a table and a flow diagram with design checks (see table 4 and figure 2).

IM pointed out the need for more data from observations of structures for further calibration of partial safety factors.

PAPER NO 7

Mr. Fuminao Okumura (FO) presented the paper.

In Japan seismic force is one of the most important factors for designing foundations. A seismic design of foundations is executed to make structures safe during earthquakes and maintain the required serviceability after the earthquakes. Serviceability limit state for high speed railways is quite severe. Deformations of foundations are strictly restricted. In accordance with these limit states, design standard for foundations of railway structures are being revised with completion expected in 1994. FO explained the limit state design principle for railway structures and discussed test results of lateral loading tests of spread foundations, their evaluation and resulting design procedures.

PAPER NO 8

Mr. Trevor Orr (TO) presented the paper.

TO has examined the likely effects of the introduction of limit state design and Eurocode 7 on geotechnical engineering in Ireland.

TO's conclusions were:

- Adaption of a constant set of partial factor values for all situations is more rational and consistent but will require the designer to assume more responsibility for the selection of the appropriate design soil parameter values.

  For certain situations, for design of foundations according to the limit state method, the serviceability limit state may be the controlling condition and greater attention must be given to the determination of soil stiffness parameter values and settlement.

- Use of the limit state method with the partial factor values contained in Eurocode 7 will, in most situations, lead to very similar designs to those obtained previously using the traditional method.

After the 8 speakers, Roger Green concluded as follows.

CONCLUSION

The paper presented by KB outlines some of the general initial discussion for limit states

design in the national building code of Canada. The difficulties of converting site data to limit states design are outlined by RDA and JH. Quality assurance was well discussed by KO. Codes for design were the topics of 4 papers (FK, IM, FO and TO). The paper by TO is complete as it provides a comparison between both old and new design methods. Note should be taken that TO's presentation considered only the geotechnical engineering aspects of the design problem.

RG acting on behalf of all attending recognized the outstanding contribution that Niels Krebs Ovesen has made to this Symposium, to geotechnical engineering and especially to the sound and rational development of a limit states design philosophy.

Roger Green asked for comments from the audience.

N. Krebs Ovesen mentioned that Eurocode 7 will be used for the design of the new bridge across Øresund between Sweden and Denmark.

J. Hanisch wanted to know how to guide a student who wished to become a geotechnical engineer. Should he recommend the student to study statistics or soil mechanics? The audience did not answer this question clearly.

G.G. Meyerhof pointed out that the determination of strength parameters is the most important factor within soil mechanics and argued for the method "Conservative mean values".

This session is declared closed.