A new era in structural design for concrete

Background

Publication by CEN of EN 1990 *Basis of Structural Design* marks the start of availability of the long-awaited Eurocodes. This standard provides the framework for the whole suite of Eurocodes, which includes the design of concrete structures, as well as geotechnical and seismic design. Other standards published subsequently in the series are EN 1991-1-1 "*general actions – densities, self-weight, and imposed loads for buildings*" and EN 1991-1-2 "*actions on structures exposed to fire*".

The design standards for the main structural materials (EN 1992-1-1 for concrete, etc) should be ready for Formal Vote this autumn and, all being well, should be published in 2004. This first generation of Eurocodes will contain some elements of choice for countries, although recommendations will usually be given for the choices.

One important exception lies in EN 1990, in which the criteria for choosing between three load combination expressions for structures are not specified. The choice should be given in the National Annex for EN 1990 and affects, among other things, the consistency in reliability over the range of potential designs.

CEMBUREAU/BIBM/ERMCO commissioned study

In order to help Members in their national discussions, CEMBUREAU/BIBM/ERMCO commissioned Prof. Gulvanessian of BRE, as leader of the CEN TC 250 Project Team for Basis of Structural Design, to review the implications of the possible choices. The final report was reviewed independently and separately by Prof. Jensen, Prof. Spehl and Prof. Calgaro, members of the same CEN Project Team.

The full documentation is available on the CEMBUREAU website (www.cembureau.be) in easily accessible form, including an Executive Summary and reports from the independent reviewers.

BRE reviewed an earlier Nordic study commissioned by NKB and INSTA-B and prepared by SAKO (2), the Joint Nordic Group for Structural Matters. This study had been carried out with the objective of "comparing the level of consistency of safety for various ratios between the permanent and variable actions by considering the three principal structural materials: concrete, steel and glulam timber". The Nordic report demonstrated that the three load combination expressions give quite differing levels of reliability for different ratios of variable load to total load (χ).

For most practical cases, concrete structures have a value of χ between 0.2 and 0.6 whereas steel and timber have a value between 0.5 and 0.8. Hence, the choice of load combination expressions in the National Annex for EN 1990 is crucial in order to obtain a consistent level of safety.

The Findings

The choice of the loading expressions should be governed by the following considerations:

- The potential for achieving adequate consistency in reliability over the range of potential designs;
- Ease of use for designers, considering both the super-structure and the sub-structure;
- The use of the same load combination rules and partial and combination factors for actions for all the materials;
- The reliability currently implied nationally, by using the appropriate National Codes of Practice;
- Improved economy.

The findings of the study for CEMBUREAU/BIBM/ERMCO can be summarised in a table for the three expressions (Cases A, B & C) against four criteria of the criteria, assuming that the same expression would be used for design in all materials in a structure:

Consideration	**Case A [expression 6.10]**	**Case B [expressions 6.10a, 6.10b]**	**Case C [expressions (6.10a (mod), 6.10b)]**
The level of reliability from use of national codes	Dependent on the country (e.g. same in UK)	Dependent on the country (e.g. same in Nordic countries and The Netherlands)	Dependent on the country
Consistency of reliability for range of χ	No Higher reliability for χ between 0.2 and 0.6	Yes	No Lower reliability for $\chi < 0.3$
Usability	As for current National Codes that use the format of expression 6.10	Additional checks required compared to case A	Exceptionally, additional checks required compared to case A
Economy Considering Actions only, for a given resistance	As for UK practice	Greater economy for χ between 0.15 and 0.6 As for Nordic countries and The Netherlands practice	Greater economy for χ between 0.15 and 0.6

Conclusion

Each of these expressions is already in effective use in one country or another. Case B gives a greater consistency of reliability over the range of load ratios than Case A and is therefore more equitable to all materials. When used with appropriate partial and combination factors for all materials Case B would still achieve current target levels of reliability.

CEMBUREAU/BIBM/ERMCO are very pleased to make the report available publicly. The Associations believe that the report will make a very valuable contribution to the practical implementation of the Eurocodes and in particular to the process of making choices by national competent authorities.

Dr John Moore - Chairman of CEMBUREAU Project Group 2.5 "Eurocodes"