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## **THE ASSUMPTIONS BEHIND THE EUROCODES**

This paper is a revised version of Appendix E of the 16<sup>th</sup> Biennial Report.

### **Introduction**

- 1 All design codes of practice are constructed around a number of assumptions and limitations; these relate to the competency of those using the code, the analysis and design process and the material itself. In the traditional 'BS' codes of practice these assumptions generally featured in the Foreword or Introduction e.g. BS5950, Clause 1.02<sup>1</sup>. This note considers the implications of the equivalent assumptions relating to the structural Eurocodes which are given in BS EN1990.

### **Eurocode requirements**

- 2 BS EN 1990 (Basis of design) states in Clause 1.3 that '*A design which employs the Principles and Application Rules is deemed to meet the requirements of EN 1990, provided the accompanying assumptions are satisfied*'. These six assumptions are fundamental to achieving compliance with the Eurocodes generally, and, specifically, the execution of safe structures. It is important these assumptions are not forgotten amongst the technical detail of BS EN1991-9, and that designers have a strategy for ensuring they are met. They are examined in paragraph 7.
- 3 Clause 2.2 of BS EN1990 states that: '*the reliability required for structures within the scope of EN1990 shall be achieved by:*
  - *Design in accordance with EN1990-1999*
  - *Appropriate execution*
  - *Quality management procedures*'
- 4 Clause 2.5 (Quality Management) refers to '*organisational measures*' and '*controls at the stages of design, execution, use and maintenance*' being in place.
- 5 There is a note (following Clause 2.5) which indicates that EN ISO 9001: 2000 is an acceptable basis for quality control management, where relevant. Hence there is an assumption that a structured quality control system is required although not necessarily one which is formally registered.
- 6 Annex B to BS EN1990 (Management of structural reliability for construction works) provides greater explanation and is referenced in the commentary to assumption 3.

### **The six assumptions behind Clause 1.3**

- 7 These assumptions are scheduled below, together with a commentary:
  - 7.1 *1-The choice of the structural system and the design of a structure is made by appropriately qualified and experienced personnel.*

NOTE: this should include 'Adequate supervision and quality control' as noted in Assumption 3.

    - 7.1.1 The choice of an appropriate structural system, and the adequacy of the associated design is clearly very important. SCOSS has advocated project risk reviews [1] which would allow this assumption to be tested in the early days of a project. In so far as these choices might affect safety, the Construction (Design and Management) Regulations 2007 (CDM) also

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<sup>1</sup> This requires one person to have overall responsibility for structural stability.

require consideration to be given to the structural system and design process. The considerations might include:

Choice of system	Does this provide adequate robustness? Can it be safely and economically constructed and maintained? Will interfaces be appropriately engineered and controlled? Is it an established system, used in normal circumstances, or is it unusual in some way?
Structural model validation	Does the structural model sufficiently represent the actual structure? Are the sensitivities of the model known?
Output verification	Has the input been checked and the output reviewed to determine its accuracy within acceptable bounds?
Codes and their applicability	Does the proposed structural analysis extend beyond the code limitations; are there additional actions that need consideration?  Eurocodes do not necessarily include all elements of comprehensive design. Excluded items may be identified in the National Annex (NA), and covered in Non-Contradictory and Complementary Information (NCCI) but on occasions critical issues may lie outside the scope of these documents also.
Non-codified items	A project specific assessment should be made to ascertain if there any items of note outwith the EN or associated NA (as noted above).
Interim stability issues	It is essential that interim stability issues are identified by the designer. Have these been examined and identified in some way e.g. on the drawings?
Measures to prevent progressive collapse	Do the adopted measures provide the robustness required? Do they take account of interfaces between different materials and/or proprietary units?
Actions	Has the design taken account of all foreseeable actions?
Personnel	See 7.2 below

7.1.2 A record of such a review should be retained in the project files.

7.1.3 SCOSS has developed a guidance note relating to the independent review of certain structures [2]; this will greatly assist in compliance with assumption 1 in these cases.

7.1.4 The use of appropriately qualified and experienced personnel is commented on in 7.2 below.

## 7.2 *2-Execution is carried out by personnel having the appropriate skill and experience.*

NOTE: although this relates to the 'execution' phase i.e. construction, the principles apply to all phases of a project. (Note: this is due to be amended in a Corrigenda).

7.2.1 The need for personnel who have the appropriate skill and experience is a requirement which relates to both the design phase and the execution phase. Both phases are commented on in this section and fall within the ambit of the Construction (Design and Management) Regulations 2007 (CDM2007).

7.2.2 These regulations require those involved in 'construction work' to be competent unless under supervision. The associated Approved Code of Practice (ACoP) [3] gives guidance in respect of the corporate competence of the organisations and of the individuals involved. It is important (and a specific requirement) that those who lack competence e.g. from a shortage of experience, are allocated appropriate supervision.

*Design*

7.2.3 In the early days of Eurocode application few design practitioners will have any experience in its use. Hence the supervision, checking and review processes will need to reflect this 'immaturity' to ensure that an appropriate level of confidence is attained. Although much of the Eurocodes is similar to existing codes of practice such as BS8110 or BS5950, there are some key differences which could lead to errors until fully assimilated into contemporary practice e.g.

- In steel design the orientation of the x-x and y-y axes differ to current practice,
- The Eurocodes adopt the continental style of ',' for a decimal point. Thus 2.34 is given as 2,34, and spaces are introduced e.g. 1 000 in lieu of ', '.
- New software that does not have the benefit of established use to have identified any bugs/misinterpretations.

7.2.4 Further examples of potential misunderstandings are given on the SCOSS website, on the Eurocode Expert website ([www.eurocodes.co.uk](http://www.eurocodes.co.uk)) and in occasional 'Q&A' articles in the Structural Engineer.

7.2.5 Part of the project risk assessment (illustrated in paragraph 7.1.1) should be devoted to an assessment of the proposed design staff.

*Contractors*

7.2.6 Designers may need to alert the client to any specific requirements, relating to those who may construct the structure. These might relate to the complexity of the structure or fabrication needs. These can then be ensured during the pre-qualification and tendering process. Particular attention should be paid to ensuring the requisite standard is applied to all subsequent sub-contract arrangements.

7.3 *3-Adequate supervision and quality control is provided during the execution of the work, i.e. in design offices, factories, plants, and on site.*

NOTE: as 'execution' relates to the construction phase of the project, this assumption should perhaps not include 'in design offices'. However, as noted under assumption 1, the need for 'adequate supervision and quality control' applies throughout a project. (Note: this is due to be corrected in a Corrigenda)

7.3.1 The requirement for adequate supervision and quality control is applicable to all stages of the project. It is clear from paragraph 5 that such supervision and quality control should be of a recognised standard, broadly consistent with one complying with ISO BS 9001.

7.3.2 Most sections of the Eurocode have references to other BS ENs which spell out the requisite quality standards relating to the construction stage e.g. BS EN 3834 (welding); BS EN 13670 (execution of concrete structures).

7.3.3 There are no specific cross references to the supervisory levels or quality control of designers. This links back to paragraph 7.2.3.

7.3.4 BS EN1990 allows for some variation in supervision and quality control, within the scope of a recognised quality management system, depending upon the classification of the structure (Annex B Table B4 and B5). These tables are repeated below.

7.3.5 The 'RC' classification in the tables refers to a structure's reliability; it relates to the consequences of failure, as noted below (see also Table 8.4 of ref 10):

Consequence Class	Reliability Class	Description and examples
CC3	RC3	<b>High</b> consequence: grandstands, public buildings
CC2	RC2	<b>Medium</b> consequence: residential or office buildings
CC1	RC1	<b>Low</b> consequence: agricultural buildings

- 7.3.6 Designs to the Eurocodes will normally be based around CC2/RC2. For buildings, the categorisation is replaced by Table A.1 in Annex A of BS EN1991-1-7 (equivalent to Table 11 in the Approved Document A relating to the Building Regulations).

Table B4

<b>Design Supervision Levels</b>	<b>Characteristics</b>	<b>Minimum recommended requirements for checking of calculations, drawings and specifications</b>
DSL3 (relating to RC3)	Extended supervision	Third party checking:
DSL2 (relating to RC2)	Normal supervision	Checking by different persons than those originally responsible and in accordance with the procedure of the organisation.
DSL1 (relating to RC1)	Normal supervision	Self checking: performed by the person who has prepared the design

- 7.3.7 Checking ‘...in accordance with the procedure of the organisation’ is taken to mean in accordance with the design organisation’s quality control system noted in paragraph 5. Annex 5 B4 clause (2) states that design supervision levels may be linked to these reliability classes or the importance of the structure, in accordance with National requirements or the design brief, and implemented through the quality management measures mentioned in paragraph 5.
- 7.3.8 Without supplementary clarification, this is considered to be too vague; it is suggested therefore that it will need careful clarification on a project by project basis and should feature also as part of the project risk review.

Table B5

<b>(execution) Inspection levels</b>	<b>Characteristics</b>	<b>Requirements</b>
IL3 (relating to RC3)	Extended inspection	Third party inspection
IL2 (relating to RC2)	Normal inspection	Inspection in accordance with the procedures of the organisation
IL1 (relating to RC1)	Normal inspection	Self inspection

- 7.3.9 Inspection ‘in accordance with the procedures of the organisation’ is taken to mean in accordance with a quality control system noted in paragraph 5. However this Table relates to the procedures of the ‘executing’ organisation i.e. the contractor, which may not match the expectations or requirements of the designer. Hence, this may require contractual clarification.
- 7.4 *4-The construction materials and products are used as specified in EN 1990 and ENs 1991 to 1999 or in the relevant supporting material or product specifications.*

- 7.4.1 This must be achieved through adequate contract documentation, coupled with appropriate supervision as noted in 2 above. SCOSS is aware, for example, that:
- changes are sometimes made on site to specified items [4], without the necessary involvement of the designer.
  - some products are incompletely specified e.g. steel [5]

Such occurrences will invalidate this assumption.

- 7.4.2 The use of CE marked products is becoming more common and will further accelerate in the near future. It is important that the scope and limitations of EU driven certifications measures are understood [6,7,8] and that construction contracts contain appropriate controls.

## 7.5 *The structure will be adequately maintained.*

7.5.1 As is the case with current codes of practice, the partial safety factors for materials denoted in the Eurocodes do not allow for deterioration. Hence it is important that structures are maintained during their life to avoid diminution of the safety margin. This need requires designers to produce a *maintenance philosophy strategy* or similar statement: *CIRIA* describes how this might be done [9]. The essence of this advice is that maintenance should be discussed during the design phase and that the client should buy-in to the strategy proposed. The statement should set out the assumptions regarding the nature of maintenance, its frequency and the assumed means of access and egress; it should consider also, as appropriate [10]:

- Costs of design, construction and use
- Costs arising from hindrance of use
- Risks and consequences of failure of the works during its working life and costs of insurance covering these risks
- Planned partial renewal
- Costs of inspections, maintenance, care and repair
- Costs of operation and administration
- Disposal
- Environment

7.5.2 BS EN1993-1-2 (Fire) Clause 1.3 adds the comment that ‘any passive fire protection systems taken account of in the design should be adequately maintained’. Hence for this to be realised the required actions must be passed on to the client, or those responsible for maintenance. In the case of buildings, the Approved Document for Part B requires the designer to make appropriate information available to those in charge of the building in order that compliance with the Regulatory Reform (Fire Safety) Order 2005 may be achieved.

7.5.3 Such considerations are supported by the requirements of CDM2007 in respect of the need to eliminate safety hazards and reduce risk, to pass on information, and to contribute to the Health and Safety File. It is anticipated that the client interaction suggested will encourage discussions on ‘capital’ versus ‘whole-life’ costs.

7.5.4 A key element of any maintenance regime is ‘inspection’, the detail of which will vary, structure to structure. Specific structures already have detailed guidance in respect of maintenance e.g. car parks [11] and bridges [12].

7.5.5 In all cases the client should clearly understand the safety implications of failing to implement maintenance in a competent manner.

## 7.6 *The structure will be used in accordance with the design assumptions.*

7.6.1 Structures may be designed to a client’s specific requirements or to general standards. However, in neither case is the client likely to appreciate the engineering limitations on the structure.

7.6.2 This Eurocode assumption will require designers to schedule the key design assumptions regarding:

- i) Its ‘Use’ (as assumed in the design).
- ii) Design life
- iii) Design actions
- iv) Means of achieving resistance to progressive collapse
- v) Details of any special (project related) actions considered

7.6.3 This data should feature as part of the Health and Safety File, if there is one, or communicated to the client in some other way in other cases (preferably via the drawings).

## Summary

If current designs are given as being 'in accordance with a specified BS' it infers that measures have been taken to ensure compliance with the assumptions given in the Foreword and Introduction of the named code. Evidence suggests that this is not always done.

The advent of the Eurocodes provides a useful opportunity to remind ourselves of these assumptions and to have particular regard to the six assumptions given in BS EN1990. This paper is intended to be an initial attempt to identify the key issues.

## References

1	Reflections on structural safety The Structural Engineer Vol <b>80</b> No 8. 16 April pp11-12
2	Appendix 1 of the SCOSS 16 <sup>th</sup> Biennial Report <a href="http://www.scoss.org.uk/publications.asp">http://www.scoss.org.uk/publications.asp</a>
3	Managing Health and Safety in Construction Approved Code of Practice HSE Books L144
4	SCOSS 15 <sup>th</sup> Biennial Report. paragraph 4.3.19
5	Designing for safe construction The Structural Engineer Vol <b>84</b> No 10 16 May 2006 pp17-18
6	For example at <a href="http://www.communities.gov.uk/index.asp?id=1131335">http://www.communities.gov.uk/index.asp?id=1131335</a> Also: CE marking under the Construction Products Directive. Updated 2004
7	A Guide to Certification and Approval IP 5/08 Building Research Establishment
8	SCOSS 15 <sup>th</sup> Biennial Report section 4.3 <a href="http://www.scoss.org.uk/publications.asp">http://www.scoss.org.uk/publications.asp</a>
9	Safe access for maintenance and repair CIRIA C686 2009 2 <sup>nd</sup> Edition.
10	Designers' Guide to EN 1990 Eurocode: Basis of structural design H Gulvanessian J-A Calgaro M Holický p27
11	Inspection, Assessment and Maintenance of car park structures Thomas Telford Ltd
12	Management of Highway Structures Roads Liaison Group September 2005

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