APPENDIX A

INDEPENDENT REVIEW OF BUILDING STRUCTURES: GUIDANCE NOTE

Purpose of Note

This guidance note has been written to highlight the rationale for, and explain the implementation of independent reviews of large, complex, innovative or unusual structures. It also applies to more common structures but where there may be abnormal risk e.g. complex ground conditions, adjacency of existing structures.

The purpose of the independent review is to add value to a project by questioning the design team on their hazard elimination and risk reduction measures relating to the design, construction, use, maintenance and decommissioning of the structure. The concept of an independent assessment is not new; it is a well established process. The Highways Agency has adopted a system of independent checks on most highway structures for many years; the nuclear, and other specialist sectors also adopt rigorous review procedures. Some enlightened private sector clients have also seen the benefits. Although the detail and approach of these client-instigated reviews may vary they all have the common aim of reducing risk and adding value to the project.

However, although the process set out in this note operates through an independent reviewer in common with the examples quoted above, it differs in its approach from most existing examples. The key characteristics of this process are that:

- It is a high level ‘review’, not a ‘check’ as conventionally performed (that is for others).
- The reviewer is seen as the designers ‘critical friend’, whilst retaining independence
- The design team retain ownership of the design but are challenged to justify and consider design decisions and their impacts.
- The reviewer is able to act objectively without attracting liability.
- It should be an iterative process i.e. the reviewer becomes involved at an early stage and contributes throughout the design development.

Independent Review of Building Structures

1 For some time SCOSS has been considering how best to promote the public safety requirements inherent in large or complex projects, where currently there is no accepted adoption of independent review. The concept of independent reviews is considered useful since these already exist across our industry albeit in an inconsistent way. Most highway structures undergo some form of independent check[1]; in potentially hazardous industries there is a process of independent design verification (e.g. in the nuclear industry and in the entertainment rides industry, both of which involve public safety governed by the integration of several engineering disciplines such as civil, structural, mechanical and control). Although building structures are submitted to Building Regulation control that process is often too mechanistic to tease out safety issues inherent in major structural or infrastructure projects, which often fall outside the scope of routine regulation and, on occasions, outside the scope of standard Codes of Practice (and sometimes the experience of

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[1] This includes a code compliance check; some view the check as risk averse, which is different from the approach suggested in this note.

building control reviewers). Building Regulations only deal with the finished state and not with the construction stage (when the risk of failure is often higher) or with structural maintenance considerations.

2 The independent review is not a further layer of bureaucracy; it is designed to be useful to all parties and to assist in reducing risks and adding value to the project. As noted above, it is already accepted in specific sectors as a client-sponsored safeguard which recognises that the wider benefits outweigh the additional cost.

Objective of independent review

3 The usual objectives are to review:

- i) Design philosophy (including the design safety objectives)
- ii) Major hazards and ascertain if they have been identified and dealt with[2].
- iii) The robustness of the structure and whether it has been adequately considered.
- iv) Models of analysis and that they have been adequately validated by the designers. Also, to ascertain that the results have been reviewed in terms of magnitude and pattern.
- v) Design assumptions including the relationship to construction, use and maintenance, materials and specification.
- vi) Design interfaces.
- vii) Procurement and contractual arrangements including their compatibility with structural robustness.

4 However it is worth noting that there is often benefit to the project if the scope of such a review is widened to include other project issues: for example client brief, expected deliverables and finance; sustainability issues could also be included. This is the holistic approach.

Selection of structures

5 The selection of structures (including temporary works structures) for independent review should ideally be based on risk. Given the practical difficulties of doing this however, and the likely need for guidance, it is proposed that the structures are generally chosen according to the categories of structure used in Table 11 of the Building Regulations, Approved Document A. These were derived from a risk related analysis.

6 Hence, it is recommended that any structure which falls into one of more of the following categories should be subjected to an independent review:

Category	**Example**
Potential hazard to large numbers of people	Theatres, stadia, large offices, underground stations, tunnels, bridges, long or deep retaining walls,

[2] see for instance the reference to ‘abnormal hazards reasonably foreseeable’ in Approved Document A para 5.1e. Examples of such hazards are also given in a topic paper on the publications page of the SCOSS website (Topic paper - A risk managed framework for ensuring robustness).

Are of critical design, materials or form	Use of specialist software in safety critical situations, Minimal redundancy, Tall structures, Use of new proprietary products where these perform key structural functions, Buildings designed using tests or first principles, rather than code formulae, Buildings with elements outside primary code limits Structures with complex and critical soil/structure interaction. Structures requiring special construction techniques
Have to resist significant and unusual hazards	Industrial processes, significant impact forces, terrorist actions, significant climatic effects.
Where procurement and contractual arrangements are critical	Use of design/build in complex situations; use of self-certification;
Have a crucial design/construction interaction	Structures with critical temporary stability or temporary works requirements.

This approach aims to select projects which are large, complex, innovative or unusual (a suggestion already promoted by others) and those with high risk.

7 This categorisation derives from a structural safety perspective. However, there may be compelling grounds for an independent review on economic, insurance, business criticality or similar grounds. (The chosen categories tie in with, and expand on, the suggestions made in the SCOSS 14th Biennial Report).

Implementation of review

8 The review may be carried out by someone (or a team) from the same organisation as that originating the design, or by an external reviewer. However they must be independent of the originating team.

9 Suggested ‘rules’ for conducting the review are proposed as follows:

i) To be of value, the review must be conducted at high level*. It will be to consider whether the design principles are sound, that the construction proposals are properly considered and adequate proposals are in place for execution. To complete such work satisfactorily, the reviewer(s) must be thoroughly experienced and technically aware across the full range of disciplines, design and construction phases, inherent in the project. The reviewer(s) must be technically skilled to a level whereby design submissions can be properly appraised.

**The parallel activity of design calculation and code compliance checking should continue to take place.*

ii) To be of value, all parties in the project must regard the reviewer as a ‘critical friend to the team’. In turn, that implies willingness by the reviewer to help resolve problems in an open manner without loosing independence. The reviewer must therefore be someone of integrity, not to be swayed by contractual positions but equally ethically bound not to use confidences to the contractual detriment of any party. The reviewer’s duty is to act independently of the team, but to the benefit of all.

iii) If the reviewer is to provide maximum assistance, in order to help resolve the inevitable difficulties that arise, (s)he must not be constrained in offering best judgement for fear of financial penalty (civil action), notwithstanding the obligation to use reasonable skill, care and diligence.

iv) The reviewer must be independent of the team. However, the interaction with the team should be flexible and open with the emphasis on reducing risk and adding value. The review should commence at an early stage so that key project decisions may be considered in a contemporaneous manner. A key focus should be placed on safety and risk reduction through highlighting and addressing concerns. This can very effectively be achieved through presentations by the team to the reviewer along with the generation and maintenance of risk registers. The reviewer should point out errors or concerns and allow the designers to explain their rationale; solutions must be fully owned by the team.

v) The team should be encouraged to provide the written draft reports and outputs, stemming from presentations, workshops and discussions with the reviewer. The drafts are then assessed and commented on as appropriate by the reviewer. This process thus serves as a useful check on communication and also enables the input and value from the reviewer to be maximised. It also places the onus on the team to address the issues and develop solutions thus maintaining the necessary ownership. However, whilst the onus is on the team, it does not preclude the reviewer from pro-actively making constructive contributions.

vi) The cost of the review must be proportionate to the risk i.e. it must add value; it is a matter of negotiation between the parties. However the budget must be reflect the required input if the process is to bring any real benefit to those more directly involved.

Liability of the Reviewer

10 In order for the independent review concept to work efficiently and to bring added value to the project it is essential that those undertaking the role, whilst using due skill care and diligence, are not constrained by fear of formal action (para 9 iii).

11 If the reviewer comes from the same organisation that is employed to design the facility, then the question of liability (in the corporate sense) does not arise. It is then a question of ensuring that internal procedures and culture allow and encourage the reviewer (as an individual or group) to act according to their professional judgement.

12 If the reviewer is from a separate organisation from that of the designers then, appointment documents should be constructed to avoid subsequent action. This might appear to be radical; however, if the process is conducted as suggested, with the reviewer being the ‘team’s friend’ and of established reputation, and ownership of change rests with the designers, it becomes a logical approach.

APPENDIX B

CENTRE OF CONSTRUCTION INDUSTRY SAFETY EXCELLENCE: CHAIR OF CONSTRUCTION SAFETY[1]

Background

Although the construction industry has made significant strides in recent years, in terms of improving its safety record, there is some way to go before it can claim success. It is considered that a major influence in achieving these future improvements will be the role of academia in:

- Delivering the core risk management education to its students such that they graduate, with the appropriate knowledge base
- Providing specialist learning opportunities, e.g. MSc courses, and also
- Providing co-ordinated industry-linked research to allow and encourage knowledge transfer.

At present there is no co-ordinated network between industry, the regulator (HSE) and academia. This is considered to be a significant shortcoming and a barrier to progress.

Whilst 'risk management' with specific applications is well understood by academia[2], 'health and safety risk management' is a subject area that much of academia (in the Higher Education Sector) finds difficult to deal with [1].

Introduction

This paper sets out a proposal for enhancing education in occupational health and safety (within a structural engineering framework), for strengthening the knowledge network between industry and academia in this area, and for identifying, co-ordinating and implementing practical problem-solving research.

The paper considers the issues associated with the establishment of a Centre of 'construction safety' excellence, including a professorial Chair of Construction Safety, at a UK University. In this context 'construction' is intended to be a holistic term (usefully illustrated through the '3Ps' approach of *people, process* and *product* as set out in the 15th Biennial report) applied to the whole process of adding to, maintaining and decommissioning the built environment.

SCOSS is concerned primarily with structural safety and hence the Centre would be expected to have a structural engineering bias in its approach. However this is inextricably linked with 'occupational safety' (reflecting also the interests and remit of one of our sponsors, i.e. HSE).

It is considered that what is often referred to as 'health and safety' is in fact part of the project risk management process and should be treated as such, hence the more appropriate term 'health and safety risk management'. This is the approach taken by the Joint Board of Moderators [2] amongst others.

[1] The title is important: this needs to convey the message that the Chair is interested in safety at all stages of the project process (see text also).
[2] Such as on technical issues or relating to project risk management.

The rationale

Points that are supportive of such a centre of excellence include:

- The need as a profession to send out a message that our role as providers of infrastructure is underpinned by a need to make sure safety in design, construction and operation is integrated and just as important as any of the other technical issues with which we deal.

- The Royal Academy of Engineering and others have made valuable contributions to the debate over safety but that message needs to be expanded and consolidated into the education curriculum.

- The intellectual demands are formidable: How do we improve safety and how do we measure what we have and decide when enough is enough? How do we tackle the safety issues of an ageing infrastructure? Are we doing enough to reconcile construction safety risk with risk in other areas (e.g. rail)?

- Safety issues are disparate: they apply to fires, crowd control, construction, on-going maintenance, interaction between design and construction, contractual arrangements, terrorism, and so on. These interact with structural safety issues such as safety factors and building design and inspection. So there is a need to collate general principles and provide an education service for the future.

- We do have a strong foundation to build on. Lessons have been learned from other industries e.g. the off-shore industry, the rail industry, from accidents such as that involving the Herald of Free Enterprise, from structural failures, and from large construction projects like the Channel Tunnel, T5 and so on. The chemical industry and nuclear industries have evolved techniques for assessing the safety of plant using Safety Assessment Principles and deterministic and probabilistic techniques. There are administrative procedures such as HAZOPs, which explore failure paths, and skills such as the drafting of Safety Cases that could be more widespread. Yet as a community of engineers we have no recognised centre for the collation, recording, evolving or promotion of all this information. That is inconsistent if we really attach as much importance to public safety as we claim.

These raise a wide range of issues; in taking this proposal forward some rationalisation may be required in order to keep the brief within practical limits.

Existing University ‘safety’ centres

There are a number of centres of ‘safety’ excellence in existence, in addition to Universities offering ‘safety’ related courses; for example:

University	Centre	Comment
UCL/IC	Centre for Transport Studies	Lloyds Register sponsored Chair (Professor Andrew Evans) in Transport Risk Management.
Aberdeen	School of Engineering & Physical Sciences	Chair of Safety Engineering (Prof Michael Baker). Centre has developed an MSc in ‘Safety Engineering, Reliability

University	Centre	Comment
		and Risk Management' geared towards the oil and off-shore industry. (*Note 1)
Aston	Engineering Systems & Management	Richard Booth, Professor of Occupational Health & Safety. Undergraduate courses but no MSc or substantive research.
Cranfield	Institute for safety, risk and reliability (www.cranfield.ac.uk/safety)	The Institute focuses on trans-disciplinary and multi-sector approaches to safety research, consultancy and teaching.
Liverpool		Is incorporating a generalised risk syllabus developed by HSE/HSL.
Sheffield		MSc in Process safety and loss prevention.
Loughborough	Civil Engineering	Prof Alistair Gibb has led on a number of occupational 'safety' projects. The European Construction Institute (ECI) is also based at Loughborough.

* Note 1: The Aberdeen programme is closely aligned with one of the ten priority themes identified by EPSRC in its call for outline proposals in January 1999, namely "Risk, Safety and Reliability". Students are drawn from a wide range of first degrees and industries. It was decided not to introduce distance learning.

The need for engineers to have a better understanding of safety and reliability issues stems from the increasing need to try to obtain a suitable balance between excessive safety and consequent waste of resources, on the one hand, and under-design with the possibility of high failure costs and undesired failure consequences on the other (Professor Michael Baker).

There are some elements of this course which will be of direct interest to the construction industry.

There are a number of individuals (e.g. Graham Dalzell) in the process/off-shore sectors that have direct experience of undergraduate inputs.

It is noticeable that there is no existing construction-related centre of safety excellence and hence this proposal would appear to complement rather than detract from existing provision.

Proposal

The proposal therefore is for the establishment of a centre of excellence for construction safety studies with the inclusion of a chair of construction safety. The scope is suggested as:

- To further the collation and dissemination of information on construction industry safety issues

- To develop links with other university centres with an interest in safety issues such that overall benefit may be obtained
- To develop teaching aids and syllabi (for use throughout academia)[3]
- To develop post-graduate learning opportunities
- To further industry-related research
- To develop partnerships with industry and government agencies
- To review 'risk' terminology and approaches so as to bring clarity and consistency
- To act as a foil to the Regulators bringing balance to arguments submitted respectively by enforcers and practitioners recognising that in partnership the industry needs to set standards as to what constitutes the norm in acceptable safety standards.
- To act as a public figure head in the media on construction safety issues.

It is suggested that the Centre of Construction Safety be supported by a Steering Group (industrial panel) drawn from across industry (e.g. HSE, CIRIA, CIC, CC, CCG) as means of providing guidance and reinforcement of the academia/industry sectors.

These proposals reinforce and develop the arguments put forward by Allan Mann in his joint ICE/IStructE lecture[4].

Model of Operation

There are a number of ways in which such a proposal could be delivered.

	Model	Comment
1a	Provision of funding to an existing university department in order to allow progression of a specific project, e.g. development of an MSc course or teaching material.	A schedule of projects should be identified (from a scoping study) from which the work would be drawn. A minimum solution
1b	Part funding to allow existing/new staff member to be appointed as 'Chair' for say 5 years in order to fulfil some specific objectives, e.g.: - teaching material for undergraduates - flexible syllabus[5] - MSc course in construction safety - to contribute to the debate arising from the bullet points scheduled above - liaison with other existing 'safety' centres in order to co-ordinate research knowledge and joined-up thinking.	Although appointed to one university the work and modus operandi would be for the benefit of all HE.
2	New Centre, including Chair of Construction Safety.	Would consist of Chair, researcher, research assistants. A major investment. Funding for say 5 years.

[3] This would be a major departure from the norm, whereby the incumbent, although based at one University, would be aiming to benefit academia at large.

[4] *Construction Safety: An agenda for the profession*, 28 April 2005 at ICE.

[5] taking account of syllabus development work at Liverpool John Moore's University (via HSE), Inter-Institutional Group H&S Panel and JBM requirements.

Cost Estimates
Some preliminary costings have been computed for the options identified above.

Option 1a: this will be project related and hence might vary between £50,000 (for a medium sized project) to around £100,000 (staff costs and the like for the establishment of an MSc and teaching material). See also 'offset costs'.

Option 1b: this is suggested as a 5 year appointment of an individual. The cost is estimated to be in the order of £375,000 which includes for the salary and associated employers costs, and assumed disbursements (travel etc), but assumes that office accommodation costs and nominal secretarial assistance is provided by the University, at no charge. The Chair would be on a fixed term engagement. See also 'offset costs'.

These costs assume a full time post, fully funded. An industry based salary has been assumed.

Option 2: this is a major venture. However it may be possible for the researchers to be funded through existing educational funding routes, and for the accommodation to be provided by the University at no charge. If so, the cost would be as Option 1b, plus the cost of an assistant. This is estimated as £525,000 in all. (Note that Atkins recently announced a 5 year Chair at Greenwich for a reported cost of £750,000. This may include other items. The costs are very dependent upon the assumed 'free of charge' items however). See also 'offset costs'.

Off-set costs
In all cases illustrated above, the costs could be off-set by:

- any research project income
- the use of existing academic posts, which only require 'top-up' costs to be met in order to achieve 'Chair' status
- contribution or match funding by the University or others as has been the case in other similar examples
- sponsorship (this is examined below)
- industry levy.

Sponsorship Funding
Funding sources need to be identified and followed through. These would include:

- Public sector e.g. HSE
- Private sector e.g. Construction industry organisations and companies
- Education/Engineering funding bodies: e.g. EPSRC, RAE.

Deliverables
It is suggested that specific deliverables include:
- Development of a teaching syllabus and associated material on construction safety for undergraduate courses in Civil/Structural Engineering
- Development of specialised MSc courses
- CPD courses for academics involved in teaching of civil and structural engineering

- EPSRC Network co-ordinator[6]
- Establishing industry geared 'risk terminology' for improved communication and better understanding within industry and with the public.
- Identification of industry related research needs
- Implementation of specific research.

The scope and the deliverables will be constrained by the level of funding obtained.

[6] Drawing together disparate groups with a common interest in order to make a credible application for research funding and to raise the profile of this area with EPSRC.

APPENDIX C

STRUCTURAL SUBMISSIONS UNDER THE BUILDING REGULATIONS, PART A: MINIMUM COMPETENCE STANDARDS AND PROVISION OF INFORMATION

This note relates to England and Wales

1 Introduction

1.1 Demonstration of compliance with Part A of the Building Regulations is an important safeguard against an inadequate margin of safety. This is a legal requirement that is usually discharged through compliance with the 'deemed to satisfy' codes of practice scheduled in Approved Document A.

1.2 Good practice would suggest that the submission made to Building Control is to a professional standard (regardless of whom actually makes the submission) reflecting the safety-critical nature of the submission, the technical complexity, and the legal obligation. This infers that the submission should:

i) clearly set out the key assumptions so that those assessing it may understand the approach taken.
ii) be co-ordinated
iii) be checked

Unfortunately, these basic requirements are frequently not achieved and there is no formal guidance on the matter.

This discussion note sets out what are considered to be:

- the essential standards and
- points of information that should be given at the beginning of the submission/calculations.

2 Background

2.1 Despite the fact that structural engineering is safety-critical (and formally recognised by HSE as such), there are no pre-requisites placed on those who choose to make submissions. The introduction to BS5950 (steelwork design code) states:

> *It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people and that construction and supervision should be carried out by capable and experienced organisations.*

Similar expectations apply to other material design codes of practice.

2.2 The use of standard details from Part A may signal to some that no specific expertise is required.

2.3 Those 'designers' who are submitting designs in furtherance of a business activity, have legal responsibilities under the Health and Safety at Work Act and in particular, the CDM Regulations, no matter what the size of project. They also have a duty of care under civil law. Unfortunately, those 'designers' who are not part of a business, typically general householders, have no responsibilities under HSWA.

Notwithstanding, existing legislation is a blunt tool in terms of ensuring standards are attained.

2.4 The process of determining compliance with the Building Regulations by local authorities has been significantly affected by a combination of:

i) the obligation to recover their costs in discharging these duties, often leading to severe constraints on input,
ii) a lack of suitably competent staff,
iii) the influence of Approved Inspectors.

2.5 This situation needs to be viewed against the effect of commercial pressures on industry, skill shortages and the introduction of new codes of practice in respect of the maintenance of standards.

2.6 There is strong anecdotal and direct evidence to suggest that the current situation is undermining the importance of structural engineering to the health, safety and welfare of those in and around buildings, and is creating a situation where there is an 'accident waiting to happen'.

3 Essential competence standards

Individuals

3.1 Part A is concerned with structural safety. The analysis, design and checking of structures to ensure structural safety requires competent input. There are examples where even the simplest of 'designs'-even using standard details- can lead to problems if the wider implications are not understood.

3.2 Ideally those undertaking this role should be members of an appropriate professional institution e.g. IStructE or ICE. Alternatively, they should be able to demonstrate appropriate competence in respect of education, training and experience.

3.3 In most cases it is not appropriate for someone without this background to be involved, regardless of the scale of the work.

Submissions

3.4 Submissions should be presented in an acceptable format i.e. one that allows ready assessment of the technical detail, methods used, software adopted.

3.5 Those originating submissions should not rely on the building control approval process as a primary check on their work. Anyone undertaking structural design has an obligation to satisfy themselves that it meets accepted standards and that they have exercised due skill and care.

3.6 All submissions should:

- Justify structures as structurally stable and complete (even if further elements of the project are yet to be submitted). A check cannot be undertaken on an incomplete structure.
- Include sufficient quantities of co-ordinated drawings and details to allow a proper understanding of the submission,
- Explicitly identify the party responsible for each element of design, and for overall stability.

4 Essential information

4.1 In order that submissions may be adequately assessed, it is suggested that all submissions should schedule the answers to the following technical questions on a frontispiece to the calculations:

	Question	**Comment**
1	Is the submission made on a 'deemed to satisfy' basis ?	If only in part, describe the boundary.
2	If yes to Q1, list the structural design codes with which it complies:	This is particularly important as we will be entering an era when Eurocodes will be used alongside existing codes.
2a	If Yes to Q1, and the submission utilises standard details from Approved Document A, confirm that the structure satisfies any limitations on the use of these details.	
2b	If no to Q1, explain the basis of design	This requires sufficient detail to allow others to understand the structural principles used.
3	Into what class has the structure been placed for purposes of disproportionate collapse design (Table 11 of AD-A)	If the structure is in a number of classes describe the division.
3a	Describe: i) how the class has been arrived at, and	i) This is particularly important with existing structures which are subject to a material change.
	ii) the measures taken to guard against progressive collapse.	ii) The Approved Document allows a number of structural options.
4	Describe (illustrating as required to give sufficient clarity) the load-path to the foundations and how lateral stability is achieved.	This should deal with both the final and key interim construction stages.

5	Confirm that: i) the structure may be safely built and,	i) A requirement of the CDM Regulations
	ii) that suitable information in this regard will be made available to the contractor.	ii) In all but simple cases this should include a description/diagram of the assumed construction sequence of the key members, illustrating any issues relating to interim stability (see Q4).
6	Name the organisation, or individual, which has overall responsibility for the stability of the structure as required by BS 8110, 5950, 6828 as appropriate.	See Clause 1.02 (BS5950); Foreword (BS8110), Clause 1 (BS5628) and Clause 1.3 (EN 1990).
7	Schedule the software used, and for what purpose; confirm that its application and limitations are understood and that the results have been verified.	

Software

4.2 The ubiquitous use of software has made the review process difficult. Many submissions are made with an abundance of output but without any explanation as to assumptions, limitations, defaults and the like. Software is often misused.

5 Conclusions and Recommendations

5.1 The Building Regulations approval process should be as simple and open as possible, consistent with safeguarding the health, safety and welfare of those in and around buildings. However it also needs to recognise that:

i) structural engineering is safety-critical
ii) submissions must be made by competent persons
iii) submissions need to make clear the fundamental assumptions on which they are formulated.

APPENDIX D

PROPOSAL FOR A '*WORKING ENGINEER'S*' GUIDE ON STRUCTURAL ROBUSTNESS AND DISPROPORTIONATE COLLAPSE

Background
SCOSS has become aware from a number of sources of concerns relating to the topic of robustness generally and disproportionate collapse specifically. This concern was articulated most recently at the workshop initiated and sponsored by SCOSS and held at IStructE on 30 October 2006.

It is clear that there is wide support for a guidance document, aimed at practising engineers, giving basic advice and solutions to common situations.

The aim of the guide would be to:
- Clarify the definitions, mechanisms and relevance of robustness and progressive collapse
- Summarise the requirements (and limitations) of the Building Regulations and the 'deemed to satisfy' material design codes (including incompatibilities and inconsistencies between codes).
- Illustrate, material by material, the specific issues and suggested solutions (*if required)*
- Illustrate solutions to hybrid construction and inter-material problems,

i.e. a practical explanation and guide to all structural designers and building control authorities which will enable consistency in the implementation and enforcement of design for robustness.

It is intended to be a working guide, not a thesis on the subject.

This note sets out a proposal for such a guide, and a suggested route for its production.

1 Scope

1.1 The scope has been derived from consideration of the concerns expressed though the SCOSS Workshop, the Verulam column in *The Structural Engineer*, and other contacts with industry. It is suggested as follows:

<table>
<tr><td>1</td><td colspan="2">Introduction
- background
- need for guide
- aims
- limitations</td></tr>
<tr><td>2</td><td colspan="2">Terms and definitions
- clarification of common terms</td></tr>
<tr><td></td><td>1</td><td>Robustness</td></tr>
<tr><td></td><td>2</td><td>Progressive collapse</td></tr>
</table>

3	**Building Regulations - Part A3**	
	1	Requirements - general - Class 1, 2A, 2B, 3
	2	Issues associated with existing buildings - classification - multiple ownership - hybrid construction
	3	Standards of submission - assumptions - use of software - single point of responsibility
4	**Design Codes and standards**	
	1	Current codes and comparisons - general (introductory assumptions) - technical issues - limitations
	2	Eurocodes (EN 1991-1-7) - assumptions
5	**Issues and solutions by material**	
	1	Steel (hot and cold formed), including composite construction
	2	Concrete (including precast work)
	3	Masonry
	4	Timber (including proprietary fabrications)
	5	Hybrid constructions
	6	Alterations and extensions
6	**Bibliography**	

Note: It is likely that the scope and content will evolve. The intent of chapters 1-4 is to describe (as needed) material specific issues. The problems associated with inter-material applications and hybrids would be covered in 5. Section 5.5 and 5.6 specifically will evolve with drafting and discussion.

1.2 The guide would take cognisance of other work in this area in order that it did not duplicate effort, including publications by NHBC, the material sectors, e.g. SCI and in *The Structural Engineer*. It is expected that guidance for class 3 structures will be limited to buildings which can be justified as needing no more than to comply with the criteria for class 2B.

1.3 The guide is not intended to be an academic treatise on this subject; it is intended for the practising engineer and building control authorities with the emphasis on safe design details, rather than the theoretical background.

Endnote

1 The initial idea for this guide came from SCI. SCOSS is grateful for their support in this respect.

2 Following discussions between SCOSS and IStructE, the latter has agreed in principle to the production of this guide. This is considered to be an important step forward.

APPENDIX E

THE ASSUMPTIONS BEHIND THE EUROCODES

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 current codes of practice these assumptions generally feature in the Foreword or Introduction e.g. BS 5950, Clause 1.02[1]. 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 BS EN1991-9, and that designers have a strategy for ensuring they are met. They are examined in paragraph 7.

3 Clause 2.2 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.*

[1] This requires one person to have overall responsibility for structural stability. It is noted that the Eurocodes do not have any similar explicit requirement.

7.1.1 The choice of an appropriate structural system and the adequacy of the associated design are 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 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 will generally be identified in the National Annex (NA), but on occasions critical issues may lie outside the scope of these 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.
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 is currently developing a guidance note relating to the independent review of certain structures [2]; this would 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: in this clause it is assumed that 'execution' is meant in the dictionary sense of 'performing a task', and hence it encompasses 'design' as well as 'construction'. Elsewhere in the Eurocodes it excludes design activity.

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 (CDM 2007).

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 BS 8110 or BS 5950, 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) 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: in this clause 'execution' is meant in the dictionary sense of 'performing a task', and hence it encompasses 'design'.

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) and, until such time as the National Annex is available, the National Structural Concrete Specification (NSCS).

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 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	**High** consequence: grandstands, public buildings
CC2	RC2	**Medium** consequence: residential or office buildings
CC1	RC1	**Low** consequence: agricultural buildings

7.3.6 Designs to the Eurocodes will normally be based around CC2/RC2

Table B4

Design Supervision Levels	**Characteristics**	**Minimum recommended requirements for checking of calculations, drawings and specifications**
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.

7.37 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.

7.38 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

(execution) Inspection levels	**Characteristics**	**Requirements**
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.

7.39 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 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, in accordance with the Construction Products Directive, 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 *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 the Regulatory Reform (Fire Safety) Order 2005 may be complied with.

7.5.2 Such considerations are supported by the requirements of CDM 2007 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.

7.5.3 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].

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

7.6 *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

8 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 Appendix is intended to be an initial attempt to identify the key issues.

References

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3. Health and Safety Executive. *Managing health and safety in construction: Construction (Design and Management) Regulations 2007: approved code of practice*. Report L144. HSE Books, February 2007
4. Standing Committee on Structural Safety. *15th Biennial Report*, Section 4.3.19 at www.scoss.org.uk/publications
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6. For example see www.communities.gov.uk/index.asp?id=1131335. Also see: CE marking under the Construction Products Directive. Updated 2004
7. Guide to be published by Building Research Establishment in 2007.
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11. National Steering Committee for the Inspection of Multi-storey Car Parks. *Recommendations for the inspection, maintenance and management of car park structures.* Thomas Telford Ltd, 2002
12. Roads Liaison Group. *Management of highway structures: a code of practice*. London, TSO, September 2005