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Introduction

1.0

1.0.1 Background

The structure of a *building* is fundamental to ensuring the safety of people in or around buildings and of existing buildings and can be affected by a number of factors inside and outside the *building* including environmental factors. These factors should be considered to prevent the collapse, excessive deformation or the disproportionate collapse of buildings.

Climatic conditions

The climatic conditions in Scotland including temperature, snow, wind, driving rain and flooding and the impact of climate change should be carefully considered in the assessment of loadings and in the structural design of buildings.

Disproportionate collapse

The methodology for assessing the risk of disproportionate collapse and a framework of additional measures commensurate to the level of risk and consequences of such collapse to all buildings in accordance with the forthcoming Structural Eurocode BS EN 1991-1-7: 2006 Accidental Actions is set out in the following reports:

a. 'Guidance on Robustness and Provision against Accidental Actions' dated July 1999';
b. ' Calibration of Proposed Revised Guidance on meeting Compliance with the Requirements of Building Regulation Part A3'.

www.communities.gov.uk

These documents are available on the website of the Department for Communities and Local Government.

Standing Committee on Structural Safety (SCOSS)
www.scoss.org.uk

The Standing Committee on Structural Safety (SCOSS) which reports to the Presidents of the Institutions of Civil Engineers and Structural Engineers to identify in advance trends and developments which might contribute to increasing risks relating to structural safety has set up a UK wide reporting system on structural safety issues, Confidential Reporting on Structural Safety (CROSS).

Appraisal of existing structures

Guidance relevant to conversions is given in 'Appraisal of Existing Structures', 1996 published by the Institution of Structural Engineers. Where this report refers to 'design checks' the choice of various partial factors should be made to suit the individual circumstances of each case.

1.0.2 Aims

The intention of this section is to ensure that the structure of a *building* does not pose a threat to the safety of people in or around buildings and of existing buildings as a result of:

a. loadings;
b. the nature of the ground;
c. collapse or deformations;
d. stability of the *building* and other buildings;
e. climatic conditions;
f. materials;
g. structural analysis;
h. details of construction;
i. safety factors.

Loads used in structural calculations should take account of possible dynamic, concentrated and peak load effects that may occur.

1.0.3 Latest changes

The following is a summary of the changes that have been introduced between 1 May 2005 and 30 April 2007.

1.0.1	References added for disproportionate collapse, SCOSS and existing structures
1.0.5	Reference added for forthcoming Guidance to Stone Masonry
1.0.6	Annexes
1.1.0	Key issues on nature of the ground and stability of other buildings
1.1.1	Reference to specialist advice
1.1.2-1.1.3	Updated references to British Standards
1.1.4	New guidance on nature of the ground
1.1.5	New guidance on stability of other buildings
1.2.0-1.2.5	Updated guidance on disproportionate collapse covering all buildings

Annexes 1.A to 1.F Small buildings structural guidance.

1.0.4 Relevant legislation

Safety of Sports Grounds Act 1975
Fire Safety and Safety of Places of Sport Act 1987

When designing or verifying sports grounds, reference should be made to the Guide to Safety at Sports Grounds (fourth edition 1997). The guide has no statutory force but many of its recommendations will be given force of law at individual grounds by their inclusion in safety certificates issued under the Safety of Sports Grounds Act 1975 or the Fire Safety and Safety of Places of Sport Act 1987.

Guide to Safety at Sports Grounds (fourth edition 1997)

Chapter 4 and 14 of the Guide to Safety at Sports Grounds (fourth edition 1997) provides guidance on permanent and temporary structures at sports grounds and makes recommendations for designers to follow including minimising the risk of disproportionate collapse and designing stadia on the basis of risk assessments having regard to the likely hazards, for example, if the stadium is intended to be used as a venue for pop concerts.

Section 89 of the Civic Government (Scotland) Act 1982

Section 89 of the Civic Government (Scotland) Act 1982 requires that no person shall use or permit the use of a raised structure for seating or standing accommodation unless such use has been approved by the local authority. Certain raised structures are exempt from this including any structure that has been granted a building warrant.

Dynamic performance and testing of grandstands

Guidance on the 'Dynamic performance requirements for permanent grandstands subject to crowd action' November 2001 and Dynamic testing of grandstands and seating decks, June 2002 has been published by the Institution of Structural Engineers as a supplement to the Guide to Safety at Sports Grounds (fourth edition 1997)

Temporary demountable structures

The Institution of Structural Engineers has published guidance on the 'Procurement, design and use of Temporary demountable structures' (second edition 1999) such as grandstands, marquees and stage structures. Towers and masts to support media facilities are also included. The guidance is intended to assist event organisers, venue owners, local authorities, contractors and suppliers of demountable structures and for competent persons who are responsible for their design.

1.0.5 Alternative approaches

Where alternative approaches to the structural design are proposed other than using the guidance contained in this section, the structural design should take account of all of the factors identified in clause 1.0.2 above. For example, care should be taken where alternative numerical values are placed on factors of safety as this may have a detrimental effect on the overall stability of the structure.

Structural Eurocodes in the UK

As part of the European Union's desire to remove technical barriers to trade, a series of European Codes of Practice in the field of civil and structural engineering known as Structural Eurocodes are being published by CEN, the Standards body for Europe. Like other harmonised European standards, each member of the European Union set their own 'Nationally Determined Parameters' (NDP's). Structural Eurocodes should only be used as an alternative to British Standards provided the National Annexes have been published.

There will be a period of co-existence during which time Structural Eurocodes and national codes (i.e. British Standards) should be considered equivalent. The period of co-existence will commence from the date the last package of standards (i.e. concrete, steel, timber, masonry, etc.) is made available from CEN to the British Standards Institution. It is anticipated that this period should commence in 2007 and end in 2010 when British Standards would be withdrawn and thereafter only the Structural Eurocodes would be referenced as guidance in meeting section 1: Structure.

Implementation of Structural Eurocodes

For more detailed guidance on the background and implementation of Eurocodes, see 'Implementation of Structural Eurocodes in the UK' (February 2003) produced by the Office of the Deputy Prime Minister (now Department for Communities and Local Government) on behalf of the United Kingdom and 'The National Strategy for Implementation of the Structural Eurocodes: Design Guidance' (April 2004) produced by the Institution of Structural Engineers.

Scottish Ministers are planning to publish 'Guidance on Stone Masonry' during 2007 which will give guidance in the use of stone masonry.

1.0.6 Annexes

The Small *buildings* structural guidance (SBSG) which provides structural guidance to designers of small *domestic buildings* is contained within the following annexes to this section:

Annex 1.A	General
Annex 1.B	Stability
Annex 1.C	Foundations
Annex 1.D	Masonry walls
Annex 1.E	Timber frame walls
Annex 1.F	Timber floors and roofs

1.1 Structure

1.1 Functional standard
1.1.0 Introduction
1.1.1 General
1.1.2 Loading
1.1.3 Design and construction
1.1.4 Nature of the ground
1.1.5 Stability of existing buildings

standard

1.1

mandatory

Every *building* must be designed and *constructed* in such a way that the loadings that are liable to act on it, taking into account the nature of the ground, will not lead to:

(a) the collapse of the whole or part of the *building*;

(b) deformations which would make the *building* unfit for its intended use, unsafe, or cause damage to other parts of the *building* or to fittings or to installed equipment; or

(c) impairment of the stability of any part of another *building*.

1.1.0 Introduction

Loadings

The effect of the loads acting on a *building* should be assessed both separately and in various combinations with each other to ensure the *building* can be designed to transmit these loads safely to the ground.

Nature of the ground

The stability of a *building* and other existing *buildings* in the vicinity can be affected by ground conditions which should be investigated and assessed to ensure that the ground can safely support the *building*.

Collapse

The collapse of the whole or part of a *building* is clearly a matter of the highest importance with respect to public safety. The design and *construction* of *buildings* should take into account all contributing factors such as loads, climatic conditions, partial safety factors for materials and loads and design methodology to ensure that it will have an acceptable probability that it will not collapse (ultimate limit state) during its design lifetime.

Deformations

Similarly deformations of *buildings* while not leading to an ultimate collapse can lead to public safety concerns particularly where they become unfit or unsafe for use. This can become apparent in several ways ranging from cracking, movement or springiness of floors, doors or windows not opening or closing, damage to pipes and other services within the *building.* The design and *construction* of a *building* should ensure that, by taking into account the factors set out above, the *building* does not fail in normal use (serviceability limit state).

Stability of existing *buildings*

The stability of existing *buildings* can be affected if the design and *construction* of a new *building* does not take into account any potential impacts on existing *buildings* . This could lead to a risk of collapse or damage to existing *buildings* with a consequent risk to public safety. Examples of potential impacts would be ground conditions or funnelling of wind. A new requirement has been added to the standard requiring this matter to be taken into account.

Conversions

In the case of *conversions* , as specified in regulation 4, the *building* as *converted* shall meet the requirements of this standard in so far as is *reasonably practicable* , and in no case be worse than before the *conversion* (regulation 12, schedule 6).

1.1.1 General

In order to be safe, a *building* should be capable of resisting all loads acting on it as a result of its intended use and geographical location. To achieve this, the structure of a *building* should be designed with margins of safety to ensure that the mandatory functional standard has been met.

In clause (b) of standard 1.1 deformations are not intended to cover aesthetic damage such as shrinkage and other minor cracking.

Specialist advice

Specialist advice from chartered engineers or other appropriately qualified persons should be sought if the designer is in any doubt about the loads acting on a *building* or how these loads can be accommodated by the structure and safely transmitted to the ground.

Reference can be made to the updated wind and snow loading maps contained in the following Building Research Establishment reports:

a. 'Wind loading on traditional dwellings-Amendment of simplified design guidance for the Scottish Office Small Buildings Guide' (1999) (Project number CV4071);
b. 'Proposed revision of the simplified roof snow load map for Scotland' (2003) (Client report number 211-878).

Consideration should be given to guidance in other sections of the Technical Handbook that can influence the structural design of a *building.*

1.1.2 Loading

The loads to which a *building* will be subjected should be calculated in accordance with the following British Standards:

a. for *dead loads* and *imposed loads* (excluding roof loads), BS 6399-1: 1996;
b. for imposed roof loads, BS 6399-3: 1988;
c. for *wind loads*, BS 6399-2: 1997;
d. for loading of any *building* for *agriculture*, BS 5502-22: 2003;
e. for earth retaining structures (e.g. basements), BS 8002: 1994;
f. any greater load to which the *building* is likely to be subjected.

1.1.3 Design and construction

The structural design and *construction* of a *building* should be carried out in accordance with the following British Standards:

a. for *foundations*, BS 8004: 1986;
b. for structural *work* of reinforced, prestressed or plain concrete, BS 8110-1: 1997, BS 8110-2: 1985 and BS 8110-3: 1985;
c. for structural *work* of steel, BS 5950-1: 2000, BS 5950-2: 2001, BS 5950-5: 1998, BS 5950-6: 1995, BS 5950-7: 1992 and BS 5950-8: 2003;
d. for structural *work* of composite steel and concrete *construction*, BS 5950-3.1: 1990 and BS 5950-4: 1994;
e. for structural *work* of aluminium, BS 8118-1: 1991 and BS 8118-2: 1991; for the purpose of section 7.2 of BS 8118-1: 1991, the structure should be classified as a safe-life structure;
f. for structural *work* of masonry, BS 5628-1: 2005, BS 5628-2: 2005 and BS 5628-3: 2005;
g. for structural *work* of timber, BS 5268-2: 2002, BS 5268-3: 2006 and BS 5268-6.1: 1996;
h. for earth retaining structures (e.g. basements), BS 8002: 1994
i. for structural design of low rise *buildings*, BS 8103-1: 1995, BS 8103-2: 2005, BS 8103-3: 1996 and BS 8103-4: 1995.

1.1.4 Nature of the ground

The *foundations* of *buildings* should be designed to sustain and transmit the loadings to the ground in such a manner that there will be no ground movement which will impair the stability of the *building*. All aspects of the nature of the ground should be taken into consideration including ground movement caused by:

- swelling, shrinkage or freezing of the subsoil; or
- landslip or subsidence (other than subsidence arising from shrinkage).

There may be known or recorded conditions of ground instability, such as that arising from landslides, disused mines or unstable strata which, if ignored, could have an adverse effect on a *building*. Such conditions should be taken into account in the design and *construction* of the *building* and its *foundations*.

www.communities.gov.uk

Attention is drawn to Planning Policy Guidance Note 14 (PPG 14) Development on unstable land. Although PPG 14 contains specific reference to England & Wales, it does set out the broad planning and technical issues relating to development on unstable land.

Information on the scale and nature of problems arising from mining instability, natural underground cavities and adverse *foundation* conditions is available from the following:

www.bgs.ac.uk

- British Geological Survey, Murchison House, West Mains Road, Edinburgh, EH9 3LA;

www.coalminingreports.co.uk

- The Coal Authority, 200 Lichfield Lane, Mansfield, Nottinghamshire, NG18 4RG.

Information can also be obtained from local authorities who hold Building Standards Registers and other relevant records.

If it is considered that a geotechnical investigation should be carried out, BS 5930: 1999 deals with the investigation of *sites* for the purpose of assessing their suitability for the *construction* of the *work* including obtaining information on the geotechnical conditions of the ground on the *site*. It provides recommendations on certain constraints or problems that can affect a *site*, including geotechnical aspects.

1.1.5 Stability of existing buildings

The stability of existing *buildings* may be affected by a new *building* located in its vicinity. The design and *construction* of the new *building* should take into account the effect on existing *buildings* in accordance with BS 8004: 1986.

The following factors can also affect the stability of an existing *building* and should be taken into account:

- dead and *imposed loads* from the new *building*;
- *wind loads* including funnelling effects from the new *building*;
- pressure bulb extending below existing *building*;
- changes in groundwater level;
- loss of fines during pumping operations or climatic conditions.

1.2 Disproportionate collapse

1.2 Functional standard
1.2.0 Introduction
1.2.1 Disproportionate collapse
1.2.2 Determine building risk group
1.2.3 Assess additional measures
1.2.4 Design and construct additional measures
1.2.5 Other sources of guidance

contents

standard

1.2

mandatory

Every *building* must be designed and *constructed* in such a way that in the event of damage occurring to any part of the structure of the *building* the extent of any resultant collapse will not be disproportionate to the original cause.

1.2.0 Introduction

Ronan Point

This standard was introduced in the United Kingdom following the disaster at Ronan Point on 16 May 1968. The scope of this standard which was previously restricted to *buildings* of 5 or more *storeys* was extended in 2005 to require designers to consider accidental overloading and the possibility of progressive collapse to all *buildings* and the guidance has now been expanded to provide guidance for all *buildings*.

Explanation of terms

Nominal length of load-bearing wall construction should be taken as:

- in the case of a reinforced concrete wall, the distance between lateral supports subject to a length not more than 2.25 x *storey* height;
- in the case of an external masonry wall, or timber or steel stud wall, the length measured between vertical lateral supports;
- in the case of an internal masonry wall, or timber or steel stud wall, a length not more than 2.25 x *storey* height.

Storey height is the distance from the underside of one floor to the underside of the floor immediately above.

Basement storey is a *storey* which is below the level of the ground *storey* and in the case of a sloping ground level is wholly below the lowest ground level around the *building* .

Key element is a structural member upon which the stability of the remainder of the structure depends and should be capable of sustaining an accidental design loading of 34 kN/m ^{2} applied in the horizontal and vertical directions (in one direction at a time) to the member and any attached components such as cladding, having regard to the ultimate strength of such components and their connections. Such accidental design loading should be assumed to act simultaneously with 1/3rd of all normal characteristic loading (i.e. wind and *imposed loading*).

Load bearing wall construction includes masonry cross-wall *construction* and walls comprising close centred timber or lightweight steel section studs.

Educational building is any *building* used for educational purposes including kindergartens, schools, colleges and university *buildings* .

Buildings accessible to the general public is intended to include *buildings* where members of the public can enter during normal opening hours and are allowed to access all parts of the *building* , other than those parts restricted to staff only.

Conversions

In the case of *conversions* , as specified in regulation 4, the *building* as *converted* shall meet the requirements of this standard in so far as is *reasonably practicable* , and in no case be worse than before the *conversion* (regulation 12, schedule 6).

1.2.1 Disproportionate collapse

A *building* which is susceptible to disproportionate collapse is one where the effects of accidents and, in particular, situations where damage to small areas of a structure or failure of single elements could lead to collapse of major parts of the structure.

Buildings should be provided with a level of robustness by adopting the principles of risk analysis, categorising *buildings*, taking into account both the risk of the hazard and its consequences and providing additional measures commensurate to the level of risk and consequences of such collapse of the *building*.

To ensure that *buildings* are designed and *constructed* to sustain a limited extent of damage or failure without a disproportionate level of collapse from an unspecified cause, the following procedure should be followed:

- determine *building* risk group;
- assess additional measures;
- design and *construct* additional measures.

1.2.2 Determine building risk group

The issues to be considered with respect to assessing the risk group of a *building* are its occupancy level, use, the number of *storeys* and floor areas.

The risk of an extreme event such as an explosion or other incident occurring would not be decreased simply by providing these measures and there is no certainty that demolition or *building* alteration would be carried out in accordance with good practice but the consequences of such an incident occurring would be considerably reduced.

Risk group	Building type
1	*Agricultural* and related *buildings* [1];
2A	Hotels not more than 4 *storeys* [2];
	Shared residential accommodation, residential care buildings and other *residential buildings* all not more than 4 *storeys*;
	Offices not more than 4 *storeys*;
	Factories (class 2) not more than 3 *storeys* ;
	Shops and enclosed shopping centres not more than 3 *storeys* and each *storey* area of not more than 2000 m^2 [4];
	Single *storey* educational *buildings* [3];
	*Assembly buildings (*other than educational *buildings), entertainment buildings* and other *buildings* accessible to the general public all not more than 2 *storeys* and each *storey* area not more than 2000 m^2 [4].
2B	Hotels [2], *shared residential accommodation, residential care buildings* and other *residential buildings* all more than 4 *storeys* but not more than 15 *storeys;*
	Educational *buildings*; more than 1 *storey* but not more than 15 *storeys* [3] ***;***
	Shops and enclosed shopping centres; not more than 3 *storeys* and with each *storey* area more than 2000 m^2 [4] or; more than 3 *storeys* but not more than 15 *storeys*;
	Hospitals not more than 3 *storeys*;
	Offices more than 4 *storeys* but not more than 15 *storeys*;
	*Assembly buildings (*other than educational *buildings), entertainment buildings* and other *buildings* accessible to the general public all not more than 2 *storeys* and all with each *storey* area more than 2000 m^2 but not more than 5000 m^2 [4];
	Open sided car parks and *storage buildings* (class 2) not more than 6 *storeys*.
3	Every Non- domestic *building* not covered in risk groups 1, 2A and 2B;
	Grandstands accommodating more than 5000 spectators;
	Storage buildings (class 1), *Factories (class 1)*

Notes

1. *Agricultural* and related *buildings* unless exempt under clauses 7 and 8 of Schedule 1 of the Building (Scotland) Regulations 2004.
2. Hotels in risk group 2A have been identified separately from *residential buildings.*
3. *Educational buildings* in risk groups 2A and 2B have been identified separately from *assembly buildings* .
4. For the purposes of this table
   - Where a *gallery* area is not more than 20% of the plan area of the *building* or 20 m^2 whichever is the less then it should be ignored for the purposes of calculating the *storey* area;
   - Where the *gallery* area is more than 20% but not more than 50% of the plan area of the *building* or 20 m^2 whichever is the less then the floor area of the *gallery* should be added to the floor area in calculating the floor area;
   - Where the *gallery* area is more than 50% of the plan area of the *building* then the *gallery* should be considered to be a separate *storey* in calculating the number of *storeys* .

The nomenclature of the risk groups 1, 2A, 2B and 3 is synonymous with the consequence classes in Table A.1–Categorisation of consequence classes of BS EN 1991-1-7: 2006.

In determining the number of *storeys* in a *building*, *basement storeys* may be excluded provided such *basement storeys* fulfil the robustness of risk group 2B *buildings.*

For *buildings* intended for more than one type of use the risk group should be that pertaining to the most onerous risk group (e.g. 2 *storey flats* above 1 *storey shops* should be taken as 3 *storey shops* and fall within risk group 2A non-domestic).

1.2.3 Assess additional measures

The additional measures which should be provided vary extensively according to *building* type and use and the actual measures should be designed in accordance with the relevant sections of design codes. For example, high rise hotels or *flats* or *assembly buildings* or grandstands require a different degree of protection than for low rise *buildings* or storage warehouses.

The additional measures which should be applied to *buildings* of the risk groups derived from the above table are set out below:

For risk group 1 *buildings*

Provided the *building* has been designed and *constructed* in accordance with the rules given in this Technical Handbook, or other guidance referenced under section 1, for complying with standard 1.1 in normal use, no additional measures are likely to be necessary.

For Risk Group 2A *buildings*

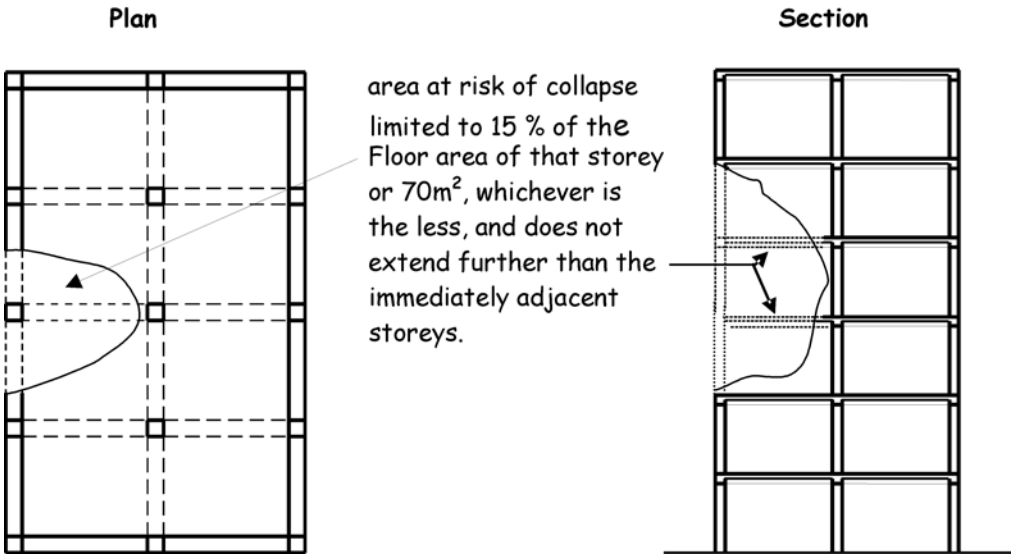
Provide effective horizontal ties, or effective anchorage of suspended floors to walls, for framed and load-bearing wall *construction*.

For Risk Group 2B *buildings*

Provide effective horizontal ties for framed and load-bearing wall *construction*, together with effective vertical ties, in all supporting columns and walls.

Alternatively, check that upon the notional removal of each supporting column and each beam supporting one or more columns, or any nominal length of load-bearing wall (one at a time in each *storey* of the *building*) the *building* should remain stable and that the area of floor at any *storey* at risk of collapse should be not more than 15% of the floor area of that *storey* or 70 m^2, whichever is the less and does not extend further than the immediate adjacent *storeys* (see diagram below).

Where the notional removal of such columns and lengths of walls would result in an extent of damage in excess of the above limit, then such elements should be designed as 'key elements'.



For risk group 3 *buildings*

A systematic risk assessment of the *building* should be carried out, taking into account all the normal hazards that can be foreseen as far as possible together with any abnormal hazards.

Critical situations for design should be selected that reflect the conditions that can be foreseen as far as possible during the life of the *building*.

The structural form and concept and any protective measures should then be chosen and the detailed design of the structure and its elements undertaken in accordance with the recommendations in the codes and standards in clause 1.2.4.

1.2.4 Design and construct additional measures

The structural design and *construction* to take account of the additional measures including horizontal and vertical ties and checking the integrity of the *building* following the notional removal of vertical members and the design of key elements, should be carried out in accordance with the following:

a. for structural *work* of reinforced, prestressed or plain concrete, BS 8110-1: 1997 and BS 8110-2: 1985;
b. for structural *work* of steel, BS 5950-1: 2000;
c. for structural *work* of masonry, BS 5628-1: 2005, BS 5628-2: 2005 and BS 5628-3: 2005.

Note that the British Standards for concrete and timber are being updated to incorporate the risk based approach for disproportionate collapse.

1.2.5 Other sources of guidance

Additional guidance has been produced by organisations providing more detailed information on disproportionate collapse as follows:

a. Technical Guidance Note – 'The Building Regulations 2004 Edition – England and Wales Requirement A3 – Disproportionate Collapse', National House Building Council (NHBC);
b. Technical Bulletin Number 3 'Design Guidance for Disproportionate Collapse', UK Timber Frame Association;
c. 'Masonry Design for Disproportionate Collapse Requirements under Regulation A3 of the Building Regulations (England & Wales) ', Brick Development Association;
d. 'Guidance on meeting the Robustness Requirements in Approved Document A', Steel Construction Institute.

The above guidance is based on England & Wales Regulation A3 and should be interpreted in relation to standard 1.2. In particular, references to *building* classes should be risk groups and the *building* types and occupancy should be interpreted as the *building* types set out in the table to clause 1.2.2.