



**National
Construction
Code**

Handbook



Structural robustness



abcb.gov.au

Copyright

© Commonwealth of Australia and States and Territories of Australia 2020, published by the Australian Building Codes Board.



The material in this publication is licensed under a Creative Commons Attribution-4.0 International licence, with the exception of

- Any third party material
- Any trade marks, and
- Any images or photographs.

More information on this CC BY licence is set out at the Creative Commons website (creativecommons.org/licenses/by/4.0)

Enquiries about this publication can be sent to:

Australian Building Codes Board
GPO Box 2013
CANBERRA ACT 2601
Phone: 1300 134 631
Email: ncc@abcb.gov.au
Web: abcb.gov.au

Attribution

Use of all or part of this publication must include the following attribution:

© Commonwealth of Australia and States and Territories 2020, published by the Australian Building Codes Board.

Disclaimer

By accessing or using this publication, you agree to the following:

While care has been taken in the preparation of this publication, it may not be complete or up-to-date. You can ensure that you are using a complete and up-to-date version by checking the Australian Building Codes Board website (abcb.gov.au).

The Australian Building Codes Board, the Commonwealth of Australia and States and Territories of Australia do not accept any liability, including liability for negligence, for any loss (howsoever caused), damage, injury, expense or cost incurred by any person as a result of accessing, using or relying upon this publication, to the maximum extent permitted by law. No representation or warranty is made or given as to the currency, accuracy, reliability, merchantability, fitness for any purpose or completeness of this publication or any information which may appear on any linked websites, or in other linked information sources, and all such representations and warranties are excluded to the extent permitted by law.

This publication is not legal or professional advice. Persons rely upon this publication entirely at their own risk and must take responsibility for assessing the relevance and accuracy of the information in relation to their particular circumstances.

Version history

Original

Publish date: 2016

Print version: 1.0

This version

Publish date: Dec 2020

Print version: 2.0

Details of amendments: Update to align with NCC 2019

Preface

The Inter-Government Agreement (IGA) that governs the ABCB places a strong emphasis on reducing reliance on regulation, including consideration of non-regulatory alternatives such as non-mandatory guidelines, handbooks and protocols.

This handbook is one of a series produced by the ABCB and developed in response to comments and concerns expressed by government, industry and the community that relate to the built environment. Handbooks expand on areas of existing regulation or relate to topics that have, for a variety of reasons, been deemed inappropriate for regulation. They provide non-mandatory advice and guidance.

The Structural Robustness Handbook has been developed to foster an improved understanding of this issue. This handbook addresses the issues in generic terms. It is expected that this handbook will be used to develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

Contents

| | |
|--|-----------|
| 1 Background | 1 |
| 1.1 Scope | 1 |
| 1.2 Design and approval of Performance Solutions..... | 1 |
| 1.3 Using this document | 2 |
| 2 Structural robustness | 3 |
| 2.1 Background to structural robustness | 3 |
| 2.1.1 Characteristics of structural robustness..... | 4 |
| 2.1.2 Identifying structural robustness problems | 5 |
| 2.1.3 Codes and standards..... | 5 |
| 2.2 Current relevant international approaches..... | 6 |
| 2.2.1 Eurocode 1 | 6 |
| 2.2.2 ASCE/SEI 7-05..... | 6 |
| 2.3 Design guidance..... | 7 |
| 2.3.1 Provision for minimum requirements | 7 |
| 2.3.2 Provision of horizontal and vertical ties..... | 7 |
| 2.3.3 Notional horizontal loads | 7 |
| 2.3.4 Notional removal of structural elements..... | 7 |
| 2.3.5 Provision for critical elements | 8 |
| 2.3.6 Selection of appropriate structural form..... | 8 |
| 3 NCC Structural robustness requirements | 9 |
| 3.1.1 Hierarchy of performance | 9 |
| 3.2 Performance Requirements..... | 10 |
| 3.3 Compliance solutions..... | 11 |
| 3.3.1 Performance Solution - Verification Method | 12 |
| 3.3.2 DTS Solution | 13 |
| 4 Examples | 15 |
| 5 Further reading | 20 |

| | |
|---|-----------|
| Appendix A Compliance with the NCC | 22 |
| A.1 Responsibilities for regulation of building and plumbing in Australia | 22 |
| A.2 Demonstrating compliance with the NCC | 22 |
| Appendix B Acronyms, notation and units | 25 |
| B.1 Notation and units | 25 |
| Appendix C Definition of terms | 26 |
| C.1 Other terms of interest | 26 |

REMINDER

This Handbook is not mandatory or regulatory in nature and compliance with it will not necessarily discharge a user's legal obligations. The Handbook should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The Handbook also needs to be read in conjunction with the relevant legislation of the appropriate State or Territory. It is written in generic terms and it is not intended that the content of the Handbook counteract or conflict with the legislative requirements, any references in legal documents, any handbooks issued by the Administration or any directives by the appropriate authority.

1 Background

The NCC is a performance-based code containing all Performance Requirements for the construction of buildings. A building, plumbing or drainage solution will comply with the NCC if it satisfies the Performance Requirements, which are the mandatory requirements of the NCC. To comply with the NCC, a solution must achieve compliance with the Governing Requirements and the Performance Requirements. The Governing Requirements contain requirements about how the Performance Requirements must be met.

This document was developed to provide guidance to practitioners seeking to demonstrate compliance with the structural robustness requirements of the NCC.

1.1 Scope

The handbook is focused on the Australian regulatory aspects of structural robustness. It provides support in understanding the structural robustness requirements of the NCC, specifically the relevant Performance Requirements and Verification Methods in Volumes One and Two.

1.2 Design and approval of Performance Solutions

The design and approval processes for structural robustness solutions is expected to be similar to that adopted for demonstrating compliance of other NCC Performance Solutions. Since the design approval process for Performance Solutions varies between the responsible State and Territory governments it is likely to also be the case with structural robustness and requirements should be checked for the relevant jurisdiction.

Notwithstanding the quantified input and acceptance criteria, other qualitative aspects of structural robustness, which are discussed in this document, require assessment and analysis throughout the design and approval process. The advice of an appropriately qualified person should be sought to undertake this assessment and analysis where required, and may be aided by the early and significant involvement from regulatory authorities, peer reviewer(s) and / or a technical panel as appropriate to the State or Territory jurisdictions.

1.3 Using this document

Defined terms are used in this handbook. They may align with a defined term in the NCC or be defined for the purpose of this document. See Appendix C for further information.

Further reading on this topic can be found with the references located in the body of this handbook.

Different styles are used in this document. Examples of these styles are provided below:

NCC extracts

Examples

Alerts

Reminders

2 Structural robustness

Structures are designed to withstand a number of frequently occurring actions and a number of extreme, but expected, events. During construction and over their life, structures are also exposed to a number of unexpected events. While structures are generally not specifically designed for these events, it is expected that they can withstand these accidental actions without being damaged to an extent disproportionate to the original cause. This is generally known as structural robustness or prevention of the progressive and/or disproportionate collapse.

The importance of structural robustness in structural design is universally acknowledged. Almost all structural regulations and codes of practice include structural robustness as one of the fundamental requirements. However, with the exception of United Kingdom (and now Australia), the requirements are generally qualitative and do not provide clear guidance on how to design and demonstrate compliance.

The difficulties in dealing with this issue are:

- (i) accidental actions are not quantified
- (ii) the acceptable extent of damage is not defined.

2.1 Background to structural robustness

The public has a general expectation that structures are safe. It is expected that structures should be able to resist high frequency events. However, this expectation is lower for extreme and rarely occurring events. Some events can be easily defined and designed for such as self-weight, imposed actions, wind, snow and earthquake. However, structures can also be subjected to accidental actions (such as explosions, impacts, etc.) that are difficult to define. Structural robustness is the means to protect structures against these unforeseen actions and that, regardless of how they are designed, the damage (if any) should be proportional to the magnitude of the accidental loading.

Most structures have some degree of built-in structural robustness as horizontal resistance is provided for wind and earthquake actions. Older structural codes also

have empirical rules to prevent members and connections becoming too fragile, such as limiting slenderness ratios for members and minimum numbers of fasteners for connections. However, these empirical rules have been gradually removed from design standards in the rationalisation process of these documents.

Progressive collapse due to ‘unbuttoning’ is an example of a lack of structural robustness. This usually occurs at multiple fastener connections or larger supporting systems where a number of identical components are used to carry a large load. The failure of one component transfers its load to the next component and causes it to also fail. The process repeats itself resulting in the failure of a number of components or total failure of the structure.

2.1.1 Characteristics of structural robustness

The expected characteristics of structural robustness include:

- (a) Ability to resist lateral loading at all stages of construction and throughout the life of the structure.
- (b) Ability to absorb impacts due to accidental loading.
- (c) Ability to tolerate inaccuracies/uncertainties in the design and construction process as well as building movements.
- (d) Ability for the structure to redistribute loads safely.

The following structural characteristics have major roles in contributing to structural robustness:

- Ductility: Ability to carry load while undergoing large deformation.
- Stability: Ability to resist whole body movements such as sliding and overturning.
- Buckling: Sudden inability to carry compression loading.
- Load paths: Ways the forces are transferred from one element to another until they reach ground-anchoring points.
- Redundancy: Availability of multiple load paths.
- Impact resistance: Ability to absorb energy released by sudden impacts.
- Joint strength: Ability of the connection to transfer the forces from one structural member to another.

Design Alert:

Fire is an important accidental loading case and its effects on structural robustness should be examined because certain load carrying elements may become ineffective in the event of a fire. The effects of the fire protection system on structural robustness are also worth examining. However, these problems are outside the scope of this handbook and are specifically covered by Performance Requirement CP1.

2.1.2 Identifying structural robustness problems

Problems with structural robustness often occur in relation to:

- (a) Partially built structures or unusual situations such as structures within structures (where the need for lateral restraints is often ignored).
- (b) Uplift or another form of instability when the restrained forces are finely balanced with the destabilising actions.
- (c) Difficulties in connecting different materials such as timber roof trusses on top of concrete walls.
- (d) Over reliance on a single element to carry a large portion of a structure, such as transfer beams that support a number of columns and/or other beams.
- (e) Long span beams and cantilevers that are prone to instability without adequate lateral restraints.
- (f) Flexible structures that are prone to large deformation.

From the above, it is apparent that structural robustness is a performance attribute relating to, but not the same as, strength and resilience. Strength is the ability of a structure to resist a specified action, and is often computable. Resilience is the ability of a structure or a group of structures to resist and recover from damaging extreme events.

2.1.3 Codes and standards

While structural robustness is a common notion in building codes and standards, its definition does vary.

ISO2394 (1986) and Eurocode 1 (1994) define 'robustness' as the ability of a structure *'not to be damaged by events like fire, explosions, impact or the consequence of human error, to an extent disproportionate to the original cause'*.

ASCE (2006) refers to 'structural integrity' meaning *'to sustain local damage with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage'*.

BCA (2006) used the terms *'prevention of progressive collapse'* while NCC (2012) adopted a similar form of wording to the ASCE statement. Neither offered any direct Deemed-to-Satisfy (DTS) Solutions, beyond the notional allowances within design standards, or verification procedures.

2.2 Current relevant international approaches

This section identifies some general guidance available from two international documents. Neither of these documents are NCC referenced documents.

2.2.1 Eurocode 1

The European Committee of Standardisation's Eurocode 1 (EN1990) focuses on accidental actions and provides guidance on the following:

- avoiding, eliminating or reducing the hazard
- selecting structural form with low sensitivity to the hazard
- selecting a design that can survive the accidental removal of an individual element
- avoiding structural systems which may collapse without warning
- tying the structure together.

2.2.2 ASCE/SEI 7-05

American Society of Civil Engineers' ASCE/SEI 7-05 focuses on local damage and prevention of progressive collapse by providing:

- continuity
- redundancy
- energy dissipating capacity (ductility).

2.3 Design guidance

This section discusses some available design techniques for designing robust structures.

2.3.1 Provision for minimum requirements

This technique is often used in traditional design standards. Minimum requirements are introduced to maintain a certain level of structural robustness. For example for members, there are limitations on slenderness and for connections there are a minimum number of fasteners, etc. These requirements are empirical and typically based on experience. However, modern design standards tend to avoid them and use qualitative performance requirements in their place.

2.3.2 Provision of horizontal and vertical ties

Inclusion of ties is an obvious way to prevent structures from “falling” apart. Examples of structural ties are roof tie downs for wind uplift or ring beams on top of unreinforced masonry walls to keep the walls together under earthquake action. Effective anchorage of floors to roofs and walls could also be considered as a form of tie. One important consideration in the provision of ties is to ensure there are sufficient load paths for the actions to be transmitted to the ground. Ties are also useful in allowing catenary and vierendeel actions to develop under extreme situation, therefore preventing total collapse.

2.3.3 Notional horizontal loads

This requires all structures to have some horizontal load capacity regardless of how they are designed. Most structures have this built-in, as they have already been designed for lateral wind and earthquake forces.

2.3.4 Notional removal of structural elements

This is the only method that allows some form of assessment of structural robustness to be made. Members of a structural system are hypothetically removed and the consequential damage assessed. Solutions are then developed to limit the amount of acceptable damage.

It is not always necessary to do complicated structural analysis, as a qualitative application of 'what if' scenarios often provides valuable insights into the issues involved.

2.3.5 Provision for critical elements

Critical elements are structural elements whose failure will result in the collapse of the structure. When this situation is unavoidable, the element should either be protected from accidental actions or be designed for a nominated accidental load which is estimated to be strong enough for a range of theoretical accidental actions.

2.3.6 Selection of appropriate structural form

A more sophisticated technique of ensuring structural robustness is the selection of the structural form. Some structural forms provide more redundancy than others and this could help in limiting the damage since alternative loading paths might be able to contribute to the load carrying capacity once the designed loading path fails.

However, this is not always possible due to other design requirements.

3 NCC Structural robustness requirements

The structural robustness requirements in the NCC include the Performance Requirements **BP1.1(a)(iii)** of Volume One and **P2.1.1(a)(iii)** of Volume Two, introduced in NCC 2012. Verification Methods for these Performance Requirements, **BV2** of Volume One and **V2.1.2** of Volume Two, were introduced in NCC 2016.

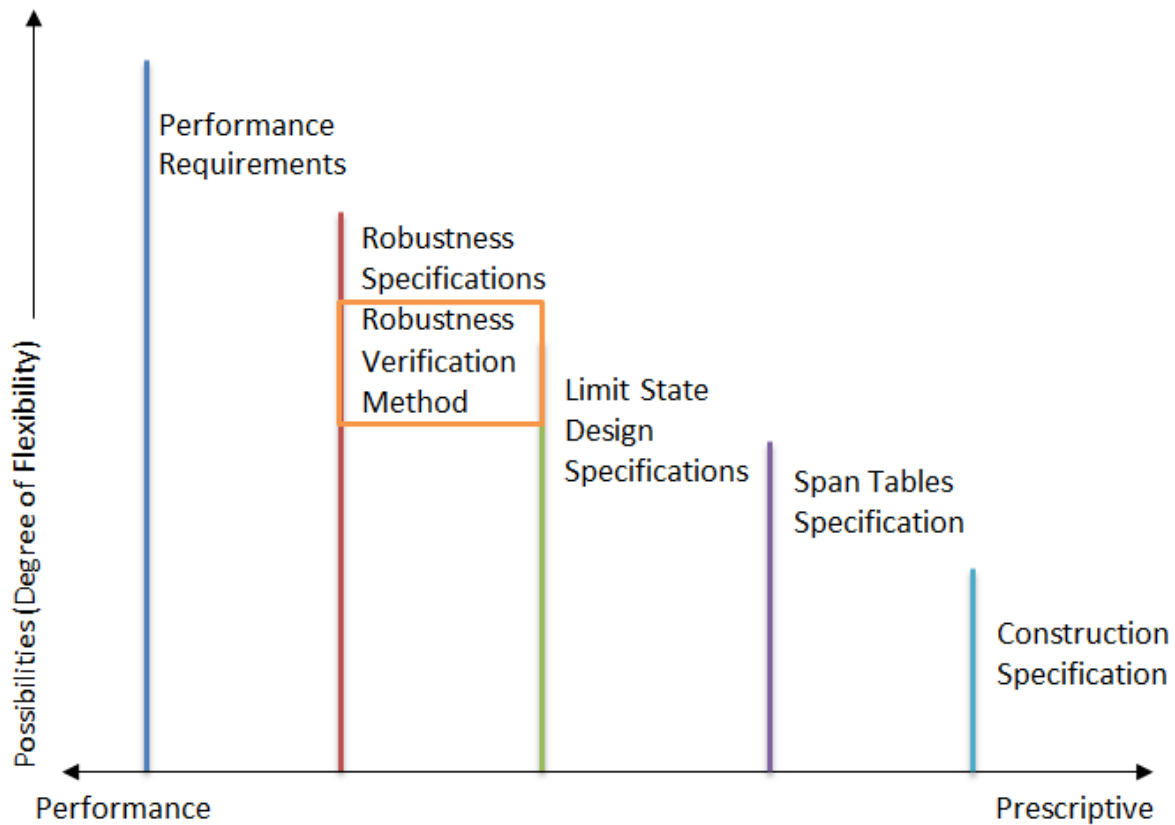
BP1.1 is supported by a comprehensive list of documents in the DTS Provisions, while **P2.1.1 (a), (b)** and **(c)** have supporting DTS Provisions through Acceptable Construction Manuals, and Acceptable Construction Practices. These manuals and documents cover most aspects of the limit state design method for most construction materials. However, if designers wish to or have to operate outside DTS Provisions, they must develop a Performance Solution. **BV2** and **V2.1.2** are designed to support those who wish to follow the Performance Solution path.

3.1.1 Hierarchy of performance

There are various levels of performance specification, from prescriptive, which involves detailed descriptions of how the process should be completed, to pure performance, which allows a greater degree of flexibility in achieving the same requirements or objectives. Figure 3.1 describes the relationship of prescriptive and performance-based specifications, including where a Verification Method sits within this relationship.

The structural robustness Verification Method is one way, but not the only way, to demonstrate compliance with the NCC Performance Requirements. This Verification Method is a performance-based process to assess a structure's robustness.

Figure 3.1 Level of performance hierarchy



3.2 Performance Requirements

The NCC contains five structural Performance Requirements. **BP1.1** and **BP1.2** of Volume One and **P2.1.1(a)**, **(b)** and **(c)** of Volume Two address general structural performance.

The Performance Requirements are specifically written to cover strength performance that is the relationship between the actions and the resistance provided by the structure. The actions are described in **BP1.1** and **P2.1.1(a)** and **(b)** whilst the resistance is described in **BP1.2** and **P2.1.1(c)**.

BP1.1 and **P2.1.1(a)** and **(b)** consist of two parts:

1. a list of the required performance attributes; and
2. a list of the factors to be considered, namely the actions to which a building 'may reasonably be subjected'.

The list of performance attributes covers the serviceability performance, strength performance and structural robustness. The concept of structural robustness applies to the chosen structural system of the building.

BP1.2 and **P2.1.1(c)** cover general principles in formulating structural resistance.

The NCC Performance Requirements relevant to structural robustness are **BP1.1(a)(iii)** in NCC Volume One and **P2.1.1(a)(iii)** in NCC Volume Two.

BP1.1(a)(iii) / P2.1.1(a)(iii)

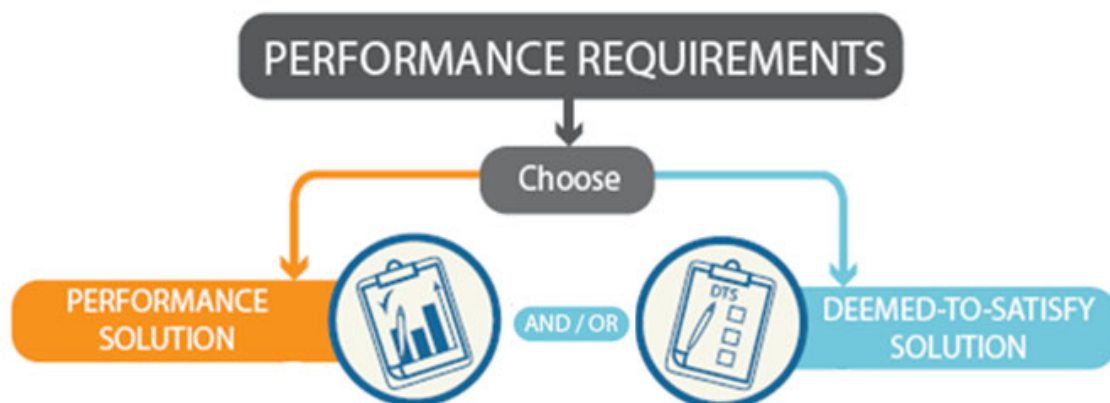
- (a) A building or structure, during construction and use, with appropriate degrees of reliability, must—
- ...
- (iii) be designed to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage;

3.3 Compliance solutions

Compliance solutions are the means of satisfying the Performance Requirements.

The NCC provides different options for compliance being: a Performance Solution, a DTS Solution or a combination of these. This is shown in Figure 3.2.

Figure 3.2 Performance-based compliance framework



There are two possible compliance solutions contained within the NCC. These are described in the following sections.

3.3.1 Performance Solution - Verification Method

In order to meet the structural robustness requirements of the Performance Requirements through the Verification Methods, **BV2** and **V2.1.2**, a structure is required to demonstrate that it is sufficiently robust against accidental actions. The Verification Method is identical in both Volumes. The NCC extract below shows this Verification Method.

BV2 Structural robustness

Compliance with **BP1.1(a)(iii)** is verified for structural robustness by—

- (a) assessment of the structure such that upon the notional removal in isolation of—
 - (i) any supporting column; or
 - (ii) any beam supporting one or more columns; or
 - (iii) any segment of a load bearing wall of length equal to the height of the wall,
 the building remains stable and the resulting collapse does not extend further than the immediately adjacent *storeys*; and
- (b) demonstrating that if a supporting structural component is relied upon to carry more than 25% of the total structure, a systematic risk assessment of the building is undertaken and critical high risk components are identified and designed to cope with the identified hazard or protective measures chosen to minimise the risk.

The first part of the Verification Method, **BV2(a)** and **V2.1.2(a)**, provides acceptance criterion for the conceptual analysis of notional removal. This is the same as that adopted in UK regulation. **BV2(b)** and **V2.1.2(b)** provides some guidance on the approach which should be undertaken for critical structural elements (those which carry greater than 25% of the total structural load).

This risk approach can also be used if compliance with the DTS Provisions or Verification Method cannot be achieved. It can be used to identify the high risk critical components and appropriate design measures to mitigate the risk (see Section 2.3) or to minimise the risk with protective means.

While the Verification Method is generally applicable to all buildings, it is expected that it will be used only for buildings of high importance, when the risk of

disproportionate collapse is high or when a DTS Solution is not applicable (e.g. for new materials).

Two examples of when the Verification Method may be used are provided in Section 4.

Reminder:

The Verification Method is one way, but not the only way, to demonstrate compliance with the NCC Performance Requirements. Part A2 of NCC Volume One and Two detail all possible Assessment Methods available to develop a compliance solution.

3.3.2 DTS Solution

For designs with conventional materials and methods, corresponding NCC referenced documents already have built-in structural robustness provisions. Some examples are listed below.

Structural design actions AS/NZS 1170.0

Section 6 of AS/NZS 1170.0 is about structural robustness. The main requirements are:

- providing load paths to foundation (general)
- vertical and horizontal ties (general)
- design for notional horizontal forces (specific).

The specific notional horizontal forces specified in AS/NZS 1170.0 are:

- the structure as a whole: 1% -1.5% of long-term gravity loads ($G + \Psi_c Q$)
- connections and ties: 5% of long-term gravity loads ($G + \Psi_c Q$)
- walls: 5% of permanent load (G) acting laterally.

Steel structures AS 4100

Robustness is not specifically mentioned, but the following clauses are relevant:

- Notional horizontal forces are nominated for multistorey structures, which is equal to 0.002 (0.2%) of total design vertical loads at floor level (Clause 3.2.4).
- Minimum design actions on connections are specified (Clause 9.1.4).

Concrete structures AS 3600

Robustness is not specifically mentioned, but the following clauses are relevant:

- Notional horizontal forces are nominated for walls: 2.5% of total vertical load but not less than 2 kN per metre length of wall (Clause 11.3).
- Limit on slenderness of columns (Clause 10.5.1).

Timber structures AS 1720.1

Robustness is not specifically mentioned, but the following clause is relevant:

- Extra strength is required for 'primary structural elements' (i.e. members and joints whose failure could result in the collapse of a structure) (Table 2.1 & 2.2 of Clause 2.3 – capacity factors).

Masonry structures AS 3700

Robustness is specifically mentioned in Clause 4.6, and the following requirements are specified:

- Nominated lateral pressure of 0.5 kPa for walls (Clause 4.6.2).
- Limiting ratio (Height/Thickness) for isolated piers (Clause 4.6.3).
- For members providing lateral support (Clause 2.6.3): the greater of:
 - 2.5% of vertical load on masonry members; or
 - 0.5 kPa lateral pressure on the appropriate tributary area.
- For connections to lateral supports (Clause 2.6.4): 1.25 times the horizontal design load.

All the above documents are NCC referenced documents.

4 Examples

This section provides examples illustrating basic elements of the structural robustness Verification Methods, **BV2** and **V2.1.2**.

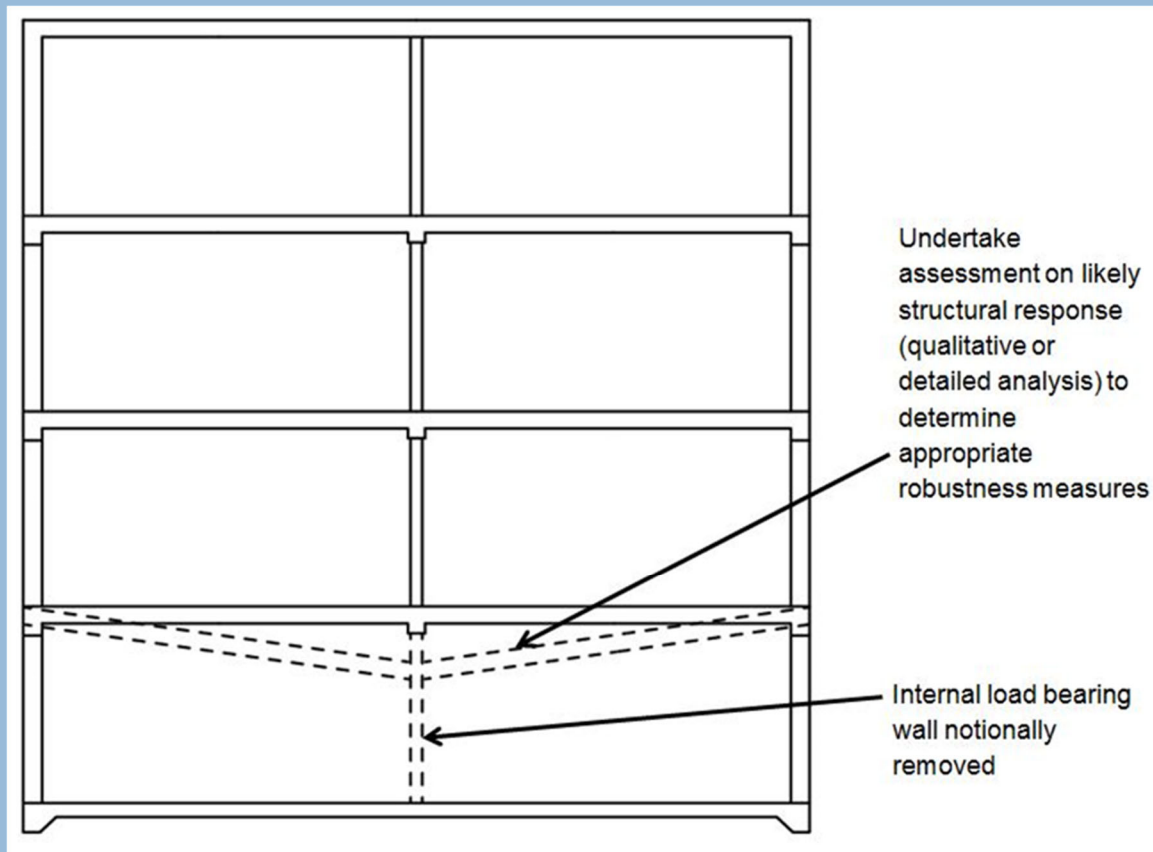
Robustness issues vary with the materials and methods of construction. For examples of how to design for structural robustness, readers are referred to the documents listed in the Bibliography from which the following two examples are selected to demonstrate the basic elements of the Verification Method:

1. notional removal of a load carrying member; and
2. systematic risk assessment.

Example 1: Notional removal of a load bearing wall

Consider the building in Figure 4.1 below. It has external and internal walls supporting continuous concrete slab. The structural robustness of the system is examined by removing the internal wall of the bottom floor.

Figure 4.1 Example 1 building (section view)



Step 1: Assess the required strength of the slabs with all the walls in place.

The slabs are continuous over the internal supports and should have the capacity to support the gravity loads on the floors. The slabs are not required to support the weights of the internal walls, as they are stacked up the height of the building.

Step 2: Examine the consequences of removing the internal wall at the bottom floor.

Total collapse of all floors is possible since the slabs are not designed to support the weights of the walls and floors above.

Step 3: Find way to limit the extent of damage.

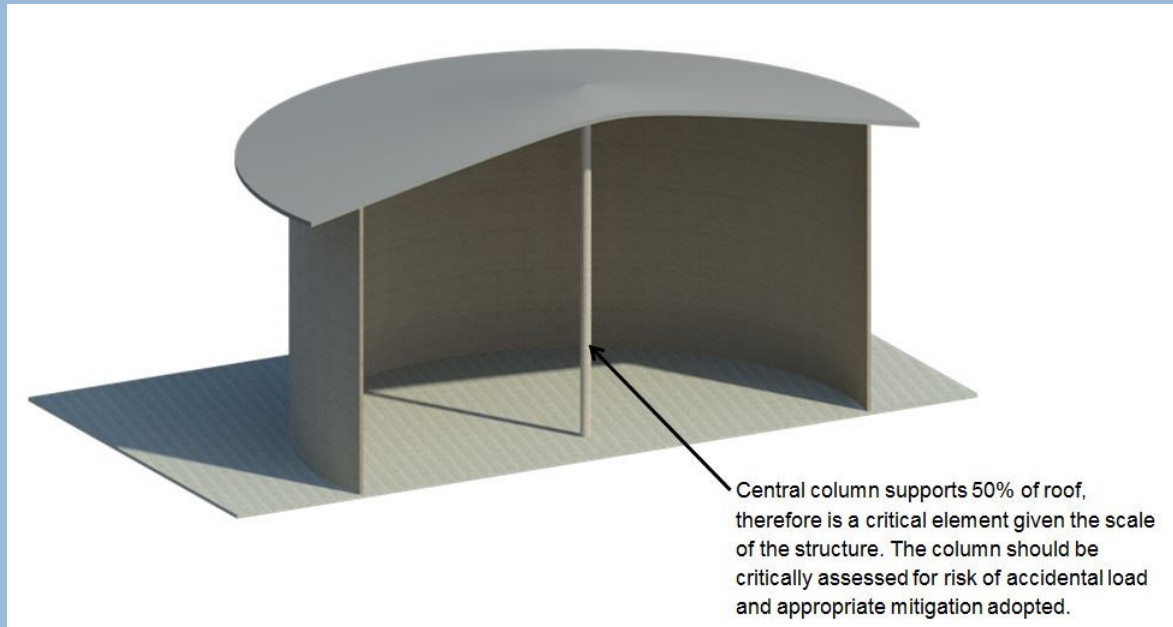
Design all the slabs to carry the weight of a single storey wall, i.e. supported on the external walls only.

Outcome: If Step 3 is followed, there is a good chance that the resulting damage will be limited to the floor above the removed wall. The solution is therefore conformed to the structural robustness requirement.

Example 2: Systematic risk assessment

Consider the roof of an 80 m diameter circular building with a central supporting column in Figure 4.2 below.

Figure 4.2 Circular building with central supporting column



Step 1: Examine the required load carrying capacity of the central column.

The central column will be required to carry 50% of the roof weight.

Step 2: Examine the consequences of removing the central column.

Total collapse of the roof would occur, as there is no alternative path for the roof weight.

Step 3: Both of the above steps have shown the structure does not conform to structural robustness requirements part (a) of the *Verification Method* and the only option is to carry out a systematic risk assessment (part (b) of the *Verification Method*) to reduce the risk of any accident that might affect the load capacity of the central column.

Step 4: Examine the likelihood of accidents.

The most likely accident for a building is vehicle impact action at floor level. There are many ways to reduce this likelihood and consequence that will need examination to find the most suitable solutions. For example:

1. change the design to eliminate the need for a central column (e.g. from flat roof to conical roof)
2. provide protective measure against vehicular impact to the central column (e.g. a concrete barrier around the central column that can absorb the impact of a vehicle crashing into it).

Outcome: Either of the solutions in Step 4 can be considered to comply with the structural robustness requirements.

5 Further reading

The following reference documents are recommended if further information is required on this topic.

- The Institution of Structural Engineers 'Practical guide to structural robustness and disproportionate collapse in buildings' October 2010.
- F. Knoll and T. Vogel 'Design for Robustness' IABSE 2009.
- Canisius, T.D.G. (Editor) 'COST TU0601 –Structural Robustness Design for Practising Engineers' September 2011.
- Forest and Wood Products Australia (FWPA) 'Robustness in Structures' (2016).

APPENDICES



Appendix A Compliance with the NCC

A.1 Responsibilities for regulation of building and plumbing in Australia

Under the Australian Constitution, State and Territory governments are responsible for regulation of building, plumbing and development / planning in their respective State or Territory.

The NCC is an initiative of the Council of Australian Governments and is produced and maintained by the ABCB on behalf of the Australian Government and each State and Territory government. The NCC provides a uniform set of technical provisions for the design and construction of buildings and other structures, and plumbing and drainage systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The NCC is given legal effect by building and plumbing regulatory legislation in each State and Territory. This legislation consists of an Act of Parliament and subordinate legislation (e.g. Building Regulations) which empowers the regulation of certain aspects of buildings and structures, and contains the administrative provisions necessary to give effect to the legislation.

Each State's and Territory's legislation adopts the NCC subject to the variation or deletion of some of its provisions, or the addition of extra provisions. These variations, deletions and additions are generally signposted within the relevant section of the NCC, and located within appendices to the NCC. Notwithstanding this, any provision of the NCC may be overridden by, or subject to, State or Territory legislation. The NCC must therefore be read in conjunction with that legislation.

A.2 Demonstrating compliance with the NCC

Compliance with the NCC is achieved by complying with the Governing Requirements of the NCC and relevant Performance Requirements.

The Governing Requirements are a set of governing rules outlining how the NCC must be used and the process that must be followed.

The Performance Requirements prescribe the minimum necessary requirements for buildings, building elements, and plumbing and drainage systems. They must be met to demonstrate compliance with the NCC.

Three options are available to demonstrate compliance with the Performance Requirements:

- a Performance Solution,
- a DTS Solution, or
- a combination of a Performance Solution and a DTS Solution.

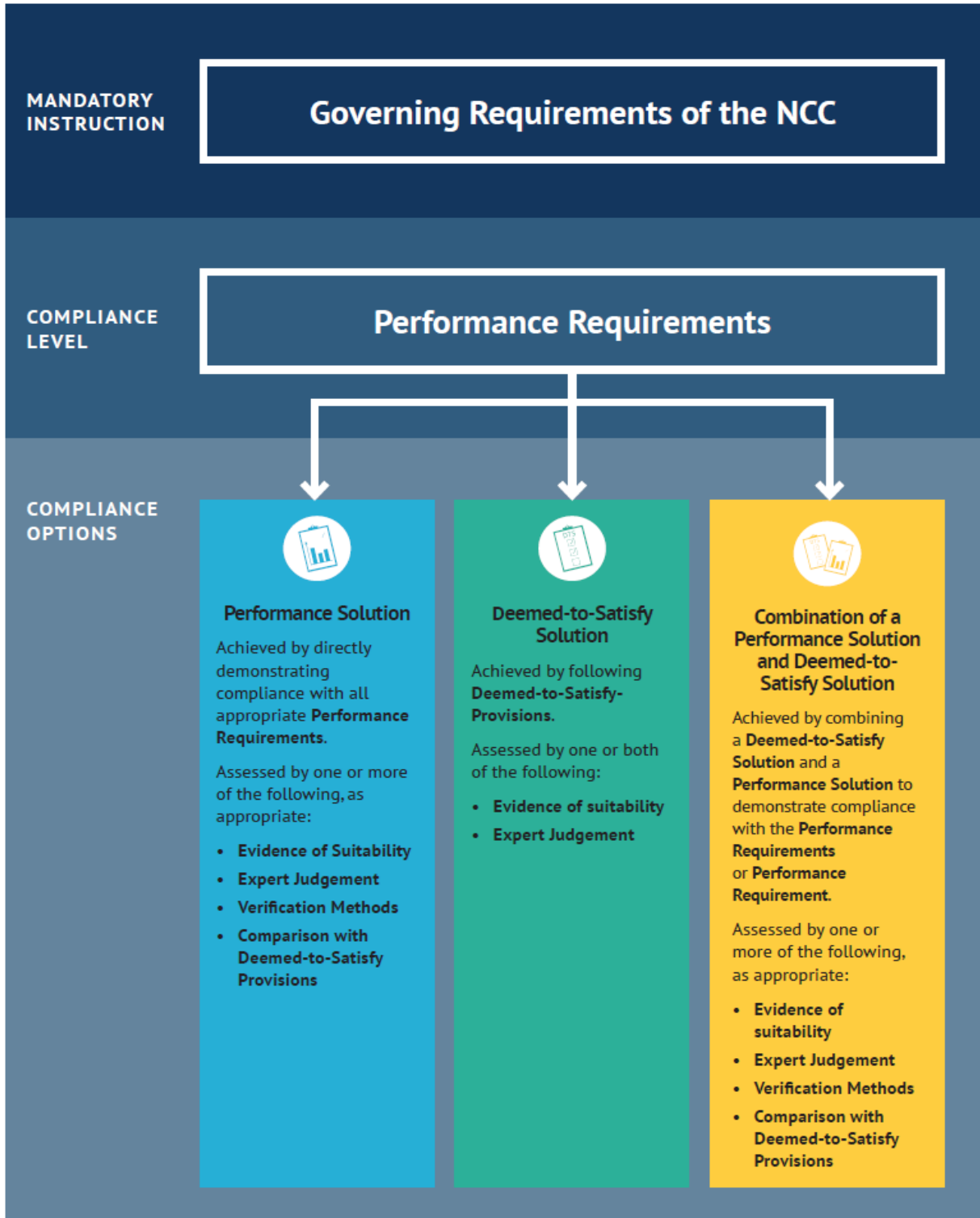
All compliance options must be assessed using one or a combination of the following Assessment Methods, as appropriate:

- Evidence of Suitability
- Expert Judgement
- Verification Methods
- Comparison with DTS Provisions.

A figure showing hierarchy of the NCC and its compliance options is provided in Figure A.1. It should be read in conjunction with the NCC.

To access the NCC or for further general information regarding demonstrating compliance with the NCC visit the ABCB website (abcb.gov.au).

Figure A.1 Demonstrating compliance with the NCC



Appendix B Acronyms, notation and units

The following table, Table B.1 contains acronyms used in this document.

Table B.1 Acronyms

| Acronym | Meaning |
|---------|---------------------------------|
| ABCB | Australian Building Codes Board |
| BCA | Building Code of Australia |
| DTS | Deemed-to-Satisfy |
| NCC | National Construction Code |

B.1 Notation and units

The units and notation used in this handbook are designed specifically for use with the structural robustness Verification Methods. The symbols used are outlined in Table B.2.

Table B.2 Notation and units

| Symbol | Meaning |
|----------|------------------------------|
| G | Permanent action effect |
| kN | kilonewton |
| kPa | kilopascal |
| Q | Live Load action effect |
| Ψ_c | Live Load Combination Factor |

Appendix C Definition of terms

NCC definitions for the terms used in this handbook can be found in Schedule 3 of NCC Volume One, Two and Three. Building Classifications can be found in Part A6 Building classifications of NCC 2019 Volumes One, Two and Three.

Reminder:

Defined terms are amended in the NCC from time to time, so it is important to always refer to the relevant edition for the correct explanation of these terms. States and Territories may also vary or add to the definitions contained in the NCC. These are detailed in the relevant State or Territory appendix.

C.1 Other terms of interest

Accidental action means an unspecified action, usually of short duration, which might occur on a building.

Disproportionate collapse means collapse of a building or structure, which is disproportionate to the initial cause.

Extreme event means an extreme occurrence or change of a particular set of circumstances.

Hazard means potential to cause damage.

Notional removal of element means analytical procedure where supporting structural elements are removed one at a time and the residual building is checked for the extent of resulting damage.

Progressive collapse means sequential spread of damage from an initiating event, from element to element, resulting in the failure of a number of elements.

Risk means the chance of something happening that will have an impact. It is measured in terms of likelihood and consequence.