National Construction Code

Access Verification Methods

Handbook

Australian Building Codes Board

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The Australian Building Codes Board

The Australian Building Codes Board (ABCB) is a standards writing body responsible for the National Construction Code (NCC), WaterMark and CodeMark Certification Schemes.

The ABCB is a joint initiative of all levels of government in Australia, together with the building and plumbing industry. Its mission is to oversee issues relating to health, safety, amenity, accessibility and sustainability in building.

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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 by the ABCB in response to comments and concerns expressed by government, industry and the community related 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 Access Verification Methods Handbook assists in understanding D1V2 and D1V3 of NCC Volume One. It addresses issues in generic terms, and is not a document that sets out specific compliance advice for developing solutions using D1V2 and D1V3. It's expected this handbook guides readers to develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

D1V2 and D1V3 provide performance-based pathways for practitioners to demonstrate a building is compliant with the relevant access Performance Requirements of the NCC using a Verification Method as the Assessment Method.

Contents

Reminder

This handbook is not mandatory or regulatory in nature. 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 NCC and 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. 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. 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.

This document provides guidance to practitioners seeking to demonstrate compliance with the Performance Requirements using the Verification Methods D1V2 and D1V3 for access to and within a building, including ramps used by wheelchairs.

1.1 Scope

This handbook firstly provides an overall introduction to the concept of the Verification Methods followed by further guidance on how to use these Verification Methods.

1.2 Design and approval of Performance Solutions

The design and approval processes for solutions using the Access Verification Methods (D1V2 and D1V3) 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 designs incorporating the Access Verification Methods and requirements should be checked for the relevant jurisdiction.

Notwithstanding the quantified input and acceptance criteria, other qualitative aspects of D1V2 and D1V3, discussed in this handbook, 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. This may be aided by the early and significant involvement from regulatory authorities, peer reviewer(s) and/or a technical panel as appropriate to the relevant jurisdiction.

1.3 Using this document

Acronyms used in this document are provided in Appendix A.

General information about complying with the NCC and responsibilities for building and plumbing regulation is provided in Appendix B of this document.

Additional information about other legislative requirements is provided in Appendix C.

Further reading on accessible features and buildings is also provided in Appendix D.

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

NCC extracts[1]

Examples

Alerts or Reminders

[1] NCC extracts italicise defined terms as per the NCC. See Schedule 1 of the NCC for further information.

2 Complying with Access Performance Requirements

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

The Performance Requirements that may be satisfied using D1V2 (for the purpose of access) are D1P1, D1P2, D1P6, E3P4 and F4P1. For the purposes of ramps, D1V3 may be used to satisfy D1P2. Note that D1V2 and D1V3 are not the only methods of demonstrating compliance with the Performance Requirements.

Alert

Other Performance Requirements not covered by D1V2 and D1V3 may need to be considered in order to comply with NCC Volume One A2G2(3) and A2G4(3). It is necessary to understand the inter-relationships between other requirements and the relevant requirements within D1V2 and D1V3 to ensure no design conflicts arise.

2.1 NCC Compliance pathways

Compliance with the NCC is achieved by complying with the NCC Governing Requirements and relevant Performance Requirements. There are 3 options available to demonstrate compliance with the Performance Requirements:

- a Performance Solution
- a Deemed-to-Satisfy (DTS) Solution, or
- a combination of a Performance Solution and a DTS Solution.

Within the Performance Solution pathway, some options available are:

(1) Direct application of the Performance Requirements, and

(2) Verification Methods.

Table 2.1 outlines where these options can be used to show compliance with Performance Requirements D1P1, D1P2, D1P6, E3P4 and F4P1.

Table 2.1 Options for demonstrating compliance

Performance Requirement	Direct application of Performance Requirements (Performance Solution)	D1V2 (Performance Solution)	D1V3 (Performance Solution)	DTS Provisions (DTS Solution)
D1P1	Y	Y	N	Y
D1P2 (General)	Y	Y	N	Y
D1P2 (Ramps)	Y	Y	Y	Y
D1P6	Y	Y	N	Y
E3P4	Y	Y	N	Y
F4P1	Y	Y	N	Y

See Appendix B for further information on demonstrating compliance with the NCC.

2.2 Access Performance Requirements

The Performance Requirements related to D1V2 and D1V3 are reproduced below.

D1P1 Access for people with a disability

Access must be provided, to the degree necessary, to enable—

(a) people to—

(i) approach the building from the road boundary and from any accessible carparking spaces associated with the building; and

(ii) approach the building from any *accessible* associated building; and

(iii) access work and public spaces, accommodation and facilities for personal hygiene; and

(b) identification of *accessways* at appropriate locations which are easy to find.

Limitations

D1P1 does not apply to a Class 4 part of a building.

D1P2 Safe movement to and within a building

So that people can move safely to and within a building, it must have—

- (a) walking surfaces with safe gradients; and
- (b) any doors installed to avoid the risk of occupants—
  - (i) having their egress impeded; or
  - (ii) being trapped in the building; and
- (c) any stairways and ramps with—
  - (i) slip-resistant walking surfaces on—
    - (A) ramps; and
    - (B) stairway treads or near the edge of the nosing; and
  - (ii) suitable handrails where necessary to assist and provide stability to people using the stairway or ramp; and
  - (iii) suitable landings to avoid undue fatigue; and
  - (iv) landings where a door opens from or onto the stairway or ramp so that the door does not create an obstruction; and
  - (v) in the case of a stairway, suitable safe passage in relation to the nature, volume and frequency of likely usage.

D1P6 Paths of travel to exits

So that occupants can safely evacuate the building, paths of travel to *exits* must have dimensions appropriate to-

- (a) the number, mobility and other *characteristics* of occupants; and
- (b) the function or use of the building.

Limitations

D1P6 does not apply to the internal parts of a *sole-occupancy* unit in a Class 2 or 3 building or Class 4 part of a building.

E3P4 Lift access for people with a disability

When a passenger list is provided in a building *required* to be *accessible*, it must be suitable for use by people with a disability.

F4P1 Personal hygiene facilities

Suitable sanitary facilities for personal hygiene must be provided in a convenient location within or associated with a building, to the degree necessary, appropriate to–

(a) the function or use of the building; and

(b) the number and gender of the occupants; and

(c) the disability or other particular needs of the occupants.

3 Development of Access Performance Solutions

This section outlines the process of developing a Performance Solution using the Verification Methods D1V2 and D1V3.

3.1 Performance-based design brief (PBDB)

A PBDB is a documented process that defines the scope of work for the access Performance Solution. Its purpose is to set down the basis on which analysis of the proposed building and its Performance Solution will be undertaken, as agreed by the relevant stakeholders.

A PBDB allows all relevant stakeholders to be involved in the development of a Performance Solution, and to share their specific knowledge and perspectives with the design team.

When developing a Performance Solution, a PBDB should be undertaken involving all relevant stakeholders to the building design.

Relevant stakeholders vary from design to design. Often relevant stakeholders include: the access consultant, architect, developer, client, engineers and the building surveyor/certifier. Note that some state legislation prevents the building surveyor/certifier from being involved in the design process. If this is not the case, care is required to ensure they are not involved in design decisions that they will be certifying; as this would constitute a conflict of interest.

Alert

Building surveyor and building certifier are used synonymously throughout the country depending on the jurisdiction you are located in.

Relevant stakeholders can be determined by conducting a simple analysis as to who should be involved in the PBDB process. This analysis should identify stakeholders with a high interest in the design process.

While full agreement on all aspects of the PBDB is the preferred outcome, it is acknowledged that in some instances this may not be possible. If full agreement cannot be achieved through the PBDB process, dissenting views should be appropriately recorded so that it can be considered by the appropriate authority when determining compliance and as part of the approvals process.

3.2 Access design strategy

The PBDB should cover the access design strategy for the building, outlining the features that will be incorporated into the building to achieve the required outcome.

For example, the designer of a low-rise art gallery (Class 9b) may choose to investigate alternative options for providing ramps in their building that may not necessarily comply with the DTS Provisions. The strategy to accomplish this may be to incline some of the floors and demonstrate that the proposed solution provides equivalent safety and amenity when compared to a compliant DTS Solution. To further optimise the design, the strategy may aim to optimise the accessibility of the locations of amenities, entrances and accessible sanitary facilities.

3.3 Final report

Once the analysis is complete, a final report should be prepared that includes:

- all relevant Performance Requirements and/or DTS Provisions
- identification of all Assessment Methods
- information from the agreed PBDB
- details of the analysis undertaken and associated results
- details of conditions or limitations (if any) regarding the Performance Solution, and
- confirmation the building complies with the Performance Requirements.

Further details on preparing a final report for access Performance Solutions are provided in Section 6.

For guidance on the process for developing NCC Performance Solutions across all NCC volumes refer to the Performance Solution Process Handbook, which is available from the ABCB website.

3.4 Practitioner conduct

When preparing a Performance Solution, practitioners should exercise their duties in an appropriate manner. Key principles include:

(1) Acting in the public interest

In undertaking their duties, a practitioner should exercise their discretionary powers in ways that safeguard the public interest. A practitioner's consideration of the interests of their clients and employers must not be contrary to the public interest.

(2) Independence

In performing their professional duties, a building surveyor/certifier should be objective, impartial and conduct themselves in accordance with the relevant requirements of state and territory legislation. Other practitioners should ensure any conflicts of interest are disclosed to all relevant parties.

(3) Competence

A practitioner should not undertake professional work that they are not competent to perform. See Section 3.5 for further details of the peer review process.

3.5 Peer review

The appointment of a peer reviewer should be considered at the PBDB stage where a building and its Performance Solution are complex. This includes those that have innovative designs, or challenging aspects of modelling or analysis which fall outside the competence and expertise of the building surveyor/certifier.

The peer reviewer should have suitable qualifications and experience which give them a level of competence in order to evaluate the Performance Solution proposed.

The peer review is potentially the most complex kind of review both technically and ethically. The peer review should consider:

- whether the completed work has met its objectives
- other options that could have been included in the preliminary design
- whether the evaluation of options is rigorous and fair
- the validity of the assumptions
- the validity of the conclusions
- the process for completion of the construction work
- the validity of the recommendations
- the objectives set out for the work
- adherence to relevant regulations and codes of practice
- the fitness-for-purpose of the work.

The peer review may also consider elements of the design process, such as resources, value engineering, concept design, risk reviews and design methodology. Allowing a peer reviewer to have input into the scope of the work, the design process, project planning and the completed work review can lead to a better outcome for the project.

While the work is in progress, the peer reviewer can review inputs at specified points to aid the design process and avoid problems such as poor evaluation of options and incorrect assumptions.

4 D1V2 Access to and within a building

4.1 Overview

Verification Method D1V2 provides a structure that designers may use to complete a Performance Solution that demonstrates compliance with Performance Requirements D1P1, D1P2, D1P6, E3P4 and/or F4P1.

Access solutions are multi-faceted and dependent on the needs of the user groups of the building. This may vary markedly from case to case. D1V2 is therefore flexible and enables consideration of solutions to meet occupant needs. D1V2 allows the minimum acceptable criteria based on the unique characteristics of a building and its occupants to establish whether a building solution provides accessibility equivalent to the minimum requirements of a DTS compliant building.

The basic process of D1V2 is:

(1) Develop a PBDB to determine the metrics (measurable acceptance criteria) that can be used to measure the levels of safety and amenity provided by the Performance Requirements.

(2) Design a reference access solution for the building that meets the DTS Provisions and benchmark the level to which the building performs against the measurable acceptance criteria.

(3) Measure the level to which the proposed access solution performs against the measurable acceptance criteria. If the proposed solution performs equal to or better than the reference solution when as measured by the measurable acceptance criteria, the proposed access solution is verified against the relevant Performance Requirements of the NCC.

4.2 D1V2 Verification Method

D1V2 Access to and within a building

Compliance with D1P1, D1P2, D1P6, E3P4 and/or F4P1, for access, is verified when it is determined that the proposed building provides an equivalent level of access as a reference building when using the following process:

(a) A *performance-based design brief* is completed to define the following:
  (i) The occupant profile and *characteristics* based on the type and use of the building.
  (ii) The appropriate method for determining the level of access.
  (iii) The appropriate modelling method and tool.
  (iv) The measurable acceptance criteria.

(b) Using the appropriate method, the level of access *required* is determined by first modelling a reference building using the relevant *Deemed-to-Satisfy Provisions* of Parts D, E and F and the occupant profile and *characteristics* to determine the—
  (i) needs of the occupants that the reference building addresses; and
  (ii) facilities *required* to be accessed by each occupant profile; and
  (iii) baseline measurable acceptance criteria.

(c) The proposed building and access solution must be modelled using a modelling method and approach consistent with that used for the reference building, and the same critical features including the following:
  (i) Occupant profile and *characteristics*.
  (ii) Building location and orientation.
  (iii) Locations of all entrances and *exits*.
  (iv) Locations of facilities important to the solution, including sanitary facilities, lifts, stairwells, etc.
  (v) The number and range of facilities.

(d) The proposed solution's level of access is assessed by modelling occupant performance using *characteristics*, whereby the proposed building provides for equivalent access appropriate to the needs of each occupant profile.

4.3 Developing the PBDB

A PBDB process (Section 3.1) is critical to determining the overall framework of the D1V2 access solution and defining the inputs and features that must be considered, such as:

- The occupant profile and characteristics based on the type and use of the building.
- The appropriate method for determining the level of access.
- The appropriate modelling method and tool.
- The measurable acceptance criteria.

4.3.1 Occupant profile and characteristics

Relevant occupant characteristics are those which define how an occupant will interact with a building, including but not limited to: occupant movement speeds, turning ability, reach capability, perception of luminance contrast and hearing threshold. The occupant profile is the number and proportions of occupants that are expected to have each characteristic. The profile will be influenced by the classification and function of the building.

The occupant disability groups, and their associated characteristics, may be derived from ABS 4450.0 2016 which is based on the model developed by the Washington Group, World Health Organisation as a means of assembling population disability data. The disability groupings are:

(1) Vision

(2) Hearing

(3) Waling, including stair and ramp traversal

(4) Memory/cognition

(5) Activities of daily living

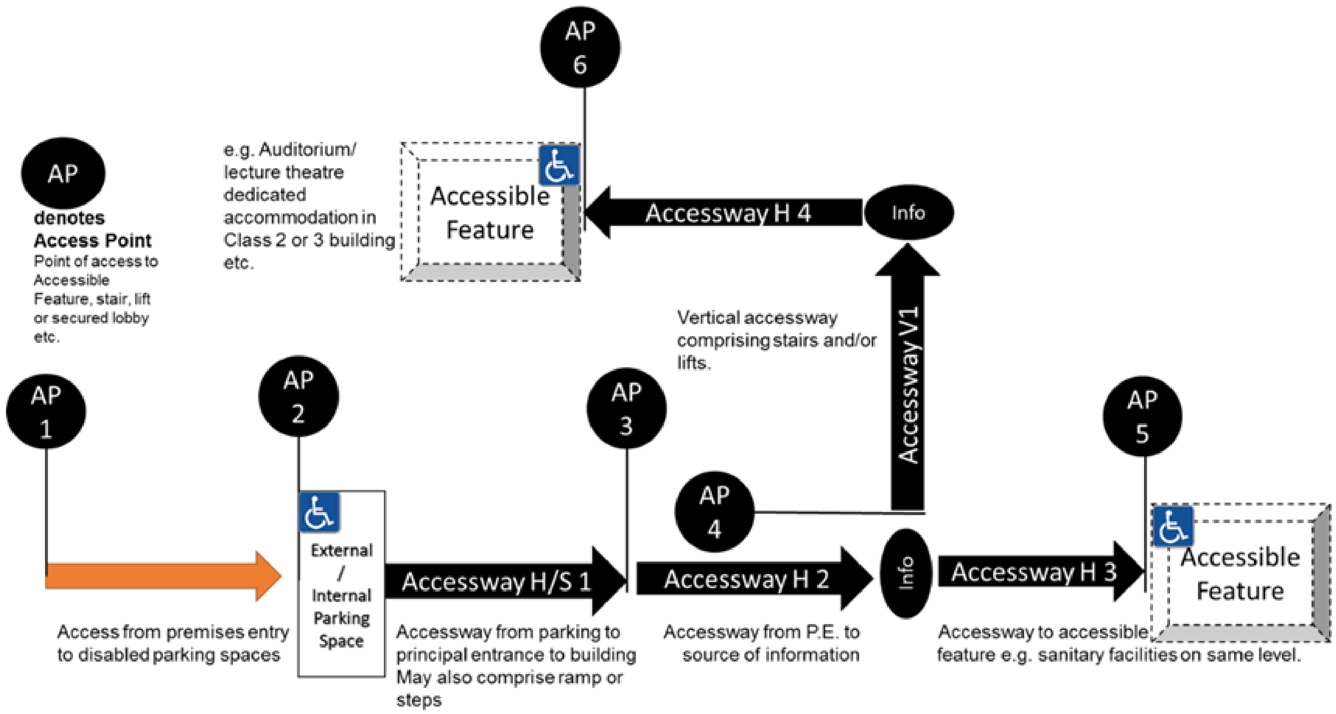
(6) Communication (including understanding).

It is suggested a representative occupant is developed for each of these groupings (also referred to as a persona). When determining the occupant profile, special attention needs to be paid to the impacts of ageing, which typically increases the level of disability. However, the final occupant profile may not include all the groupings mentioned above, depending on the classification and use of the building being assessed.

4.3.2 Method of assessing access

Figure 4.1 reflects diagrammatically a framework that may be used to assess the level of access in a building. The PBDB should use a similar framework to explain its access strategy.

Figure 4.1 Example accessway and accessible features model (access to and within a building)



For the purpose of the accessway and accessible features model of Figure 4.1:

- **Accessible feature** denotes a part of a building that is required to be accessible such as designated sanitary accommodation, accessible adult change facilities (AACF), auditoriums, conference rooms and meeting rooms.
- **Accessway H/S1** denotes a horizontal accessway (usually external) between an external accessible car parking space or dedicated car park and the principal entrance. The "S" denotes a change in level in the accessway where the levels are interconnected via a ramp or stair.
- **Accessway H** denotes an internal horizontal accessway usually comprising a corridor, passage, or designated path through an open area marked in some manner e.g. via tactile ground surface indicators or shorelines (see AS 1428.1 –2009).
- **Accessway V** denotes a vertical accessway usually comprising accessible stairs, ramps and/or passenger lifts.
- **Info** denotes signs or notices providing information on accessible facilities.

4.3.3 Analysis methods

Table 4.1 outlines possible analysis methods for different activities that may form a part of the D1V2 Performance Solution.

Table 4.1 Task types and basis of analysis for each element of accessibility framework

Task / Activity	Accessway: Flat open path	Accessway: Corridor	Accessway: Ramp	Accessway: Stair	Accessway: Lift	Access Point: principal entrance	Access Point: Enclosed accessway	Access Point: Entry accessible feature	Accessible Feature: Disabled parking space	Accessible Feature: Conference room / Auditorium	Accessible Feature: Sanitary facility	Accommodation Suite / Accessible feature: SOU	Accessible Feature: Other
Navigate	Y	Y	N	N	N	N	N	N	N	N	N	Y	Y
Identify and locate	N	N	N	N	Y	Y	N	N	Y	Y	Y	Y	Y
Safely traverse / climb	N	Y	Y	N	N	N	N	N	N	N	N	Y	Y
Manoeuvre	N	N	N	N	Y	N	N	Y	Y	N	N	Y	Y
Reach (inc. switches and controls)	N	N	N	N	Y	N	N	N	N	N	Y	Y	Y
Open/ Grasp	N	N	N	N	N	Y	Y	Y	N	N	Y	Y	N
Transfer	N	N	N	N	N	N	N	N	Y	N	Y	Y	Y
Seated	N	N	N	N	N	N	N	N	N	Y	N	N	Y
Participate	N	N	N	N	N	N	N	N	N	Y	N	N	Y

Other data sources may be used to inform the analysis, these include:

- Ancillary Codes of Practice (such as AS 1428.2 or ISO 21542-2011).
- Peer reviewed evidence based studies.
- Validated digital human models (such as Sammie or Veritas).
- Laboratory measured data.

The methods of assessing an access solution must result in an output that is able to be measured by the measurable acceptance criteria.

4.3.4 Measurable acceptance criteria

The measurable acceptance criteria are the key metrics that are suitable to determine the performance of an access solution.

Example

The method of measurement can be via a dimensional check. For example, the width of a doorway permitting access by a wheelchair where the wheelchair may be known with a representative persona user. A similar criterion may be used in determining the width of an accessway for passing.

The acceptance criteria should enable a proposed access model to be assessed against a reference access model on a pass/fail basis. Acceptance criteria need to be clearly documented in the PBDB and agreed by stakeholders in the form of a schedule. Measurable acceptance criteria may relate to:

- safe traversal of accessway and manoeuvring through doorways
- navigation of accessways
- identifying and locating accessible features, including signage and exits
- reaching, opening and grasping of fixtures, doors, controls and switches
- clearances and space for manoeuvring
- visual contrast.

4.3.5 Equity and dignity

Occupant equity and dignity should be considered by the stakeholders in the development of the PBDB. Stakeholders may, for example, set up an Equity and Dignity Scoring Model. In this model, it is the role of the stakeholders to define the scoring criteria for each access element. If used in a D1V2 approach, the PBDB stakeholders would use the model to score the building features of the reference access solution and use this to assess whether the proposed access solution adequately addresses equity and dignity of occupants and document in the final report.

4.4 Comparing the reference and proposed access solutions

4.4.1 Occupant needs

Occupant needs must be considered in accordance with the occupant characteristics and profile determined during the creation of the PBDB. Needs relate to the 'design interventions' required to make the building more accessible and usable by occupants including those with disability.

An occupant characterisation schedule may be developed to document the connection of the design responses to the measurable acceptance criteria nominated in the PBDB.

4.4.2 Reference access solution

A reference access solution within a reference building is required to be designed to determine the benchmark criteria that must be met by the proposed access solution. The reference building must be designed using the DTS Provisions that are relevant to the Performance Requirements the solution will address.

The accessible facilities required by the DTS Provisions must be included in the model for the reference building and access solution. These include, but are not limited to:

- Facilities to be accessed in accordance with D4D2, D4D3, D4D4 and D4D6
- Signage in accordance with D4D7
- Hearing augmentation in accordance with D4D8
- Tactile ground surface indicators in accordance with D4D9
- Wheelchair seating spaces in accordance with D4D10
- Access to swimming pools in accordance with D4D11
- Marking of glazing on accessways in accordance with D4D13
- The standard, number and location of passenger lifts in accordance with E3D7
- Accessible sanitary facilities in accordance with Part F4.

Drawings reflecting these aspects of the access solution may be prepared to document the reference building and access solution.

4.4.3 Consistent features between the reference and proposed access solutions

For the comparison between the access solutions to be meaningful, D1V2(c) requires the reference building model and the proposed solution use consistent:

(1) Modelling method and approach.

(2) Occupant profile and characteristics.

(3) Building location and orientation.

(4) Locations of all entrances and exits.

(5) Locations of facilities important to the solution, including sanitary facilities, lifts, stairwells, etc.

(6) Number and range of facilities.

4.4.4 Comparison of the proposed and reference access solutions using the acceptance criteria

The performance of the reference building and proposed access solutions should be assessed using the same modelling method documented in the final report.

Performance of the reference building and proposed solution are assessed by comparing the measurable acceptance criteria defined in the PBDB. The level to which the reference access solution meets the measurable acceptance criteria is used as a baseline to which the performance of the proposed access solution is compared.

An Equity and Dignity Scoring Model may be applied as a means of determining the level of accessibility achieved by the reference and proposed access solutions.

5 D1V3 Ramp gradient, crossfall, surface profile and slip resistance for ramps used by wheelchairs

5.1 Overview

D1V3 provides designers with a pathway to demonstrate the compliance of ramps with Performance Requirement D1P2. There are 4 specific requirements which must be checked for any ramp considered under this method, plus the single, overarching maximum gradient. Each ramp needs to be checked for these requirements individually in accordance with its own particular criteria.

A ramp must be designed to ensure that it can be used safely and equitably. This is determined through an assessment of its design against D1V3 which verifies:

- The pushing force required during ascent.
- The braking force during descent of a ramp must be appropriate for its users.
- The time taken for an ascent must be reasonable for the capabilities of its users.
- The crossfall, surface profile and slip resistance must be appropriate to the gradient of the ramp to ensure user safety.
- Finally, as an overarching limitation, the gradient must not be steeper than 1:8.

The physical parameters nominated in the NCC or this handbook may be varied to better suit the particular building and characteristics of the building occupants at the discretion of the designer and the appropriate authority. Such an approach is consistent with that use of Performance Solutions under the NCC and it is suggested that variations be based on peer reviewed and evidence-based research and consider equity and dignity explicitly.

Alert

D1V3 has been developed for the design of ramps to be used by wheelchair users and may be inappropriate for sensitive pedestrians.

5.2 D1V3 Verification Method

D1V3 Ramp gradient, crossfall, surface profile and slip resistance for ramps used by wheelchairs

(1) Compliance with *Performance Requirement* D1P2, in regards to the gradient, crossfall, surface profile and slip resistance of a ramp for the use of wheelchairs, is verified when—

(a) the ramp has a gradient that is not steeper than 1:8; and

(b) the pushing force required to accelerate a wheelchair and user during ascent is in accordance with (2); and

(c) the required braking force for a wheelchair and user during descent is in accordance with (3); and

(d) the projected ascent time is in accordance with (4); and

(e) the ramp crossfall, surface profile and slip resistance is in accordance with (5).

(2) The pushing force during ascent must be in accordance with the formula:

$$F_p > mg \sin \alpha + C_{\pi 1} N_1 + C_{\pi 2} N_2$$

where –

F_p = the maximum pushing force during ascent, equal to 40 N for ramps required to be usable by the general public; and

m = the design mass of the wheelchair and wheelchair user, equal to 127 kg for ramps required to be usable by the general public; and

g = the gravitational constant, equal to 9.8m/s^2, and

α = the angle of incline of the ramp; and

$C_{\pi 1}, C_{\pi 2}$ = the coefficient of rolling resistance between the wheelchair wheel and amp surface, for the rear wheels and front wheels respectively; and

N_1, N_2 = the normal force between the wheelchair wheels and ramp surface, for the rear wheels and front wheels respectively.

(3) The braking force during descent must be less than 9 N when calculated in accordance with the formula:

$$F_b = mg \sin \alpha - C_{\pi 1} N_1 - C_{\pi 2} N_2$$

where –

F_b = the braking force during descent; and

D1V3 Ramp gradient, crossfall, surface profile and slip resistance for ramps used by wheelchairs

m = the design mass of the wheelchair and wheelchair user, equal to 127 kg for ramps required to be usable by the general public; and

g = the gravitational constant, equal to 9.8 m/s^2; and

α = the angle of incline of the ramp; and

$C_{\pi 1}, C_{\pi 2}$ = the coefficient of rolling resistance between the wheelchair wheel and ramp surface, for the rear wheels and front wheels respectively; and

N_1, N_2 = the normal force between the wheelchair wheels and ramp surface, for the rear wheels and front wheels respectively.

F_b = the braking force during descent; and

(4) The time taken to ascend the ramp must be less than 17 s when calculated in accordance with the formula:

$$\boldsymbol{T} = \frac{\boldsymbol{Lm}}{\boldsymbol{t}(\boldsymbol{F_p} - \boldsymbol{mg}\sin\boldsymbol{\alpha} - \boldsymbol{C_{\pi 1}N_1} - \boldsymbol{C_{\pi 2}N_2})}$$

where—

T = the time taken to ascend the ramp in seconds; and

L = the length of ramp in meters; and

m = the design mass of the wheelchair and wheelchair user, equal to 127 kg for ramps required to be usable by the general public; and

t = the time taken for the wheelchair to achieve maximum velocity, equal to 0.8 s; and

F_p = the maximum pushing force during ascent, equal to 40 N for ramps required to be usable by the general public; and

g = the gravitational constant, equal to 9.8 m/s^2; and

α = the angle of incline of the ramp; and

$C_{\pi 1}, C_{\pi 2}$ = the coefficient of rolling resistance between the wheelchair wheel and ramp surface, for the rear wheels and front wheels respectively; and

(5) The crossfall must be no steeper than, the surface profile must be no rougher than, and the slip resistance must be no less than, the values nominated in Table D1V3 for the gradient of the ramp.

D1V3 Ramp gradient, crossfall, surface profile and slip resistance for ramps used by wheelchairs

Table D1V3: Ramp crossfall, surface profile and slip resistance

Gradient	Crossfall	Surface profile (mm)	Slip resistance
1:14	1:40	2	P4/R11
1:12	1:50	2	P5/R12
1:10	1:100	1	P5/R12
1:8	1:100	0.5	P5/R12

5.3 Input data for D1V3

5.3.1 Wheelchair data

In order to accurately determine the forces acting upon the wheelchair, a wheelchair model is required. The A90 manual wheelchair referred to in AS 1428.1-2009 has all the necessary data for manoeuvring modelling and analysis but does not have the other details that would normally be available with wheelchair specifications from the various manufacturers or suppliers.

As there is no A90 power wheelchair (PWC) model, an equivalent model should be selected. If required, manual wheelchair (MWC) and PWC footprints can be made in accordance with B.6.2 of ISO21542-2011.

5.3.2 Occupant characteristics and inputs

The following inputs are applied to one or more of the 3 equations in D1V3:

- F_p, a maximum pushing force allowed during ascent, nominally 40 N for the general public.
- F_b, a maximum braking force to bring the wheelchair to a complete stop during descent, nominally 9 N for the general public.
- T, the maximum time to ascend a ramp, nominally 17 s.
- t, the time taken to reach full velocity, nominally 0.8 s.
- m, the mass of a manual wheelchair user and chair, nominally 127 kg.
- g, the gravitational constant is 9.8 m/sec^2.

- α, the inclined gradient of the ramp in degrees for which the sine is calculated (e.g. sin 7.13° = 0.125).
- $C_{\pi1}$ and $C_{\pi2}$ are the rolling resistances for rear and front wheels respectively.
- N_1 and N_2 are the normal forces though the front and rear wheels. For an A90 wheelchair, forces should be distributed with 38.9% for N_1 (rear wheels) and 61.1% for N_2 (castor wheels). This may vary with the gradient of a ramp.
- L, the length of the ramp in metres. This should be the length between landings, as a landing allows a user to rest.

The intent of D1V3 is to allow designers to design ramps appropriately for their users. As such, the physical parameters may be varied in accordance with the characteristics of those users where validated. For example, an aged care facility might use particular wheelchairs with a different weight and/or distribution of force. Ramps used as part of a wheelchair sports facility could be designed to require a greater force for ascent, due to the greater strength of their users.

Reminder

Variations to the inputs for D1V3 should be documented in a PBDB and agreed by the appropriate authority, as part of a Performance Solution. It is suggested that such variations be based upon peer reviewed and evidence-based research.

5.3.3 Pushing force during ascent

The maximum gradient for ascent is determined through the calculation of the required pushing force using the equation from D1V3(2).

The force that the wheelchair user can apply to the wheelchair drive wheels needs to be sufficient to successfully traverse the ramp in question.

The following provides an example for D1V3(2).

Example

The following example values of $C_{\pi1}$ and $C_{\pi2}$ are from Table 3 of Sauret et al (2012).

For a rear pneumatic wheel with a pressure of 448 kPa, diameter of 610 mm and track width of 35 mm, $C_{\pi1}$ is:

- Carpet low pile: 4.84×10^{-3}
- Carpet with high pile: 6.07×10^{-3}

Example

- Hard and smooth: 1.28 X 10^{-3}

For a solid castor wheel with a diameter of 101 mm and track width of 35 mm, $C_{\pi 2}$ is:

- Carpet low pile: 3.54 X 10^{-3}
- Carpet with high pile: 4.5 X 10^{-3}
- Hard and smooth: 0.36 X 10^{-3}

Solve the equation for F_p and ensure that it is not greater than the allowable pushing force (nominally 40 N). If the pushing force is exceeded then retry with a lesser gradient.

5.3.4 Braking force during descent

The required braking force during descent is determined through D1V3(3).

The stability of the wheelchair and the user is paramount. The highest risk of destabilising is in descent. The braking system for the manual wheelchair requires the application of the braking force (F_b) via the hand. The limit for the proposed user is 9 N in accordance with the test set out in D1V3 (taken from ISO 7176). However, this may be varied where validated by peer-reviewed, evidence-based research and accepted by the relevant authority as part of a Performance Solution.

The following provides an example for D1V3(3).

Example

The following example values of $C_{\pi 1}$ and $C_{\pi 2}$ are from Table 3 of Sauret et al (2012).

For a rear pneumatic wheel with a pressure of 448 kPa, diameter of 610 mm and track width of 35 mm, $C_{\pi 1}$ is:

- Carpet low pile: 4.84 X 10^{-3}
- Carpet with high pile: 6.07 X 10^{-3}
- Hard and smooth: 1.28 X 10^{-3}

For a solid castor wheel with a diameter of 101 mm and track width of 35 mm, $C_{\pi 2}$ is:

- Carpet low pile: 3.54 X 10^{-3}
- Carpet with high pile: 4.5 X 10^{-3}
- Hard and smooth: 0.36 X 10^{-3}

Example

Solve the equation for F_b and ensure that it is not greater than the allowable braking force (nominally 9 N). If the braking force is exceeded then retry with a lesser gradient.

5.3.5 Ascent time

The time taken to ascend a ramp is calculated through D1V3(4).

D1V3(4) is used to ensure that the time taken to traverse the sloping section of ramp appropriate to the gradient being tested does not exceed 17 s.

Additional inputs for the equation in D1V3(4) are:

- L, the length of the ramp in metres. This should be the length between landings, as a landing allows a user to rest.

Solve the equation for T and ensure it is not greater than a minimum ascent time of 17 s. If this ascent time is exceeded then retry with a lesser gradient and length. The resultant velocity should also be checked.

5.3.6 Crossfall, surface profile and slip resistance

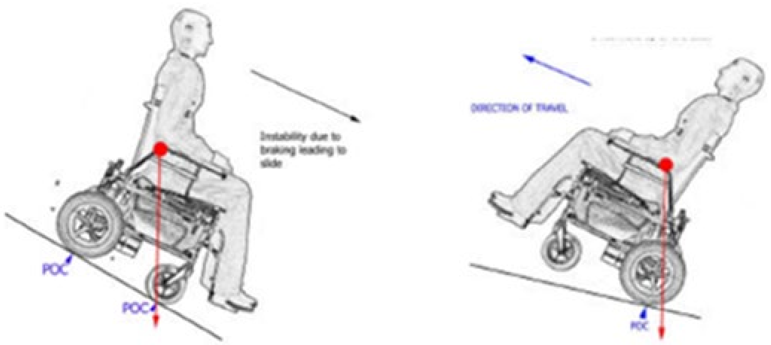
In addition to the computed requirements, Table D1V3 within D1V3(5) sets out particular requirements for:

- Crossfall – as crossfall increases so do the force demands upon each wheel in order to keep the manual wheelchair heading in a uniform direction. The F_p calculation assumes the application of an even pushing force being exerted on each rear wheel.
- Surface profile – to minimise resonance, especially for powered wheelchair users.
- Slip resistance – because a powered wheelchair can stall and start to slide on hard and very smooth surfaces if they have a low slip resistance classification (for example, P3 or less). It is for this reason that ramps with gradients steeper than 1:14 are required to have a P5 slip resistance rating.

5.3.7 Tipping check for PWCs

It is suggested that a graphical stability check be carried using a PWC model. An example is shown in Figure 5.1.

Figure 5.1 Graphical checking of stability for PWC appropriate to gradient being assessed



Centre of Gravity – see Note 1 for calculation procedure.

Downhill Scenario defined by slope where POC is point of contact

Uphill Scenario defined by slope where POC is point of contact

Note 1: Using the PWC model, draw in the vertical component of the force representing the distribution of the mass of the PWC and the user as shown in Figure 5.1.

Figure 5.2 Enlarged downhill and uphill scenarios

Downhill Scenario

Uphill Scenario

If the centre of gravity is outside of the point of contact (POC), as shown in Figure 5.1 and Figure 5.2, the wheelchair is at risk of tipping and therefore the ramp is not suitable.

6 Reporting

A final report should clearly demonstrate that compliance with the relevant NCC Performance Requirements, as agreed in the performance-based design brief, has been achieved. The content of a typical final report might include:

- An overview of the PBDB, including:
  - scope of the project
  - relevant stakeholders
  - applicable NCC Performance Requirements and NCC DTS Provisions
  - NCC Assessment Method/s used
  - approaches to methods of analysis
  - any assumptions that were made
  - limitations
  - acceptance criteria and safety factors agreed to by stakeholders.
- Overview and outline of the analysis, modelling and/or testing carried out including:
  - method of analysis used
  - calculations and outcomes
  - the sensitivities, redundancies and uncertainty studies carried out
  - variations to the required inputs and validation
  - the results obtained and relevance to the PBDB.
- Evaluation of results including:
  - comparison of results with acceptance criteria
  - any further sensitivity studies undertaken
  - any peer review or expert judgement applied and its justification.
- Conclusion including:
  - specifications of the final design that are deemed to be acceptable
  - confirmation the NCC Performance Requirement/s were met
  - all limitations to the design and any conditions of use.

Appendices

Appendix A Acronyms

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

Table A.1 Acronyms

Acronym	Meaning
AACF	Accessible adult change facility
ABCB	Australian Building Codes Board
ABS	Australian Bureau of Statistics
AP	Access Point
AS	Australian Standard
BCA	Building Code of Australia
DDA	Disability Discrimination Act
DTS	Deemed-to-Satisfy
IGA	Inter-government agreement
ISO	International Standardization Organisation
NCC	National Construction Code
MWC	Manual Wheelchair
PBDB	Performance-Based Design Brief
POC	Point Of Contact
PWC	Power Wheelchair
WHS	Workplace Health & Safety

Appendix B Compliance with the NCC

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

State and territory governments are responsible for regulation of building, plumbing and development/planning in their respective state or territory.

The NCC is a joint initiative of the Commonwealth and State and Territory Governments in Australia 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.

B.2 Demonstrating compliance with the NCC

Compliance with the NCC is achieved by complying with the NCC Governing Requirements 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.

There are 3 options available to demonstrate compliance with the Performance Requirements. These are:

- a Performance Solution
- a Deemed-to-Satisfy Solution, or
- a combination of a Performance Solution and a Deemed-to-Satisfy Solution.

All compliance options must be assessed using one or a combination of Assessment Methods, as appropriate. These include:

- 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 B.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.

Figure B.1 Demonstrating compliance with the NCC

Appendix C Acts, Regulations and design responsibilities

C.1 Disability Discrimination Act – Disability (Access to Premises – Buildings) 2010

For disability related issues, the NCC isn't the only piece of legislation which is required to be complied with for building.

The Australian Government's Disability Discrimination Act 1992 (DDA) has been in effect since March 1993. The DDA prohibits discrimination against people with disability or their associates in a range of areas including transport, education, employment, accommodation and premises used by the public.

The DDA is complaints-based (as opposed to compliance-based) legislation. It does not include legislative or regulatory guidance as to the specific steps that must be taken to ensure compliance with the general duties in relation to access to premises.

Concern with the lack of certainty regarding practical compliance obligations under the DDA led to amendments to Section 31 of the DDA, which came into effect in April 2000. This amendment allows the Australian Government's Attorney-General to formulate Disability Standards in relation to access to premises. Contravention of any Disability Standards formulated under the DDA is unlawful under Section 32 of the DDA. Section 34 of the DDA effectively provides that compliance with a relevant Disability Standard is sufficient to satisfy the DDA duty not to discriminate in relation to the subject area covered by the Standards.

The need to review the BCA access provisions as part of the development of Disability Standards in relation to access to premises stemmed from:

- recognition that the technical requirements of the BCA at that time were not considered to meet the intent and objectives of the DDA; and
- the potential for inconsistencies between 2 legislative requirements in relation to access for people with disability to buildings, being the DDA and, through state and territory building law, the BCA.

The ABCB was requested by the Australian Government to develop proposals for a revised BCA, to enable it to form part of draft Premises Standards. Once the Premises Standards had been formulated, the BCA would be amended so that the technical details of each document mirror each other. Therefore, compliance with state and territory building law and the access provisions of the BCA would mean compliance with the Premises Standards and hence the DDA.

The Premises Standard provides clarity in developing building solutions which are equitable and dignified (2 of the key aims of the DDA) for all occupants. The Premises Standard in replicating the BCA is also performance-based. The Standards state that:

- they are not intended to limit the way in which a relevant building may otherwise satisfy the applicable Performance Requirements; and
- a relevant building is taken to comply with the Access Code if the building provides a level of access that is not less than the level that the building would have provided if it had complied with the provisions.

Designers and practitioners should seek expert advice for project specific information on, particularly when undertaking Performance Solutions which relate to the disability access provisions.

C.2 Other Applicable Acts, Regulations and design responsibilities

There is other legislation (both Commonwealth, and state and territory) which may impact on building approval and design.

For instance, the NCC does not regulate matters such as the roles and responsibilities of building and plumbing practitioners. These fall under the jurisdiction of the states and territories.

State and territory building and plumbing legislation is not nationally consistent in relation to these matters with significant variations with respect to:

- registration of practitioners
- mandatory requirements for inspections during construction.

The design and approval of building and plumbing and drainage solutions will need to consider these variations.

In addition to the relevant legislation, Workplace Health and Safety (WHS) legislation is also applicable which requires safe design principles to be applied.

A Code of Practice on the safe design of structures has been published by Safe Work Australia (2012) which provides guidance to persons conducting a business or undertaking work in regard to structures that will be used, or could reasonably be expected to be used, as a workplace. It is prudent to apply these requirements generally to most building classes since they represent a workplace for people undertaking building work, maintenance, inspections at various times during the building life.

The Code of Practice defines safe design as:

"the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the structure being designed".

It indicates that safe design begins at the start of the design process when making decisions about:

- the design and its intended purpose
- materials to be used
- possible methods of construction, maintenance, operation, demolition or dismantling and disposal
- what legislation, codes of practice and standards need to be considered and complied with.

The Code of Practice also provides clear guidance for practitioners who have health and safety duties in relation to the design of structures, and includes:

- architects, building designers, engineers, building surveyors / certifiers, interior designers, landscape architects, town planners and all other design practitioners contributing to, or having overall responsibility for, any part of the design
- building service designers, engineering firms or others designing services that are part of the structure such as ventilation, electrical systems and permanent fire extinguisher installations
- contractors carrying out design work as part of their contribution to a project (for example, an engineering contractor providing design, procurement and construction management services)
- temporary works engineers, including those designing formwork, falsework, scaffolding and sheet piling
- persons who specify how structural alteration, demolition or dismantling work is to be carried out.

In addition, WHS legislation places the primary responsibility for safety during the construction phase on the builder.

From the above it is clear that the design team in conjunction with owners / operators and the builder have a responsibility to document designs, specify and implement procedures that will minimise risks to health and safety throughout the life of the structure being designed.

A key element of safe design is consultation to identify risks, develop practical mitigation measures and to assign responsibilities to individuals / organisations for ensuring the mitigation measures are satisfactorily implemented.

This approach should be undertaken whichever NCC compliance pathway is adopted.

Some matters specific to health and safety are summarised below, but this list is not comprehensive.

- The NCC and associated referenced documents represent nationally recognised minimum standards for health and safety for new building works.
- The NCC's treatment of safety precautions during construction is very limited. Additional precautions are required to address WHS requirements during construction.
- Detailed design of features to optimise reliability and facilitate safe installation, maintenance and inspection where practicable.
- Document procedures and allocate responsibilities for determining evidence of suitability for all health and safety measures.
- Document procedures and allocate responsibilities for the verification and commissioning of all health and safety measures.
- Provide details of health and safety measures within the building, evidence of suitability, commissioning results and requirements for maintenance and inspection to the owner as part of the building manual. (Note: Some State and Territory legislation contains minimum requirements for inspection of fire safety measures)
- The building manual should also provide information on how to avoid compromising fire safety through the life of a building (e.g. preventing disconnection of smoke detectors or damage to fire resistant construction).

Some health and safety measures will be impacted by other legislation that may be synergistic with the NCC requirements or potentially in conflict particularly in relation to natural hazards. These include:

- planning / development
- conservation
- state emergency risk management policies.

Appendix D Resources

D.1 Manual wheelchair use and selection

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D.3 Tactical ground surface indicators and luminance contrast

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