BUILDING PERFORMANCE

G7

G7 Natural Light

Verification Method G7/VM1

Natural Light for all buildings including those with borrowed daylight

SECOND EDITION | EFFECTIVE 29 NOVEMBER 2021

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

Preface

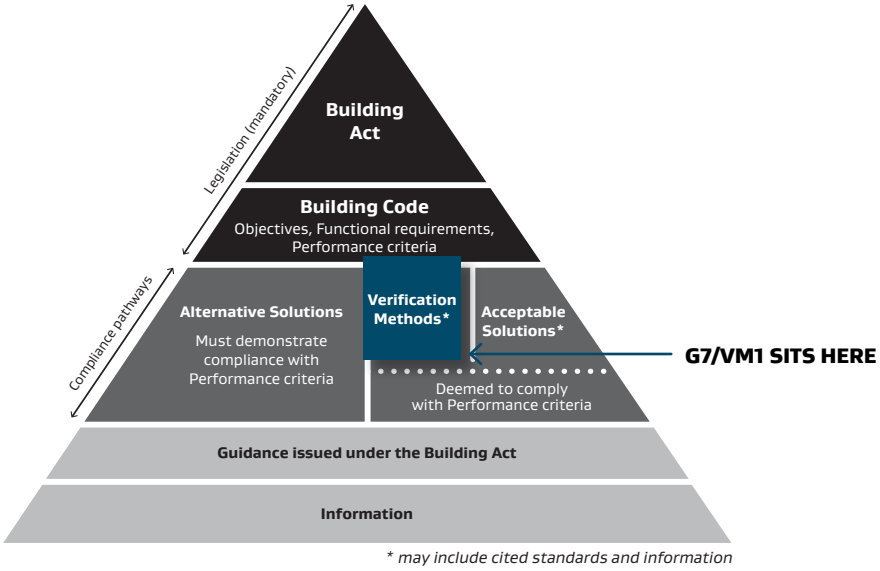
Document status

This document (G7/VM1) is a verification method issued under section 22 (1) of the Building Act 2004 and is effective on 29 November 2021. It does not apply to building consent applications submitted before 29 November 2021. The previous Verification Method G7/VM1 First Edition Amendment 2 can be used to show compliance until 2 November 2022 and can be used for building consent applications submitted before 3 November 2022.

Building Code regulatory system

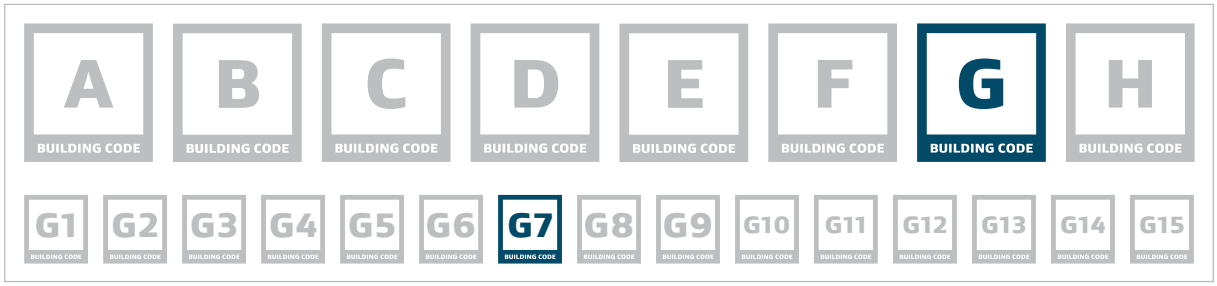
Each verification method outlines the provisions of the Building Code that it relates to. Complying with an acceptable solution or verification method are ways of complying with that part of the Building Code. Other options for establishing compliance are listed in section 19 of the Building Act.

Schematic of the Building Code System



A building design must take into account all parts of the Building Code. The Building Code is located in Schedule 1 of the Building Regulations 1992 and available online at www.legislation.govt.nz

The part of the Building Code that this verification method relates to is clause G Services and facilities and specifically G7 Natural Light. Further information on the scope of this document is provided in Part 1. General.



Further information about the Building Code, the objectives, functional requirements and performance criteria provisions that it contains, and other acceptable solutions and verification methods are available at www.building.govt.nz

Main changes in this version, acknowledgements, and features of this document

Main changes in this version

This verification method is the second edition of G7/VM1. The main changes from the previous version of G7/VM1 are:

- An introduction and scope for the verification method has been provided in Part 1. General.
- For demonstrating compliance with illuminance for habitable spaces, the BRE calculation methods described in NZS 6703 have been replaced with a new computer modelling method provided in Part 2. Illuminance.
- Requirements for awareness of the outside environment have been provided in Part 3. Awareness of the outside environment.
- References for standards and documents are provided in Appendix A.
- The definitions page has been revised to include all defined terms used in this document in Appendix B.

People using this document should check for amendments on a regular basis. The Ministry of Business, Innovation and Employment may amend any part of any acceptable solution or verification method at any time. Up-to-date versions of acceptable solutions and verification methods are available from www.building.govt.nz.

Acknowledgements

MBIE would like to acknowledge the assistance of the Singaporean Building and Construction Authority for the permission for using content from Annex B of GM RB: 2016 Green Mark for residential buildings – Technical Guide and Requirements.

Features of this document

- For the purposes of Building Code compliance, the standards and documents referenced in this verification method must be the editions, along with their specific amendments listed in Appendix A.
- Words in *italic* are defined at the end of this document in Appendix B.
- Hyperlinks are provided to cross-references within this document and to external websites and appear with a blue underline.
- Classified uses for buildings, as described in clause A1 of the Building Code, are printed in **bold** in this document.
- Appendices to this acceptable solution are part of, and have equal status to, the acceptable solution. Figures are informative only and the wording of the paragraphs takes precedence. Text boxes headed 'COMMENT' occur throughout this document and are for guidance purposes only.

Contents

Part 1. General

1.1 Introduction

1.1.1 Scope of this document

1.1.1.1 This verification method applies to all **housing**, old people's homes, and *early childhood centres* including those that have *habitable spaces* with:

a) Complex room shapes, and

b) Rooms with borrowed daylight, and

c) Rooms with multiple windows, and

d) Other room scenarios not covered by G7/AS1 and G7/AS2.

COMMENT: Old people's homes includes aged care facilities, rest homes and retirement complexes.

1.1.2 Items outside the scope of this document

1.1.2.1 This verification method does not consider the detrimental effects of 'over lighting' as this is not a requirement to demonstrate compliance with G7 Natural Light.

1.1.2.2 For *buildings* that cannot be simulated using the requirements of this document, use an alternative means to demonstrate compliance.

1.1.3 Compliance pathway

1.1.3.1 This verification method provides a solution for demonstrating compliance with the performance criteria in Building Code clauses G7.3.1 and G7.3.2.

1.1.3.2 Options for demonstrating compliance with G7 Natural Light through the use of acceptable solutions and verification methods are summarised in Table 1.1.3.2. Compliance may also be demonstrated using an alternative solution.

TABLE 1.1.3.2: Demonstrating compliance with G7 Natural Light through acceptable solutions and verification methods

Paragraph 1.1.3.2

Performance clause	Applies to	Relevant acceptable solutions and verification methods
G7.3.1 *Illuminance* G7.3.2 Awareness of the outside environment	**Housing**, old people's homes, and *early childhood centres*	For simple *buildings* up to 3 storeys in low density developments without borrowed light: G7/AS1 For simple *buildings* in low, medium and high density developments (including higher rise *buildings* and apartments) without borrowed light: G7/AS2 For all *buildings* including complex higher rise *buildings*, apartments, and those with borrowed light: G7/VM1

1.2 Using this verification method

1.2.1 Determining the classified use

1.2.1.1 Classified uses for *buildings* are described in clause A1 of the Building Code. Where a specific classified use is mentioned within a subheading and/or within the text of a paragraph, this requirement applies only to the specified classified use(s), and does not apply to other classified uses.

1.2.2 Determining the habitable space

1.2.2.1 For the purpose of determining the *habitable space* for compliance with Building Code clause G7 Natural Light; a *habitable space* is one used for activities normally associated with domestic living, but excludes any bathroom, laundry, water-closet, pantry, walk-in wardrobe, corridor, hallway, lobby, clothes-drying room, or other space of a specialised nature occupied neither frequently nor for extended periods. The intent is to ensure occupants within *buildings* are able to have access to *adequate* natural light and to have an awareness of the outside to maintain their health and wellbeing.

Part 2. Illuminance

2.1 Illuminance of habitable spaces

2.1.1 Demonstrating compliance

2.1.1.1 For *habitable spaces* of **housing**, old people's homes, and *early childhood centres*, natural light shall provide an *illuminance* of no less than 30 lux at floor level for 75% of the *standard year*. This is demonstrated through the use of the computer-based daylight modelling described in Section 2.1.2.

2.1.2 Modelling method for verification of the design

2.1.2.1 Verification of the design is achieved by demonstrating that natural light provides the required *illuminance* by using either:

a) *Climate based daylight modelling (CBDM)*; or

b) *Daylight factor (DF)* modelling.

2.1.2.2 *Climate based daylight modelling (CBDM)* provides outputs as absolute quantities expressed in lux (*illuminance*).

2.1.2.3 When *daylight factor (DF)* modelling is used to determine sufficient level of natural light, outputs are expressed in terms of percentage of outside available daylight. The calculated *daylight factor (DF)* shall be equal or more than the values of Table 2.1.2.3 for minimum *daylight factor (DF)* values.

TABLE 2.1.2.3: Minimum Daylight Factors

Paragraph 2.1.2.3

Climate region[1]	Daylight factor (%)[2],[3]
Auckland	0.26
Wellington	0.32
Christchurch	0.27
Invercargill	0.34

Notes:

(1) For locations not listed, use the *daylight factor* value for the geographically closest location.

(2) These *daylight factors* are the minimum values based on 75% of a *standard year*.

(3) These *daylight factors* are calculated by using Equation 1 of Paragraph C 4.3.1.

2.1.2.4 The computer model shall simulate ingress of daylight into *habitable spaces* of the *building* and shall accurately represent the geometry, *reflectance*, and *visible light transmittance* (*VLT*) properties of the *building* and spaces.

2.1.2.5 The orientation, with respect to north, and location (including latitude, longitude, and altitude) used in the simulation shall accurately represent that of the *building*.

2.1.2.6 Any change of plane (such as a step change in alignment) shall be included in the simulation if it exceeds 100 mm. This includes coves and dropped ceilings, steps in floors, steps/alcoves in walls, and the like.

2.1.2.7 Additional requirements for the use of computer modelling including required inputs is provided in Appendix C.

2.1.2.8 Modelling of architectural features smaller than 100 mm in any dimension is not required. Dimensions of *building elements* and furniture in the simulation shall be simulated accurately to the nearest 100 mm increment except for windows, *skylights*, and openings as specified in Paragraph C.2.4.1.

Part 3. Awareness of the outside environment

3.1 Area of transparent glazing

3.1.1 Demonstrating compliance

3.1.1.1 For *habitable spaces* of **housing**, old people's homes, and *early childhood centres*, openings to the outside shall have an area of transparent glazing suitable to give awareness of the outside. This is demonstrated through the use of a calculation method described in Subsection 3.1.2.

3.1.2 Calculation method for verification of the design

3.1.2.1 Verification of the design is achieved by demonstrating that the area of transparent glazing of the proposed *building* design is dimensioned and located as described in this subsection.

3.1.2.2 A *habitable space* with an *external wall* shall have an area of transparent glazing no less than:

a) 5% of the floor area of the space, (where there is no *habitable space* borrowing light); or

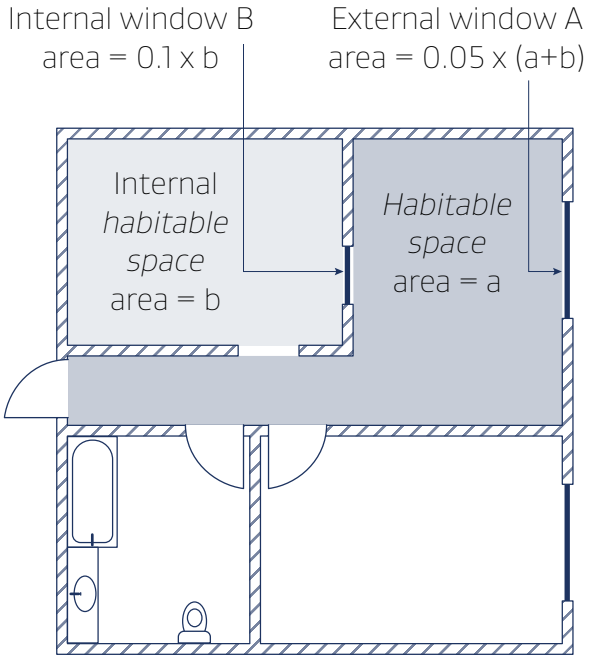
b) 5% of the total floor area of the space and the floor area of any adjacent *habitable space* that is borrowing natural light via the space (see Figure 3.1.2.2) (where there is *habitable space* borrowing light).

3.1.2.3 A *habitable space* that borrows natural light from another space with an *external wall* shall have an area of transparent glazing no less than 10% of the floor area of the space (see Figure 3.1.2.2).

3.1.2.4 Any other space with an *external wall*, other than a *habitable space*, that is used to borrow natural light from shall have an area of transparent glazing. The area of transparent glazing shall be no less than 5% of the total floor area of the space and the adjacent room that is borrowing natural light via the space.

FIGURE 3.1.2.2: Area of transparent glazing

Paragraphs 3.1.2.2 and 3.1.2.3



3.1.2.5 The area of transparent glazing shall be located in the visual awareness zone between the levels 900 mm and 2000 mm from floor level (see Figure 3.1.2.5).

3.1.2.6 When a *habitable space* is borrowing natural light via an adjacent space with an *external wall*, an observer in the space shall be able to directly see the full required transparent glazed area of the *external wall* via the internal glazed area when the observer is:

a) located at a perpendicular distance of 2000 mm from the internal wall containing the area of transparent glazing; or

b) located centrally on the opposite wall (for rooms with a depth less than 2000 mm from the area of transparent glazing of the internal wall); and

c) located at a height from the floor of 1200 mm (seated position); and

d) located at a height from the floor of 1800 mm (standing position) (see Figure 3.1.2.6).

FIGURE 3.1.2.5: Visual awareness zone for a habitable space with an external wall

Paragraph 3.1.2.5

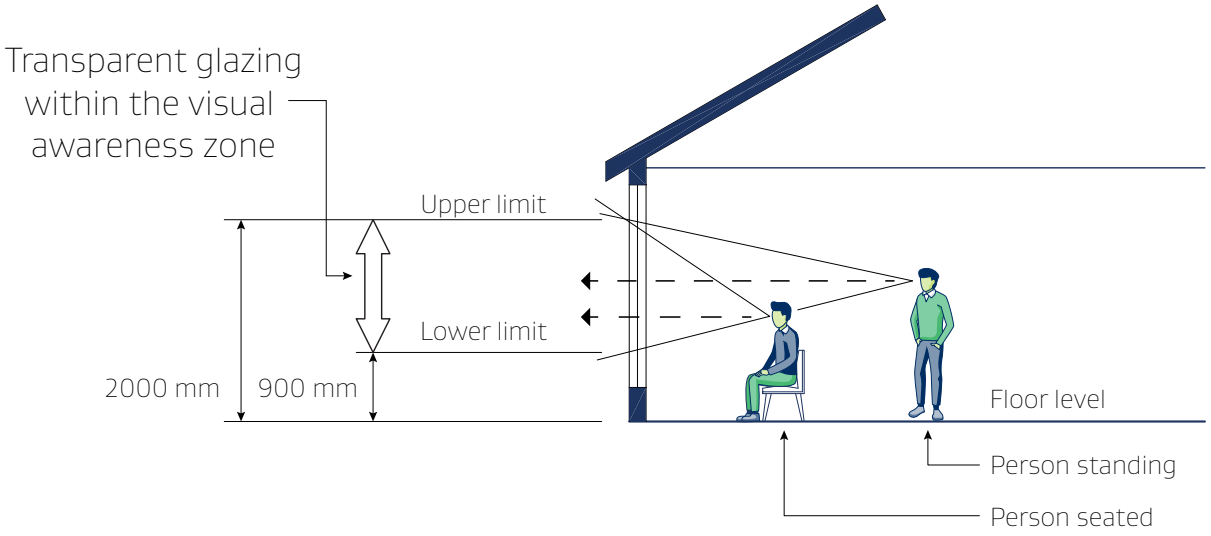
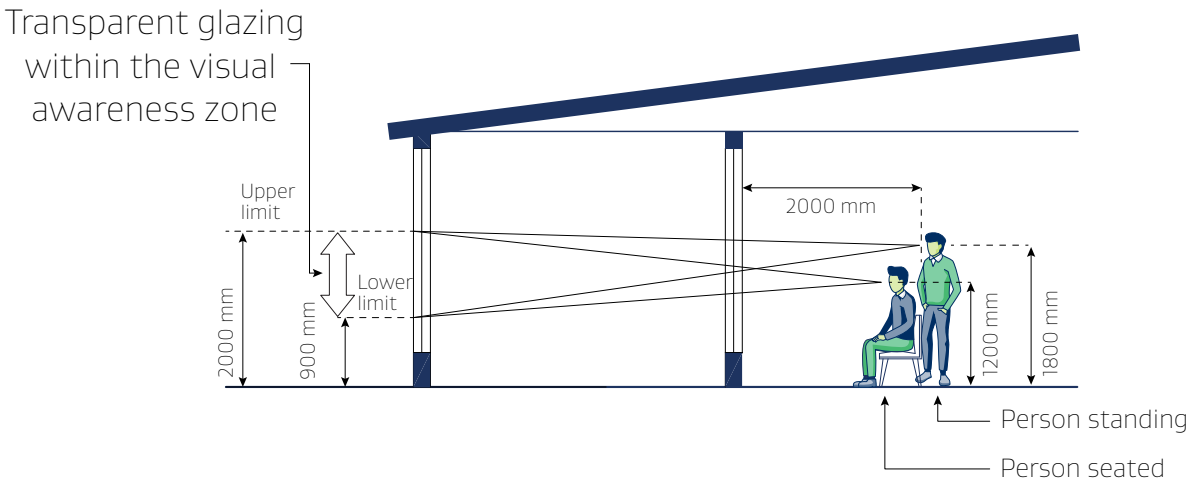


FIGURE 3.1.2.6: Visual awareness zone for a habitable space that borrows natural light from another space with an external wall

Paragraph 3.1.2.6



Appendix A. References

For the purposes of compliance with the Building Code, the standards and documents referenced in this verification method must be the editions, along with their specific amendments, listed below.

Standards New Zealand		**Where quoted**
AS/NZS 1680:-	Interior and workplace lighting	
Part 1: 2006	General Principles and Recommendations	C.3.4.1, C.4.2.1 and C.4.3.1
NZS 6703: 1984	Code of Practise for Interior Lighting Design Amend C1: 1985	Table C.2.5.1B

These standards can be accessed from www.standards.govt.nz

International Commission on Illumination		**Where quoted**
CIE 171: 2006	Test cases to assess the accuracy of lighting computer programs	C.3.1.1
CIE 110: 1994	Spatial distribution of daylight – Luminance distributions of various reference skies	C.3.1.2 , C.4.1.1

These documents can be accessed from www.cie.co.at

Appendix B. Definitions

These definitions are specific to this verification method. Other defined terms found in italics are provided in clause A2 of the Building Code.

Adequate	*Adequate* to achieve the objectives of the Building Code.
Building	Has the meaning given to it by sections 8 and 9 of the Building Act 2004.
Building element	Any structural or non-structural component or assembly incorporated into or associated with a *building*. Included are *fixtures*, services, *drains*, permanent mechanical installations for access, glazing, partitions, ceilings and temporary supports.
Climate based daylight modelling (CBDM)	The prediction of lighting qualities and quantities within a space using conditions derived from standard meteorological datasets. Climate-based modelling delivers predictions of absolute quantities (e.g. *illuminance*) that are dependent on the location and the building orientation, in addition to the building's composition and configuration.
Daylight factor (DF)	The ratio of natural light within a space as a percentage of the available daylight outside of a *building*.
Early childhood centre (ECC)	Premises used regularly for the education or care of three or more children (not being children of the persons providing the education or care, or children enrolled at a school being provided with education or care before or after school) under the age of six years old— a) by the day or part of a day; but b) not for any continuous period of more than seven days. ECC does not include home based early childhood services.
External wall	Any vertical exterior face of a *building* consisting of primary and/or secondary elements intended to provide protection against the outdoor environment
Habitable space	A space used for activities normally associated with domestic living, but excludes any bathroom, laundry, water-closet, pantry, walk-in wardrobe, corridor, hallway, lobby, clothes-drying room, or other space of a specialised nature occupied neither frequently nor for extended periods.
Illuminance	The luminous flux falling onto unit area of surface (lumen/m^2).
Luminance (cd/m^2)	Described as the visual brightness of an object. The luminous flux emitted (or reflected) from an object's surface are and measured as candelas per metre squared (cd/m^2).
Reflectance	The ratio of the flux reflected from a surface to the flux incident on it.
Roof	That part of a *building* having its upper surface exposed to the outside and at an angle of 60° or less to the horizontal.
Skylight	Translucent or transparent parts of the *roof*.
Standard year	For the purposes of determining natural lighting, the hours between 8 am and 5 pm each day with an allowance being made for daylight saving.
Visible light transmittance (VLT)	The ratio of luminous flux (light) passing through a translucent surface (e.g. glazing). It is expressed as a percentage of the flux incident upon the surface. A higher value means a greater percentage of visible light passes through the surface.

Appendix C. Computer modelling of natural light

C.1 Modelling requirements

C.1.1 Overview

C.1.1.1 This appendix provides details on the use of computer modelling to determine the level of natural light provided in a *building*. It includes requirements for the inputs used in the simulation of specific elements along with requirements for the use of *Climate Based Daylight Modelling (CBDM)* and *Daylight Factor (DF)* calculations.

C.2 Simulation of specific elements

C.2.1 Walls

C.2.1.1 All offsets larger than 100 mm in any dimensions shall be included in the simulation. Curved surfaces shall be simulated as smooth surfaces and may be faceted with a maximum facet dimension of 100 mm.

C.2.2 Internal details

C.2.2.1 All Internal partitions, fixed furniture, and joinery elements that are a permanent part of the internal area shall be included in the simulation. Loose furniture is not required to be included in the simulation.

C.2.3 External details

C.2.3.1 All fixed overhangs, louvres, balconies, and fins that are a permanent part of the *building*, and which restrict natural light entering the *building*, shall be included in the simulation.

C.2.3.2 Where the natural light entering a *building* is restricted by other structures or natural land features these shall be included in the simulation.

C.2.3.3 Where trees are known or anticipated to be present, the general form and size of the mature tree should be included in the simulation. For simplicity, it is suggested that these are represented as solid objects.

C.2.4 Windows, skylights and openings

C.2.4.1 The dimensions of windows and daylight openings shall be simulated to the nearest 10 mm. Window opening details such as wall thickness, sills, projections, frames, and mullions shall be simulated to the nearest 10 mm.

C.2.4.2 Glazing shall be simulated with a *visible light transmittance* (*VLT)* based on manufacturer's data.

COMMENT: Indicative *visible light transmittance* (*VLT)* values for glazing include:

- Single clear glass: *VLT* of approximately 90%; and
- Double clear glass with no Low E coating: *VLT* of approximately 80%; and
- Double clear glass with Low E coating or triple clear glass: *VLT* of approximately 70%; and
- Tinted or clear glass with light solar control: *VLT* of approximately 60%; and
- Tinted glass with medium solar control: *VLT* of approximately 50%; and
- Tinted glass with high solar control: *VLT* of approximately 40%.

C.2.5 Reflectance Factors

C.2.5.1 *Reflectance* factors used in the simulation shall be based on manufacturer's product *reflectance* data and be the same for the final finishes of the *building*. If manufacturer's data is not available, it is permitted to use the values in:

a) For interior surfaces finishes, Table C.2.5.1A; and

b) For other typical New Zealand building finishes, Table C.2.5.1B.

TABLE C.2.5.1A: Acceptable reflectance for interior surface finishes

Paragraph C.2.5.1 a)

Reflectance level required	Minimum surface reflectance		
	Ceilings	Walls [1]	Floor
Medium *reflectance*	0.7	0.4	0.2
High *reflectance*	0.7	0.6	0.4

Note:

(1) Does not include windows.

TABLE C.2.5.1B: Approximate reflectance of typical New Zealand building finishes reproduced from NZS 6703

Paragraph C.2.5.1 b)

Building finish	Approximate reflectance	Building finish	Approximate reflectance
White emulsion paint on plain plaster surface White glazed tiles	0.8	Fibre cement sheet Portland cement (smooth) Natural particle board	0.4
White emulsion paint on acoustic tile	0.7	Natural rimu (dressed) Varnished Pinus radiata[1]	0.3
White emulsion paint on no-fines concrete	0.6	Concrete (light grey) Portland cement (rough) Natural mahogany (dressed) Varnished particle board	0.25
Natural pine plywood	0.55	Varnished rimu (dressed)[1]	0.15
White emulsion paint on wood-wool slab	0.5	Varnished mahogany (dressed)[1]	
Varnished pine plywood[1] Natural Pinus radiata	0.45	Quarry tiles: Red, heather brown	0.1

Note:

(1) Typical varnishing would be two coats of clear gloss polyurethane varnish.

C.3 Climate based daylight modelling

C.3.1 Modelling software requirements

C.3.1.1 The computer modelling software used for *climate based daylight modelling* must be validated in accordance with CIE 171.

C.3.1.2 The computer modelling software shall use sky *luminance* based on either the CIE 110 Overcast Sky, or the Perez All-Weather Sky Model. International Weather for Energy Calculation (IWEC) data for the closest weather station shall be used as an input to the software.

C.3.2 Weather data

C.3.2.1 Weather data shall be derived from a weather station that best represents where the *building* is located and shall represent an average year for the site over at least a 10-year period. Weather data is available online in digital form from the National Institute for Water and Atmospheric Research (NIWA).

C.3.3 Time step

C.3.3.1 *Illuminance* values shall be calculated at a minimum for each hour between 8 am and 5 pm and at a minimum for the 21st day of each month of the *standard year*.

C.3.4 Calculation grids

C.3.4.1 *Illuminance* calculation grid placement shall be applied in accordance with AS/NZS 1680.1 Appendix B2 "Calculation Grids". Where an interior *habitable space* is less than 2000 mm in width, a single line of calculation points shall be placed centrally in the area to be calculated.

C.4 Daylight factor

C.4.1 Modelling software requirements

C.4.1.1 The computer modelling software shall use sky *luminance* based on the CIE 110 Overcast Sky.

C.4.2 Calculation grids

C.4.2.1 *Daylight factor* calculation grid placement shall be applied in accordance with AS/NZS 1680.1 Appendix B2 "Calculation Grids". Where an interior *habitable space* is less than 2000 mm in width, a single line of calculation points shall be placed centrally in the area to be calculated.

C.4.3 Minimum daylight factor calculation

C.4.3.1 Minimum *daylight factor (DF)* is calculated as:

Equation 1: $$DF = \left(\frac{30 \text{ lux} \times 100\%}{\text{External skylight } \textit{illuminance} \text{ (lux) for 75\% of the } \textit{standard year}} \right)$$

where:
DF is the minimum *daylight factor* (%); and
External *skylight illuminance* is measured in lux (Refer to Table 9.1 of AS/NZS 1680.1).

C.5 Documentation

C.5.1 Documentation of analysis

C.5.1.1 Documentation of computer modelling analysis shall contain:

a) The name of the modeller; and
b) The modelling program name, version number, and supplier; and
c) A list of inputs used in the model; and
d) Technical detail on the proposed *building* design; and
e) The results of the analysis to demonstrate compliance with G7/VM1.

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