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SUSTAINABILITY CHAPTER

AN ADDITION TO THE FIJI NATIONAL BUILDING CODE

2026

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INTRODUCTION

The Sustainability Chapter (SC) is drafted as an Annex to the Fiji National Building Code (FNBC) and complements the FNBC *in mainstreaming climate considerations in the delivery and upgrade of the building stock in Fiji*. The SC is a living document and should be reviewed regularly (recommended every 5 years), for ensuring requirements are sufficient in scope and performance level.

Alignment to Fiji policies:

In the *Fiji Low Emissions Development Strategy*, the roadmap guiding the nation towards carbon neutrality by 2050 is articulated. For the building sector, the contribution to this target is primarily through increased energy efficiency, largely through reduction of energy consumption for cooling needs.

The *National Climate Change Policy 2018-2030* seeks to leverage co-benefits in pro-active planning and actions on climate change adaptation, disaster risk, and low carbon development. The Policy also promotes engaging all parts of the society in climate preparedness to optimize benefits, reduce duplication and improve resource efficiency. Infrastructure development plans should account for full environmental costs and to take reference from traditional approaches and methods.

The *Climate Change Bill* adopted in 2021 requires all government entities in Fiji to mainstream climate change considerations into policies and programs. In regard to the built environment, the Climate Change Bill requires that all new developments consider foreseeable climate risks and impacts in the planning and design stage. The Fiji National Building Code shall be reviewed and updated every 5 years to ensure responsiveness to climate-induced impacts on the built environment.

Objectives of the Sustainability Chapter:

1. To mainstream planning for climate change mitigation and adaptation in the building sector.
2. To provide clear guidelines to support the sector transition towards climate readiness.
3. To enhance the resilience of building stock in Fiji to anticipated climate-induced impacts.
4. To improve inclusiveness of building designs.

The performance standard requirements in this document are referenced from available Fiji benchmark data (see Key References) and relevant standards in the region. The requirements should be reviewed regularly to update to current standards and upgraded to meet planned targets when possible.

Anticipated effects of climate change in Fiji

The latitude of The Republic of Fiji is -17.713371, and the longitude is 178.065033.

As an island nation within the Pacific Ocean, Fiji is accustomed to natural hazards such as tropical cyclones and coastal flooding. These threats to the development of Fiji are further amplified by climate change, which is projected to increase the frequency and intensity of extreme weather events.

The anticipated climate change impacts in Fiji over the coming decades include[1,2]:

1. Sea level rise leading to coastal inundation and shoreline erosion.
2. Rising average temperatures – increase in number of hot days and warm nights.
3. Increasing intensity of tropical cyclones – higher wind loads, greater volumes of rain.
4. Variable rainfall patterns – less rain in dry seasons, increased rainfall in wet seasons.

Scope of Sustainability Chapter (SC)

The Sustainability Chapter forms a part of the Fiji National Building Code and, like the code, shall apply to all new buildings in Fiji. Where major retrofits are carried out, relevant clauses from the Sustainability Chapter may also apply. Building typologies in the Sustainability Chapter remain the same as in the FNBC.

Principles for the development of the Sustainability Chapter:

1. **Complementarity** – SC is a part of the Fiji National Building Code and the contents complement, not contradict the code. Where relevant, related clauses in the code will be referenced.
2. **Minimize cost increase** – SC clauses that result in significant cost increase for buildings are presented as recommendations, where survival of occupants are not dependent on compliance. Clauses for compliance in the SC will be kept to those strictly necessary for safety of occupants. The SC utilizes graphical contents to facilitate adoption of recommendations.
3. **Facilitate adoption** across the building industry – The clauses distil information from key references with specific relevance to Fiji, and to the extent possible, are presented directly in the document text rather than cross reference other documents. However, further details for designs not covered in the SC would have to be referenced from the documents.
4. **No regrets planning** – Precautionary, inclusive planning.
5. **Optimize local knowledge and resources** – This includes recognizing vernacular architecture, local materials and indigenous knowledge and skills that promote the sustainability of buildings in Fiji.
6. **Life cycle planning** – The SC provides guidance on enhancing building performance and minimizing environmental impacts from buildings across all stages of the building life cycle.

Compliance requirements

The contents of the Sustainability Chapter mainstream climate preparedness into the design and operation processes for buildings. Some clauses are included as guidance for good practice, while those essential for ensuring safety of occupants are deemed requirements.

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[1] IPCC Report (2014) https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap29_FINAL.pdf, only impacts which can be mitigated through building responses are mentioned.

[2] International Climate Change Adaptation Initiative (2011). https://www.pacificclimatechangescience.org/wp-content/uploads/2013/06/1_PCCSP_Fiji_8pp.pdf

Each section will be accompanied with an indication of the required level of compliance, which may differ for different building types, as show below.

REQUIRED LEVEL OF COMPLIANCE	GUIDANCE	RECOMMENDED	MANDATORY

Guidance indicates the clauses provide information on adoption. *Recommended* measures are not immediately mandatory but encouraged for adoption to relevant building classes. These measures may be upgraded to mandatory clauses in subsequent updates to the Sustainability Chapter. *Mandatory* clauses require demonstration of compliance in building plans.

For the purposes of determining compliance requirements in the Sustainability Chapter, "individual dwellings" includes Class 1 buildings while "group dwellings" include relevant buildings in Classes 2 to 4. Other building classes are understood to be non-residential.

TABLE 1

Classes of buildings in the Fiji National Building Code

Class 1	Class 1A	A single dwelling being a detached house or one or more attached dwellings.
	Class 1B	Boarding/guest house or hostel not exceeding 300m² and not more than 12 people reside.
	Which is not located or below another dwelling or another Class of building other than a private garage.	
Class 2	A building containing 2 or more sole occupancy units each being a separate dwelling.	
Class 3	A resident building, other than a class 1 or 2, which is common place of long term or transient living for a number of unrelated persons.	
Class 4	A dwelling in a building that is Class 5,6,7,8 or 9 if it is the only dwelling in the building.	
Class 5	An office building used for professional or commercial purposes, excluding buildings of Class 6, 7, or 9.	
Class 6	A shop or other building for sale of goods by retail or the supply of services direct to the public.	
Class 7	A building which	
	Class 7A	Is a car park.
	Class 7B	Is for storage or display of goods or produce for sale by wholesale.
Class 8	A laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing or cleaning of goods or produce is carried on for trade, sale or gain.	
Class 9	A building of a public nature	
	Class 9A	A health care building.
	Class 9B	An assembly building in a primary or secondary school, but excluding any other parts of the building that are another class.
	Class 9C	An aged care building.
Class 10	Class 10A	A private garage, carport, shed or the like.
	Class 10B	A structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool or the like.

SECTION 1

ADAPTING TO CLIMATE CHANGE

As described in the introduction, anticipated effects of climate change affect the building stock in Fiji through increasing average temperatures and increasingly intense storms. The measures in this section discuss low carbon strategies to adapt to such impacts.

1.1 Minimize solar heat gain

Heat energy from the sun can warm up the interior of buildings by entering through windows and openings or by heating up walls and roofs, and subsequently the indoor spaces.

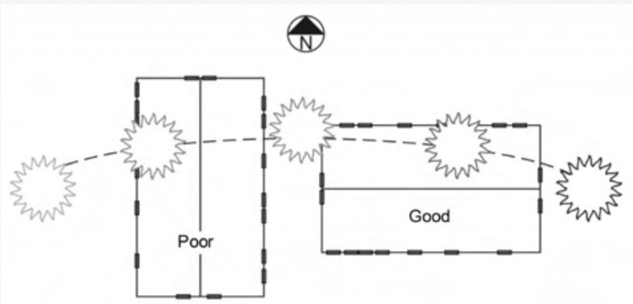
1.1.1 Building orientation

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

The orientation of buildings determines the effectiveness of passive design in maximising thermal comfort an level of natural lighting. Building orientation should consider **solar angle** and the dominant **wind direction.**[3]

a. Longer sides of buildings to face N-S direction to reduce solar heat gain through the building envelope. The shorter sides of the buildings face the E-W direction absorb less radiant heat, reducing the heating of building interior (see Figure 1.)
b. Rooms/spaces adjacent to E-W facing walls to be designed for functions that accommodate higher temperatures due to solar heating. E.g. laundry area, storage space, etc.
c. Windows in the East and West facing walls should be avoided, unless well-shaded.

FIGURE 1
Effect of Solar Angles on Building Orientation Throughout the Day



[3] The dominant wind direction in Fiji is from East-Southeast, but this should be determined for island specific projects and developments. Introducing openings towards the dominant wind direction promotes natural ventilation of the building interior.

1.1.2 Thermal mass of materials

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

Thermal mass describes a material's capacity to absorb, store and release heat. Building materials with thermal mass help in regulating the indoor temperature and maintaining thermal comfort by alternately storing heat in the day and releasing it at night. Materials with thermal mass typically have high (volumetric) heat capacity (require a lot more heat energy to change their temperature), thermal conductivity and material density. Examples of materials with high thermal mass include concrete, stone, brick and ceramic tile. Table 2 provides the thermal properties of some common building materials for reference. More on R-value in the Technical Notes.

Volumetric Heat Capacity, ***VHC = Specific Heat Capacity × density*** (kJ/m^{3}K)

a. Selection of building envelope materials should consider thermal properties in combination with intended insulation (1.1.3).

TABLE 2
Thermal properties of commonly used building materials

MATERIAL	THICKNESS (m)	DENSITY kg/m3	SPECIFIC HEAT CAPACITY J/kgK	THERMAL CONDUCTIVITY W/mk	R-VALUE (m2K/W)
Concrete block	Min=0.100 Max=0.324	2300	1000-1050	1.63	0.05
Reinforced concrete	Min=0.200 Max=0.400	2300-2400	1000	2.3-2.5	0.07
Bricks	Min=0.090 Max=0.354	1700	800	0.73	0.05-0.07
Timber	Min=0.070 Max=0.090	650	1200	0.14	0.12-0.25
Stone	N/A	2300	1000	1.8	0.014

Source: multiple[4]

1.1.3 Insulation

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

Thermal insulation reduces the transfer of heat across the material. This can reduce the heat gain inside buildings on a hot day. Materials used for insulation typically have much lower thermal conductivity than materials used for thermal mass and generally do not have a high capacity to store heat. The use of insulation for walls and roofs reduces the U-value (lower U-value means less heat transferred from building exterior to interior) and conversely increases the R-value.

A combination of good insulation and thermal mass can be used to achieve an optimum solution.

Insulation in this section refers to materials in the building envelop to resist radiant heat gain through the roof, floor and walls. (For fireproofing and acoustic insulation, refer to the FNBC DC and NC2.) Other factors that could affect the selection of insulation type include condensation control, moisture absorption, non-combustibility and acoustic performance. Table 3

4 Sources of data for Table 2: Density, thermal conductivity - Environment design guide, DES 4, Australian Institute of Architects, Melbourne; Specific heat capacity – Greenspec UK https://www.greenspec.co.uk/building-design/thermal-mass; R-values https://efficiencymatrix.com/building-material-r-values

provides indicative thermal properties for some insulation materials. Insulation suppliers should provide product-specific performance information.

a. Thermal insulation should be of adequate material and thickness to prevent significant radiant heat gain through the envelop.
b. Sheet insulation should overlap to form a continuous layer across the envelop.
c. Where reflective insulation is used, the necessary airspace between a reflective side of the insulation and a building lining or cladding to achieve the required R-Value (Table 4) must be provided. Supplier should provide insulation performance data and installation guidance.
d. Bulk insulation is more effective at reducing cooling loads in mechanically cooled buildings. The R-value of bulk insulation is reduced when compressed, installation guidance from suppliers should be followed.
e. Building components should comply with minimum R-Value in Table 4, with roof insulation for all building types aiming to achieve R-value of 5.68 (RSI 1)[5].
f. Thatch is a common roofing material for residential buildings with excellent insulating properties. Further testing is needed to document the R-value achieved with such traditional construction methods and materials. Based on historical evidence, thatch shall be deemed adequate as a roofing material for thermal comfort in individual dwellings. However, the installation of thatch roof for Class 1 buildings must pass the fire safety requirements in the FNBC Section DC.
g. The selection of thermal insulation must also take into account end-of-life disposal issues. Materials that cannot be reused and recycled and can cause significant environmental harm must be avoided.

TABLE 3

Thermal properties of common insulation materials

INSULATION MATERIALS	THICKNESS (mm)	DENSITY kg/m³	SPECIFIC HEAT CAPACITY J/(Kg. K)	THERMAL CONDUCTIVITY W/m.K	THERMAL RESISTANCE K-m2/W
Polyurethane (PU)	40 – 80 mm	30 - 40	1800	0.020 - 0.038	
Polyisocyanurate (PIR)	40 – 60 mm	32		0.022 - 0.028	4.76 - 4.54
Phenolic Foam (PF)	40 – 55 mm	35 - 200		0.020 - 0.025	4.76
Expanded polystyrene (EPS)	60 – 95 mm	15 - 30	1300	0.030 - 0.045	3.52
Extruded polystyrene (XPS)	50 – 80 mm	28 - 45	1450	0.025 - 0.037	3.44- 2.77
Glass wool	25 – 50 mm	16 - 48	1030	0.031- 0.044	3.10 - 2.25
Rock wool	50 – 100 mm	48 - 144	1030	0.035 - 0.044	2.85 - 2.25
Cellular glass/Foam glass	32 –	115	1000	0.04 - 0.05	0.041 - 0.059
Cellulose (loft)		27 - 65	2020	0.035	2.632
Hemp		192 - 288	1800 – 2300	0.038 - 0.042	2.56
Woodwool	7 – 10 mm	600	1470	0.100 - 0.125	
Fiberglass		64 - 144	600	0.036 - 0.031	3.1 - 3.4

Sources: multiple[6]

5 Higher requirement recommended in the EE Report by NBI (2014).

6 IFC EDGE User Notes (P 71) and https://www.greenspec.co.uk/building-design/insulation-materials-thermal-properties/

TABLE 4
Minimum R-value for building components for housing

	ROOF / CEILINGS	WALLS	FLOORS
Buildings Class 2 to 9 **Min. total R-value for building envelope** (Refer to NCC Vol 1 for details.)	3.2 – 4.2	1.4 - 3.3	1.0 – 2.0
Building Class 1 and 10 **Min. total R-value for building envelope** (Refer to NCC Vol 2 for details.)	3.1 – 5.1	2.4 – 2.8	1.5

Source: National Construction Code of Australia[7]

1.1.4 Sunshade to minimize heat gain

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	GUIDANCE

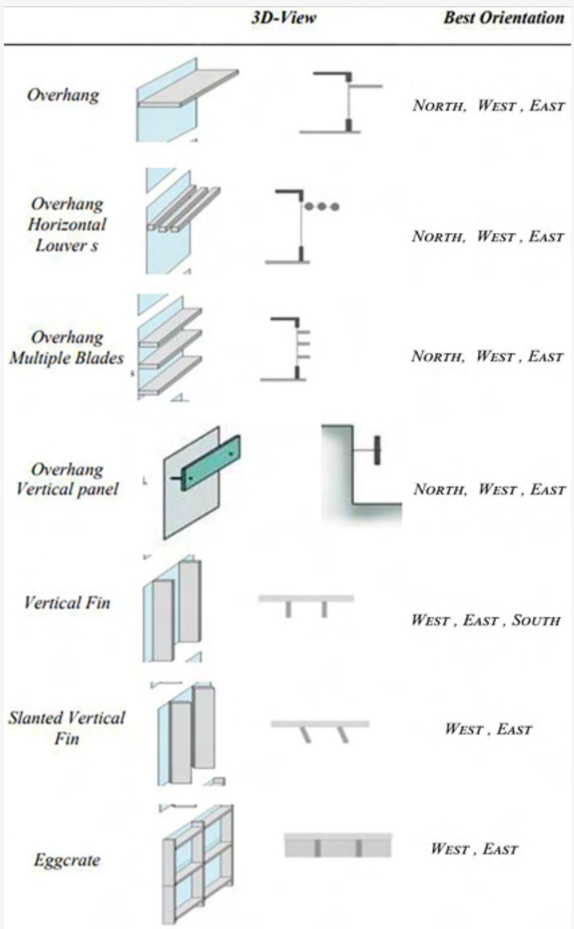
Energy from the sun passes easily through glass surfaces and heat up building interior. When windows are closed, as in air-conditioned spaces, this heat becomes trapped inside and will require greater amount of electricity to cool the room. External shading for glazing can deflect direct sunlight and improve thermal comfort inside buildings.

a. Vertical shading is more effective for façades oriented to East and West. Horizontal shading is more effective for façades oriented to North and South. Table 5 below shows the best orientation for installing different types of shading device.
b. Additional design considerations for optimizing shading in tropical climate:
   - Leverage shading from trees and shrubs to deflect direct sunlight from buildings, especially in the East and West-facing facades.
   - Features such as verandas and lattice screens can provide shading and improve thermal comfort inside buildings.

c. North-facing walls should provide shading with projection factor (D/H) of at least 0.5. Refer to Figure 2. Table 6 provides estimates for the shading factor based on window orientation and shading dimensions.

Moveable window shading can provide optimal shading throughout the day. These can be user-controlled or sensor-operated.

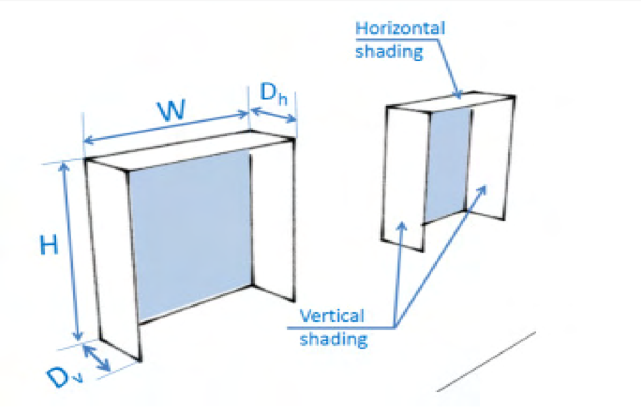
TABLE 5
External shading devices and most effective orientation



Source: IFC EDGE

[7] Data obtained from https://ncc.abcb.gov.au/ in November 2021.

FIGURE 2
Sunshade dimensions for assessing the shading factor



Source: IFC EDGE

TABLE 6
Estimation of shading factors/shading coefficient

SHADING PROPORTION	S	SE	E	NE	N	NW	W	SW	AVERAGE
				HORIZONTAL SHADING					
D_h=H/1	0.47	0.44	0.47	0.51	0.51	0.52	0.49	0.47	0.48
D_h=H/2	0.42	0.38	0.38	0.40	0.43	0.42	0.41	0.41	0.40
D_h=H/3	0.36	0.33	0.31	0.32	0.35	0.35	0.34	0.35	0.34
D_h=H/4	0.32	0.29	0.26	0.27	0.30	0.30	0.30	0.32	0.29
				VERTICAL SHADING					
D_v=W/1	0.21	0.24	0.20	0.20	0.23	0.18	0.20	0.21	0.21
D_v=W/2	0.19	0.21	0.16	0.16	0.21	0.15	0.17	0.19	0.18
D_v=W/3	0.17	0.18	0.14	0.13	0.17	0.14	0.15	0.16	0.15
D_v=W/4	0.15	0.16	0.12	0.11	0.15	0.12	0.13	0.15	0.13
				COMBINED HORIZONTAL AND VERTICAL SHADING					
D_h=H/1, D_v=W/1	0.69	0.69	0.67	0.71	0.74	0.70	0.70	0.68	0.70
D_h=H/2, D_v=W/2	0.60	0.58	0.54	0.56	0.64	0.57	0.59	0.60	0.59
D_h=H/3, D_v=W/3	0.53	0.51	0.45	0.45	0.53	0.49	0.50	0.52	0.50
D_h=H/4, D_v=W/4	0.47	0.45	0.39	0.38	0.45	0.42	0.43	0.46	0.43

Data source: IFC EDGE

1.1.5 Exterior glazing[8] performance

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	RECOMMENDED

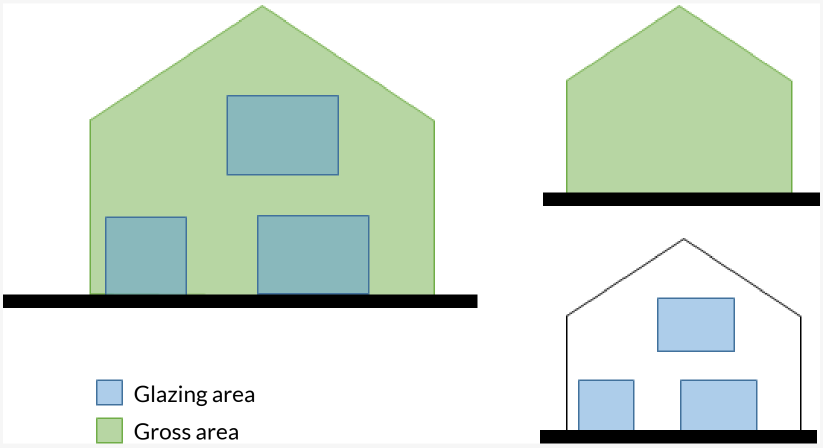
Increasingly, designers favor the use of glazing in building envelopes to increase natural lighting and connect building occupants with the view of the surroundings. This increases the amount of solar radiation absorbed through building envelopes, increasing energy consumption for air-conditioning. For fully air-conditioned buildings, a lower window-to-wall ratio can reduce cooling demand.

Window-to-wall ratio, WWR: This is the ratio of the total area of glazing over the total envelope surface area.

$$WWR\ (\%) = \frac{\Sigma\ Glazing\ area\ (m^2)}{\Sigma\ Gross\ exterior\ wall\ area\ (m^2)}$$

Figure 3 Illustrates the building areas to be used in the equation above.

FIGURE 3
Illustration on computation areas for window-wall ratio



a. Glazing in East, West and North-facing facades should not exceed WWR (see Figure 3) as shown in Table 7.
b. U-value and SHGC for façade glazing in directions should not exceed values in Table 7.
c. Where locally manufactured windows are not available, Australian Fenestration Rating Council (AFRC) 5 Star cooling-rated window should be selected.

TABLE 7
Reference design glazing values

	U-VALUE OF GLAZING W/m²K	U-VALUE OF WALLS W/m²K	SHGC	WWR
Class 1-4: Residential (houses and apartments)	5.7	1.86	0.5	25% - 35%
Class 5: Offices	5.7	1.86	0.5	40%
Hotels	5.7	1.86	0.5	40% - 55%
Class 9: Schools, Universities	5.7	1.86	0.5	40%

(Source: IFC EDGE)

[8] Glazing refers to any area in the building exterior wall covered with glass, including windows, doors and curtain walls.

1.1.6 Cool Roofs

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

1.1.6 and 1.1.7 should be considered in parallel. Both measures need not be adopted within the same building. Building roofs provide shelter for the interior from sun, rain and strong winds. The roof in a tropical climate, such as Fiji's, should be **reflective, insulated** and **ventilated.** A cool roof reflects heat energy from the sun. This reduces heat absorbed into buildings, reducing energy requirements for cooling, and maintaining a comfortable environment for building occupants.

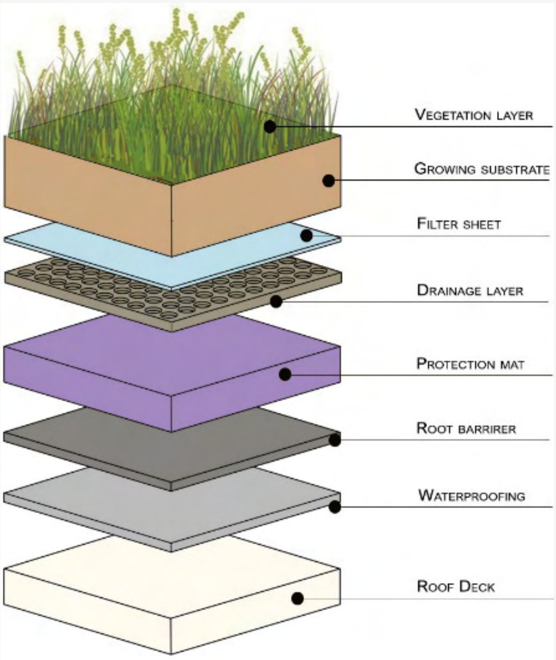
a. **Solar absorptance** is the proportion of the total incident solar radiation that is absorbed by the roofing material, with the remainder being reflected. Roofing materials in Fiji should have a solar absorptance of no greater than **0.45**;
OR

b. **Solar Reflectance Index (SRI)** is a measure of the ability of the roof to repel (reflect and emit) solar heat. SRI is measured between 0 to 100 with standard black being zero (absorbing most solar heat) and a standard white is 100. Lighter colored materials and reflective paints can improve the reflectivity and increase SRI. Roofing in Fiji should have aged SRI of at least 64. (EDGE: 45 base case, 85 best practice.)
OR

c. For mechanically cooled spaces/buildings in all building classes, bulk insulation must be installed in the ceiling to achieve at least R-1 insulation value. Insulation must be installed per manufacturer's specifications.

1.1.7 Green Roofs

FIGURE 4
Layers of Green Roof



Individual dwelling	GUIDANCE
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

Green roofs provide insulation and natural cooling through evapo-transpiration. On hot days, green roofs can be cooler than the ambient temperature, reducing the energy required for space cooling in buildings. Benefits of green roofs include:

- Increased rooftop insulation and reduced rooftop temperatures lessen HVAC loads, resulting in energy cost savings.
- Increases in property values and marketability, especially in urban areas with little green space.
- Improved stormwater retention and filtration as plants and growing medium help to neutralize acid rain and trap dust particles.

a. Fully air-conditioned buildings must designate at least 25% of roof areas for vegetation.
b. Plant selection in the design of green roofs must prioritize local species or those well-adapted to the climate of Fiji, not requiring excessive amounts of water.

Green roofs utilize rooftop spaces for vegetation. Table 8 describes the main types of green roofs.

TABLE 8
Comparing features in different types of green roofs

	EXTENSIVE	SEMI-INTENSIVE	INTENSIVE
General description	• Lightweight. • Ideal for large, flat commercial/ apartment rooftops. • Ideal for no public access. • Low maintenance needs.	• Moderate maintenance. • Occasional irrigation required.	• Regular irrigation and maintenance. • Fully landscaping, ideal for public access for recreation, farming, sport, etc.
Thickness (growing medium)	10 – 20 cm	15 – 35 cm	40 – 100 cm
Approximate load	70 – 160 kg/m^2	120 – 250 kg/m^2	> 400 kg/m^2

Structural considerations when planning for a green roof:

- The weight of plants may increase significantly over time, especially where shrubs and trees are proposed – obtain long term loading from landscape consultant.
- The weight of the green roof will be higher during rainfall events as water is trapped within the planting medium. Stormwater discharge rates should account for anticipated storms. (Refer to DF7 and NF7.)
- Consider the effect of wind load on the vegetation when selecting plants.
- If public access is allowed, roof loading should be designed accordingly.

1.2 Maximize natural ventilation (DF4, NF4)

1.2.1 Window openings for natural ventilation

Individual dwelling	MANDATORY
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

Natural ventilation provides a sustainable means of maintaining thermal comfort and indoor air quality. It is an effective way of managing energy consumption in buildings. Designing for natural ventilation can include various mechanisms:

- Single sided ventilation (openings along one wall);
- Cross ventilation (openings in opposite walls);
- Stack ventilation (openings at different levels).

The effectiveness of natural ventilation to provide cooling depends on the size of the space and placement of openings. Where natural ventilation is inadequate to provide sufficient air flow for the building, this must be complemented with mechanical ventilation (DF4.5, NF4.5.) Incorporating natural ventilation to spaces can be achieved through permanent openings in walls or openable windows.

In the FNBC (NF4.6, DF 4.6), the requirement for wall openings for natural ventilation of rooms is described. Openings can be in the form of windows, doors or others. Table 9 below shows the areas to be naturally ventilated by building class. Figure 5 illustrates the room depth for which each form of natural ventilation is effective for.

TABLE 9

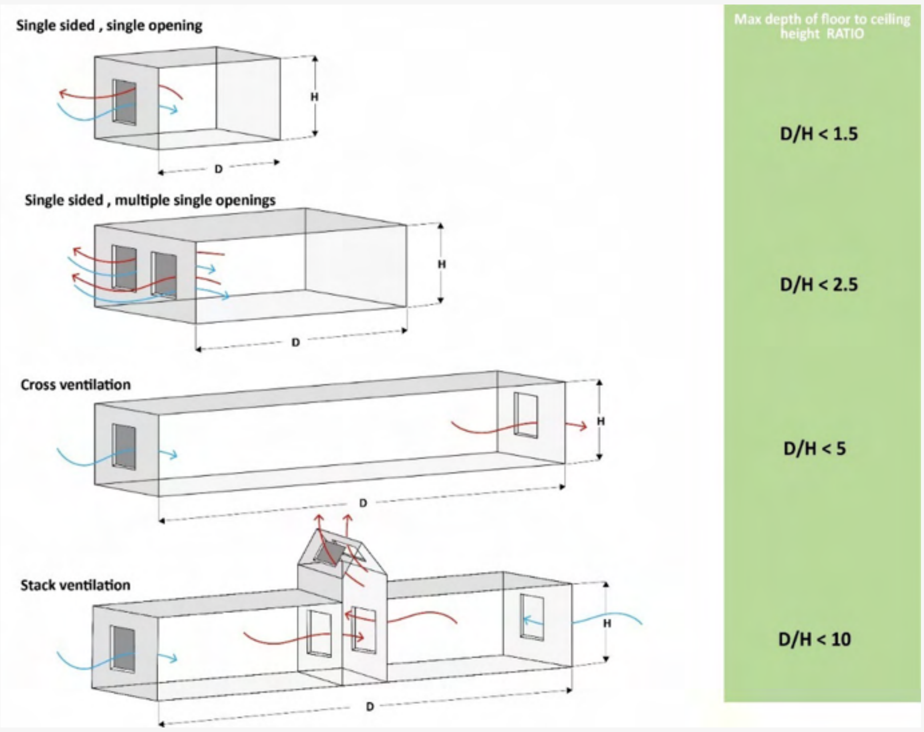
Natural ventilation requirements in different building classes

BUILDING CLASS	SPACES WHERE NATURAL VENTILATION IS REQUIRED	MIN. AREA OF OPENING REQUIRED (AS % OF FLOOR AREA)
Class 1–4: Dwellings	Bedroom, Living room	20%
	Kitchen	25%
	Corridors	10%
Class 5: Office buildings	Offices	20%
	Corridors and Lobby	10%
Class 6: Retail, café, restaurants, hairdressers	Corridors, Atrium, Common areas.	10%
Class 9: Public buildings – Hospitals	Corridors	10%
	Lobby, waiting and consultations areas, patient rooms	20%
Class 9: Public buildings – Education	Corridors	10%
	Classrooms	20%

Source: EDGE

FIGURE 5

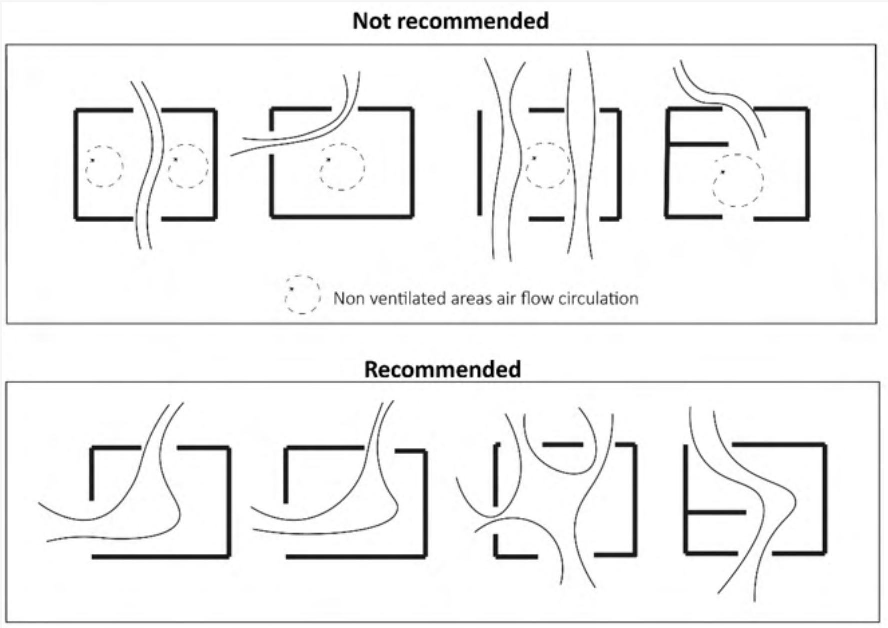
Room depth to ceiling height ratio for different ventilation mechanisms



Source: IFC EDGE

a. **Single sided ventilation:** Single sided ventilation is usually driven by wind turbulence. The effectiveness in ventilating a room depends on the room depth (D) to ceiling height (H) ratio. Rooms with single sided ventilation must maintain D/H ratio <1.5. Rooms with multiple openings in the same wall must maintain D/H <2.5. Ideally, the **windows** should be **tall** with **top and bottom openings.** Single sided ventilation is **less effective for spaces with greater depth.**

FIGURE 6
Air flow in rooms with openings for natural ventilation

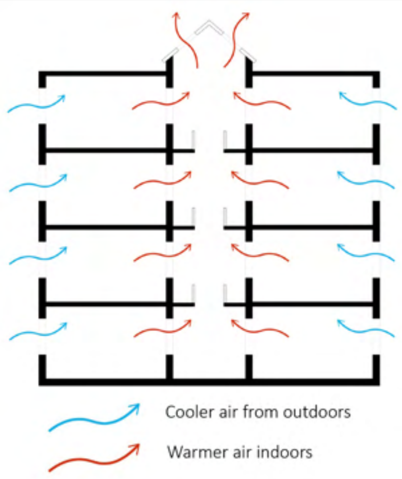


b. **Cross ventilation:** Cross ventilation achieves good air change rates driven by pressure differences across the building. Rooms with openings on two opposite walls must be designed with D/H ratio less than 5.0. Cross ventilation is used in spaces with openings on both windward and leeward sides, and also **double banked rooms** that rely on opening in corridors between rooms (see DF4.7 and NF4.7 for exceptions.) To optimize effective cross ventilation, windows on opposite walls should be placed a crossed from but not directly opposite from each other's for a better room air mix (Figure 6).

c. **Stack ventilation:** Stack ventilation employs a combination of cross ventilation, buoyancy and suction effect to ventilate an enclosed space and is a highly effective strategy for natural ventilation. Cooler air enters the building at low level and is heated by occupants, equipment, lights and others, as it flows through the space. Warmed air becomes less dense and rises through the building to be released to the building exterior at the top opening. Stack ventilating system relies on the difference of inside and outside air pressure to create the air flow through buildings. It can be particularly effective at night as internal and external temperature differences at night are higher than during the day, increasing convection.
For tall buildings, a central atrium functions as a ventilation shaft. In other buildings, the lift shaft can double as the ventilation shaft, provided there are openings at the lower and higher levels to enable air flow (see Figure 7.)

d. Stack ventilation air flow modelling is needed to illustrate how the sprinkler system, exhaust system and air flow through the opening will interact to prevent the spread of smoke and fire in the event of a fire in the building and to inform the design of openings for optimal ventilation. (FNBC NC2)

FIGURE 7
Building with central ventilation shaft to facilitate stack ventilation

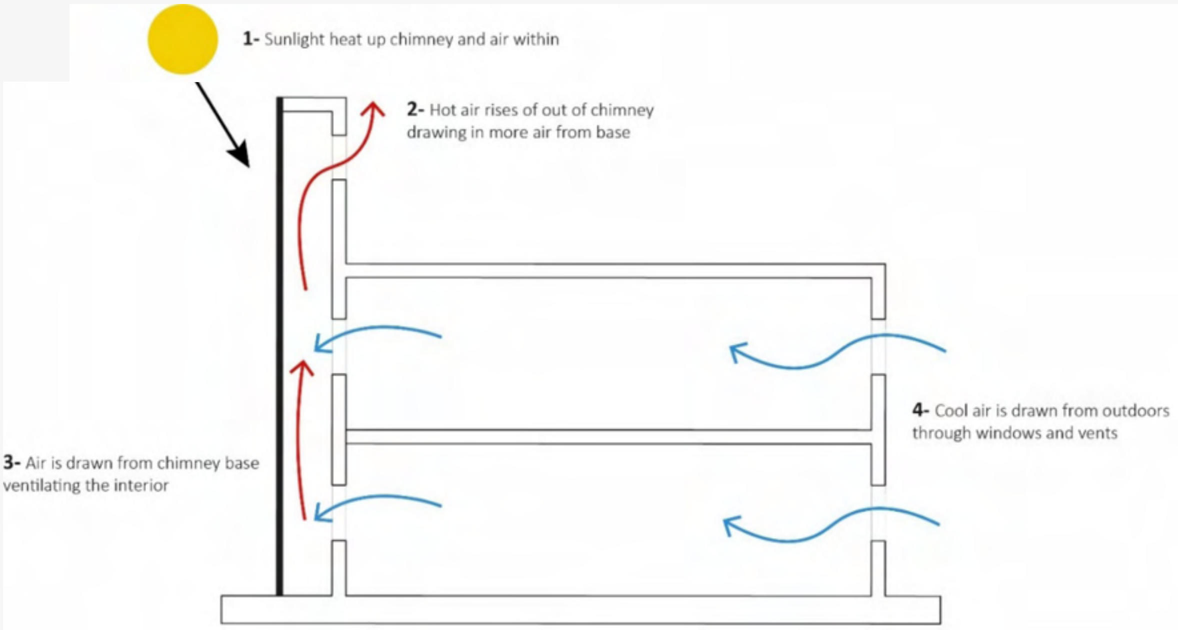


1.2.2 Solar chimneys:

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	GUIDANCE

Solar chimneys are particularly effective in humid and hot climates, relying on natural solar radiation to create the driving force for ventilation. Solar chimneys are generally tall wide structures constructed **facing the sun** (east/west orientation) with a **dark-colored matt surface designed to absorb solar radiation** (Figure 8). As the chimney warms up, the air inside also gets heated. The hot air rises up the chimney and is vented out of the top. This creates a suction force drawing air in at the bottom of the chimney.

FIGURE 8
Air flow for solar chimneys



1.3 Safe siting for buildings

As the climate warms, sea level rise is projected in the coming decades. Increasingly intense storms also lead to threats such as landslides and inland flooding. In consideration of these threats, the Government of Fiji will provide guidance on the areas suitable for the construction of buildings. Buildings to be reinforced to projected wind loads (FNBC Section B1.2).

1.3.1 Site buildings in suitably zoned areas

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

a. Applications for building permits must refer to hazard guidance[9] by the Fiji Meteorological Service and demonstrate safety of proposed development from anticipated flooding impacts. Land zoning for flooding risks may differ for different building classes. In the absence of flood maps, land use advice from the relevant departments must be sought prior to application for permit to build. Building permits should verify the land-use designation and zoning bylaws.
b. Existing buildings should seek to mitigate flood risks and associated damages if situated in flood prone areas.
c. New buildings must not be sited in areas designated by the Government of Fiji as environmentally significant sites.

1.3.2 Building design for intense storms

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

a. All buildings must be designed to withstand the updated design wind load in the FNBC to account for increasingly intense storms. (B.1.2)
b. Existing buildings should be assessed for adequacy and upgraded to meet updated design wind load in the FNBC if found inadequate.
c. Buildings should be designed to regular, compact building shapes to reduce torsion. Squares or rectangles (length < 3x widths) are optimal. L-shaped building plans or other irregular shapes should be avoided. If these are unavoidable, structural reinforcement is needed at all building corners, as indicated in structural models.
d. Pitch roof angles should be steeper than 22° to the horizontal to minimize uplift.[10]
e. Wide overhangs such as verandas should be avoided. If these are constructed, verandas should be separated from main structure as in Figure 9.

FIGURE 9
Recommended separation of veranda shelter from main building

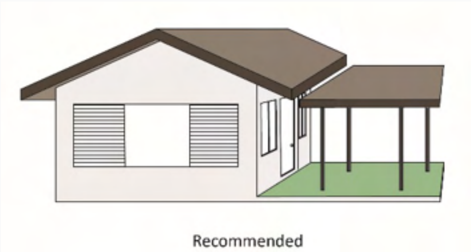
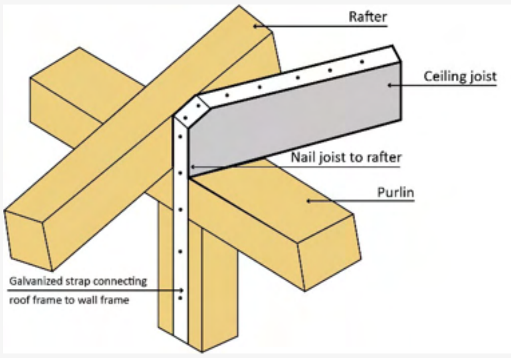


FIGURE 10
Galvanised strap to hold roof frame to wall structure



f. Ensure adequate fixings from roof and building structure to the foundation to resist uplift forces during storms (Figure 10).
g. Reinforce bracings and joints.
h. Rooftop equipment, including solar PV panels, should follow the roof pitch where possible and be securely bolted on to brackets. PV panels must not be held down through use of top-down self-tapping screws.

9 Flood and other hazard maps are not yet fully developed for the key urban areas in Fiji.

10 Cyclone resistant architecture (2007), https://nidm.gov.in/PDF/safety/flood/link2.pdf

SECTION 2

ENHANCING RESILIENCE OF BUILDING STOCK

Resilience is the *capacity of buildings to retain or rapidly regain functionality in the event of shock, or disturbance.* Climate induced stresses and shocks can affect buildings in numerous ways. In Fiji, severe storms pose the most immediate climate threat to buildings. Resilience needs for different classes of buildings will differ, as indicated in each sub-section.[11] In particular, ***Class 9 (public buildings) buildings that have been designated as Assembly Areas or Evacuation Centres (as in the National Development Plan) in the aftermath of disasters will be held to higher requirements for post-disaster resilience.***

Designing and constructing buildings for climate resilience seeks to *prevent collapse, limit damage or permit quick recovery.* Requirements for structural adequacy to prevent collapse is covered in the Fiji National Building Code (including both ultimate and serviceability limits), this chapter will discuss the aspects of ***limiting damage and promoting recovery***. This section describes the requirements for maintaining the safety and wellbeing of building occupants in the event of cyclones.

Requirements to achieve this may sometimes contradict the design for climate sustainability, which emphasis resource efficiency and waste minimization With adequate information and planning tools, building owners and managers can make informed decisions on which aspects of buildings can be allowed to fail, and to what extent, as well as plan for recovery actions.

2.1 Enhance building durability

The need to design buildings for increased storm intensity and wind speeds has already been discussed. Further actions can increase the robustness of buildings to withstand seasonal storms.

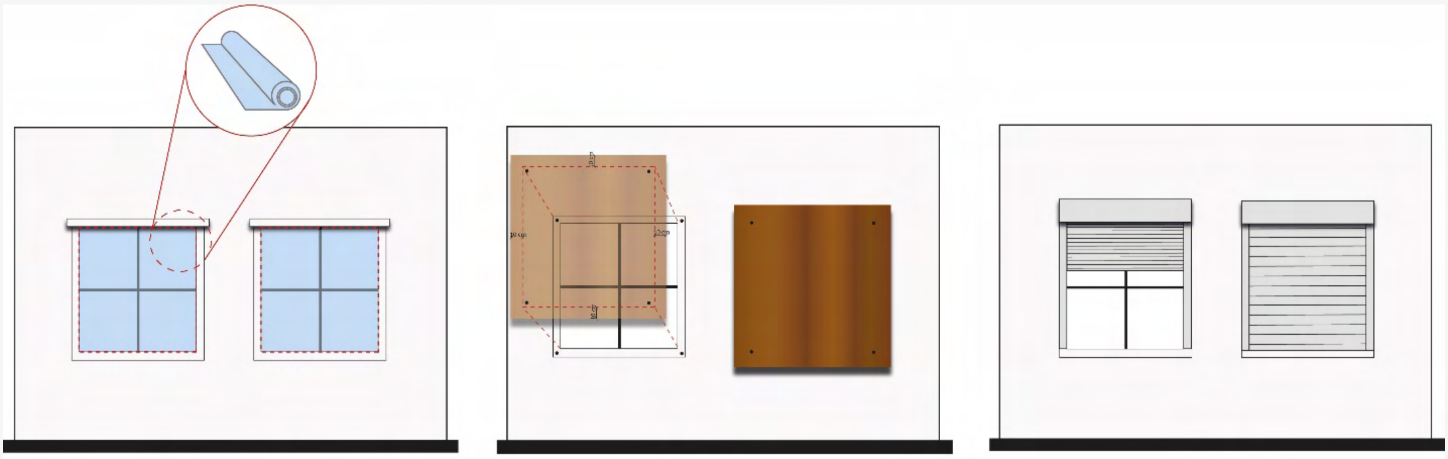
2.1.1 Reinforce windows and openings

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

Storm protection for glazing can be temporarily or permanently installed. These are barriers to prevent flying debris from breaking windows and doors during storm events when wind speeds are high. Figure 11 illustrates several options for protecting windows from storm damage.

[11] The RELi Resilience Action List provides a comprehensive approach to resilience planning for buildings and communities. RELi | C3 Living Design Project

FIGURE 11
(a) Hurricane file on window panes (b) Protective plywood sheets
(c) Retractable window shutters



Hurricane film is a plastic (often transparent) film that is installed directly on windows. The film prevents any broken glass from flying into buildings and causing injury. The protective layer also blocks out UV rays from the sun and can be left in place all year round.

Plywood is another means of protecting windows during extreme storms. These are inexpensive, but installation needs to be adequately screwed or nailed to masonry walls or window frames. Plywood layers should be at least 0.5" thick to provide sufficient protection from the wind and impact from flying debris.

Shutters operate by the same principle as plywood but are installed permanent and activated during storm events. Shutters can be made of plastic, fabric, wood or metal, with a range of functionality, maintenance needs and costs.

a. Storm protection measures must take into account anticipated impact loads from flying debris as indicated in the FNBC Section B1.2. Supplier warranty may be accepted in lieu of laboratory test certificate.
b. Doors and window assemblies must ensure watertightness under design cyclone conditions. Supplier guarantees are acceptable in lieu of laboratory certificates.

2.1.2 Regular maintenance and repairs

Individual dwelling	RECOMMENDED
Group dwelling	MANDATORY
Non-residential	MANDATORY

Design buildings with the operational phase in mind. This requires designers to plan for maintenance needs, including **access** for cleaning, inspections and repairs. Designing for **standard** parts and appliances simplifies the repairs and replacement needs throughout the building life.

Building owners and facility managers should keep a building maintenance plan to record routine maintenance and repair activities. The plan should preventative maintenance for the building structural, site drainage, landscaping, utilities, plumbing, and mechanical electrical systems.

2.2 Mitigate flood damage

The frequency, type and depth of flooding could affect the requirement for the strategies discussed in this section. The requirements will not be equally relevant for buildings at different levels of risk of flooding. While more pertinent for buildings located in low-lying and coastal areas, flooding due to storms and groundwater accumulation may also affect all buildings in general. Where possible, avoid building on low-lying and flood-prone areas.

Water entry to buildings can be prevented during floods of shallow depths (less than 0.3m) and short durations (less than 1hour). The solutions presented in this section are not exhaustive, but draw from the current solutions that can be readily adopted in Fiji. Building owners/ designers should have an integrated flood management plan consisting of flood prevention and damage mitigation.

2.2.1 Durable/ water-resistant materials (NF1.4)

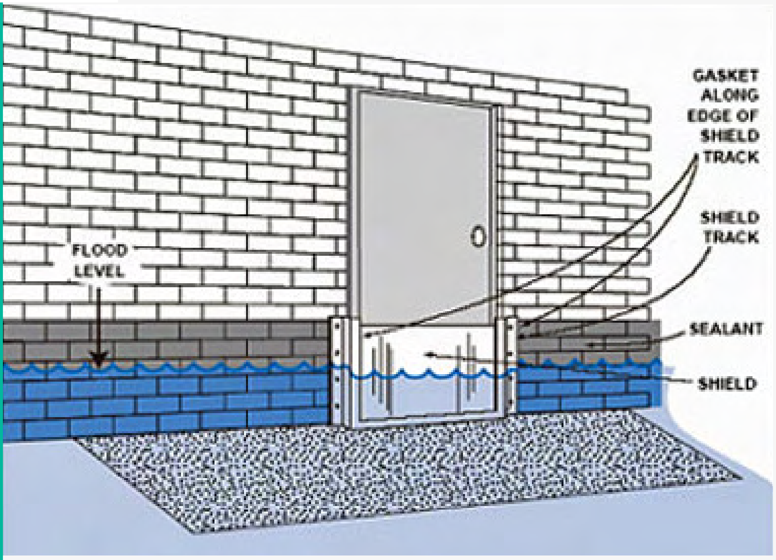
Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. Building materials must be able to withstand temporary inundation (up to 72 hours) without sustaining significant damages Such materials include concrete, glazed brick, closed-cell and foam insulation, steel hardware, pressure-treated and marine-grade plywood and ceramic tiles.

b. Coatings, sealants and veneers (Figure 12) can further help reduce water damages caused by short-term flooding (up to 72 hours). Waterproofing layers can be taped, bolted or painted on structural surfaces. These prevent water from entering buildings through structural elements and openings.

c. *Building retrofit projects should consider flooding potential and coping strategies when planning building repairs and upgrades.*

FIGURE 12
(a) Various forms of flood mitigation, (b) Spray on waterproof layer for wall protection



Source: FEMA

2.2.2 Swales and landscaping (NF1)

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

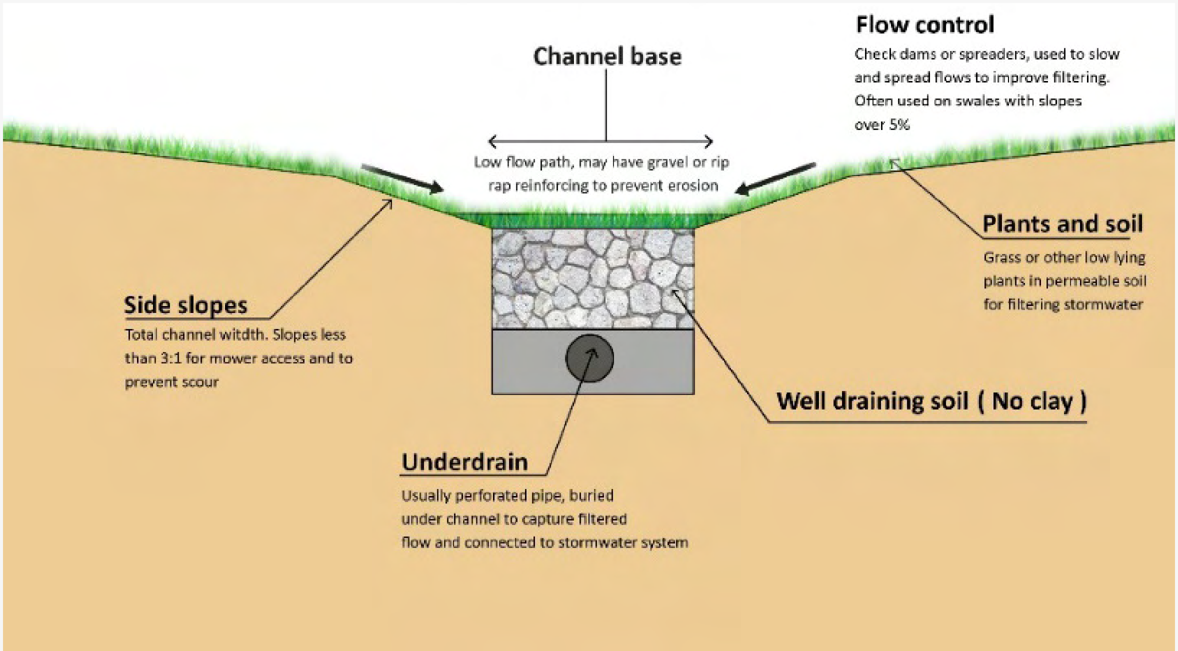
a. Increasing vegetated areas around buildings improves the capacity of land to absorb stormwater runoffs and mitigate minor flooding. Landscaped areas also reduce heat island effects and provide spaces for enhancing the wellbeing of building occupants.

b. Plant selection should be based on locally adapted species. See 3.2.3 Efficient water use on selection of plants.

Swales[12] are shallow grassy channels used to direct and slow stormwater runoff. Swales feature gradual trench that directs surface water across grass cover and through the soil. Swales help filter sediments, nutrients and contaminants from incoming stormwater before discharging to downstream stormwater system or waterways. Swales are low-cost features that are simple to construct and maintain.

Swales should be constructed on flat ground (less than 10° incline). Dams can be constructed to slow the flow of water if required. Regular maintenance mainly includes removal of litter from grass surface and clearing any silt build-up at pipe inlets and outlets.

FIGURE 13
Typical cross section and components of a swale



2.2.3 Elevate buildings

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	GUIDANCE

a. Buildings in flood prone areas can be elevated, taking reference from Fiji traditional houses, which can be built on a platform of stones, as in a *bure* or raised on a wooden frame. Elevation of buildings above the ground can also promote passive cooling but will likely increase construction costs. The required level of elevation will depend anticipated flood levels.

[12] Further reference on construction methods for swales: Swales and filter strips Construction guide (aucklandcouncil.govt.nz) Other sustainable drainage resources: B£ST (susdrain.org)

FIGURE 14

(a) Traditional bure constructed on platform of rocks, (b) Fijian house elevated on wooden frame

(a) Source: Bure on Rocks

(b) Source: Typical Village House

2.2.4 Placement of sensitive equipment

Individual dwelling	GUIDANCE
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. For buildings situated in flood-prone areas, equipment and appliances that are sensitive to water damage should be installed in elevated areas to minimize damage. These include mechanical equipment for heating, ventilating, air conditioning, plumbing and ducting fixtures and electrical equipment such as service panels, meters, switches, and outlets. Computers and other information technology equipment should also be protected. Figure 15 (A and B) show how some equipment can be installed at elevations to prevent flood damage.

FIGURE 15

(a) Elevating air-conditioner condenser units, (b) Elevating outdoor generator to prevent flood damage

b. Toxic or polluting substances, such as diesel tanks, must be anchored down (if stored outdoors) or stored above anticipated flood levels (if indoors).

2.3 Plan for outage of essential services

Planning for resilience requires the incorporation of redundancy in essential services, to ensure the wellbeing of building occupants during the immediate aftermath of extreme events, before recovery can take place. This section focuses on the key services for maintaining building functionality until recovery phase commences, if cut off from centralized support systems. *All clauses in this section are mandatory for all public buildings and buildings having a post-disaster function, such as Evacuation Centres. It is also required of all non-residential buildings that are not located on Viti Levu and Vanua Levu.*

2.3.1 Redundancy of electricity supply

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	MANDATORY

During storms, wind and flood damage can cause disruptions to the grid electricity supply. If occupants are trapped in buildings awaiting access to roads for evacuation, ensuring the continuity of electricity supply can maintain occupant access to communications, heating/cooling and lighting until help arrives.

a. Buildings should be fitted with back-up electricity supply in case of disruption of grid electricity. This can be through rooftop solar photovoltaic (PV) panels or a hybrid generator.
b. Backup electricity supply shall be adequate to provide for essential functions of the building, at least 25% of usual consumption levels.

While the installation costs for rooftop solar power generation can be higher than a diesel generator, solar PVs provide more reliable continuity in power supply during extreme events, if properly installed.[13] They do not emit greenhouse gases during operations and are not as vulnerable to events such as fuel shortages and price hikes. During normal conditions, solar PVs provide part or full building electricity demand, reducing operating costs. In some cases, standalone systems can also extend to form microgrids, supplying neighboring buildings with electricity until the grid supply is restored. The more common form of backup power for buildings in Fiji is the generator powered by fossil fuels. Where generators are preferred over rooftop photovoltaic panels, hybrid generators with the capacity to incorporate solar energy can be considered.

2.3.2 Redundancy of water supply

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	MANDATORY

During emergency events where grid electricity is disrupted, piped water services are very often also affected. In addition, water pipe networks occasionally break down and require maintenance, resulting in service disruptions. The volume of water to backup depends on the type of building, number of occupants and the period of outage anticipated.[14]

a. Buildings should store backup water supply in robust containers with reliable, and good sealing lids (see Figure 16.) These containers can be stored within buildings and must not have been used for storing toxic substances.

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[13] Solar Under Storm provides useful guidance for the design, installation and regulation of rooftop solar PV in typhoon-prone islands. https://rmi.org/insight/solar-under-storm/

[14] Potable water: About 3 liters per person per day for one week or access to well or spring water that can be accessed during power outages or community water supply within walking distance. Non-potable water: toilet flushing 20 liters per person per day; baths, dishwashing, etc. 8 liters per person per day.

Containers can be used to store water at all times or be filled after storm warnings have been issued.

b. Water tanks stored outdoors must ensure that tanks are securely anchored against storm wind loads and uplift forces (for empty tanks). Outdoor water tanks should be grounded to prevent lightning damage.

c. Outdoor tanks and their fixings should be inspected and maintained regularly to ensure stability and cleanliness of tanks. Water pump and pipes connected to the tank also need regular maintenance and checks.

d. Designated Post-disaster Assembly Areas and Evacuation Centres must maintain sufficient backup supplies for the local population for basic cleaning and cooking for the period until help arrives. This period will likely be longer for more remote areas.

e. For deep-well pumps, either stand-alone solar electricity or hand pumping options must be installed.

FIGURE 16
Possible water containers for backup supply

2.4 Safe access and evacuation

Buildings may be cut off from the road network during emergencies. This could be due to inundation, fallen trees, or other obstacles. Maintaining accessibility for both evacuation and for receiving emergency supplies are critical functions, particularly for Assembly Areas to maintain in the immediate period after emergencies.

2.4.1 Ensure all weather transportation link to/from building

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	MANDATORY

This requirement applies specifically to buildings designated as Assembly Areas and Evacuation Centres during emergencies and buildings providing critical functions such as hospitals, disaster coordination, telecommunications, security services, etc.

a. The access road to relevant buildings shall be constructed with an all-weather surface to adequately support the proposed loads of emergency vehicles, including fire enginesand ambulances. Road design for anticipated loading and drainage requirements should comply with requirements from the Fiji Roads Authority.[15]

b. The maintenance regime stipulated in the Road Works Standards and Specifications must be complied with, and access to these roads should be passable by authorized vehicles at all times (ensure no unauthorized parking blocks off access.)

c. If the Assembly Area is designed to be supported and evacuated through other modes of transport (i.e. air or water), ensure adequate infrastructure to maintain traffic during emergencies.

15 Road Works Standards and Specifications (September 2019). Roadworks Standards and Specifications (fijiroads.org)

SECTION 3

MITIGATING CLIMATE CHANGE

Buildings can contribute to climate change mitigation through reducing energy demand during operations and reducing the use of building materials with high embodied energy.[16]

3.1 Building materials

Building materials have long design lives and contribute significantly to the environmental impact from the industry. Building materials such as steel and cement have high embodied energy and, where possible, can be substituted with materials that have lower environmental impacts.

3.1.1 Avoid hazardous materials

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

a. The use of building materials and components containing substances that are harmful to human health must be avoided in buildings. Adverse impacts from materials should be considered at all phases of the building life – construction, operation and demolition/deconstruction phases. Such materials include (but are not limited to) asbestos, lead and other heavy metals, mercury, polychlorinated biphenyls (PCB), chlorofluorocarbons, and arsenic.

Asbestos (reference Public Health Act)
Asbestos stucco, vinyl flooring, acoustic ceiling material, linoleum, sheetrock, cement board, shingles, and multiple forms of insulation. When these components are disturbed during repairs, renovation or demolition of buildings, asbestos dust becomes airborne and absorbed into human bodies. Extended exposure to asbestos has been found to cause cancer, mesothelioma, and lung disease.

There is limited use of asbestos in Fiji[17] and the Code of Practice for Safe Removal of Asbestos (2nd edition) provides guidance on safe management if found in buildings.

Lead (reference Factories Act)
Lead and lead compounds are used in a wide variety of products found in and around buildings, including paint, ceramics, pipes and plumbing materials. Exposure to lead can result in severe illness for children, adults and animals. Avoid compounds containing lead in paints, plumbing and materials used in buildings.

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16 Embodied energy of building materials is the amount of energy consumed in the extraction, manufacturing, construction, maintenance, and disposal of the materials. Recycled materials are deemed as having zero or very low embodied energy.

17 https://library.sprep.org/sites/default/files/PacWaste_Asbestos_Report_Fiji.pdf

Formaldehyde

Formaldehyde is found in resins used in the manufacture of composite wood products (i.e., hardwood plywood, particleboard and medium-density fiberboard), insulation and other building materials. When constructing with wood-based products, select those that do not contain formaldehyde.

Volatile organic compounds (VOCs)

These include a variety of chemicals that are often used in the manufacture of paints, solvents, building materials, insulation, etc. VOCs cause health problems when inhaled in high quantities and pollute water sources when released into the environment.

3.1.2 Recycled content

Individual dwelling	GUIDANCE
Group dwelling	GUIDANCE
Non-residential	GUIDANCE

Building materials and components can often be recycled or reused from other projects. Designers should include at least 10% of recycled material content (of total building cost) for construction and major renovation projects.

3.1.3 Local materials

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

Local materials often have lower embodied energy as less energy is expended in the transportation of materials over long distances.

a. Building and renovation projects must include at least 15%[18] (of total building cost) of locally-manufactured materials.

b. Where local timber and bamboo is used, the timber sources and sustainability of harvesting methods must be independently certified.[19]

3.2 Improve efficiency

Expanding the scope of the current MEPSL to cover other electrical appliances in all types of buildings reduces the energy demand for building operations. Efficiency in cooling and lighting are the key areas for energy saving in Fijian buildings. Water efficiency is also another measure to enhance environmental sustainability.

3.2.1 Efficient cooling

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

In Fiji's climate, a substantial amount of building operational energy is consumed for cooling – both space cooling and refrigeration. Improving the efficiency of these operations can reduce cooling energy use by over 30%.[20] Efficiency in mechanical space cooling should be designed in parallel with passive cooling measures in Adaptation section of this document.

Fiji has been implementing the mandatory Minimum Energy Performance Standards and Labelling programme (MEPSL) since 2012. Imported household refrigerators and freezers need to comply with the relevant MEPS standard for Fiji.

a. All imported household refrigerators and freezers will be tested under standard conditions and rated on a comparative scale (6 or 10 star), based on operational energy demand.

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18 Referenced from International Green Construction Code (May 2021) CHAPTER 9 MATERIALS AND RESOURCES, 2021 International Green Construction Code (IgCC) | ICC Digital Codes (iccsafe.org)

19 There are several certification programs for sustainable forest products, including the Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI) and

20 NBI EE Phase II Report

b. Cooling appliances should meet efficiencies in Table 10[21]

c. All supply and return air ducts and plenums shall be insulated with a minimum of R-1 insulation when located in unconditioned spaces and with a minimum of R-1 insulation when located outside the building. Within a building, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-.5 insulation.

TABLE 10
Required efficiency for air cooling equipment.

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY	TEST PROCEDURE
Air-conditioner (cooling)	< 65kWr	See footnote 9	
	65 – 95 kWr	2.70 EER	AS/NZS 3823.1.2
	> 95 kWr	2.80 EER	
Refrigerant chillers, water cooled	≤ 350 kWr	4.2 EER 5.2 IEER	AHRI 550/590
Refrigerant chillers, air/ evaporative cooled	≤ 350 kWr	2.5 EER 3.4 IEER[23]	

d. For all building classes, each air-conditioning system shall be controlled by a thermostat.
- Air-conditioning must be capable of being deactivated when the sole-occupancy unit, building or part of the building being served is not occupied; and
- Air-conditioning must be capable of being set back to temporarily operate the system to maintain zone temperatures up to 30°C when serving the sole-occupancy unit of a Class 3 building; and
- Thermostats must have automatic time clock or programmable controls that are capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours; and
- Thermostats must have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

3.2.2 Efficient lighting

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

a. For all building types, at least 90% of light fixtures installed should be high-efficiency LED, linear fluorescent lamps (T8 or T5) or compact fluorescent (CFL). Incandescent light bulbs should be phased out.

b. The requirement applies to indoor and outdoor lighting but does not include emergency signages.

c. For building Classes 2 – 9, occupancy sensors installed in irregularly used spaces such as bathrooms can ensure lights are switched off when the rooms are not in use.

21 Energy Efficiency Ratio (EER) is a ratio of useful cooling output (in BTU/h) to electricity input (measured in W).

22 IEER formula found in Technical Notes.

3.2.3 Efficient water use[23]

Individual dwelling	MANDATORY
Group dwelling	MANDATORY
Non-residential	MANDATORY

a. **Landscaping** – Plant only native species that require minimal watering, use recycled water for watering gardens and lawns.
b. **Bathrooms** – Showerheads to run at flow rate of *6L/min* (base case 8L/min), when operating at pressure of 3bars (43.5psi).
c. **Bathrooms** – Faucets in public and private bathrooms of all building classes to run at *2L/min* (base case 6L/min) while operating at full pressure of 3bars (43.5psi).
d. **Toilets** – Water closets installed with option for half flush; *6L for full flush and 3L for half flush* (base case 8L and 4L.)
e. **Kitchen** – Faucets in kitchen sinks with maximum flow of *8L/min* (base case 10L/min) while operating at full pressure of 3bars (43.5psi).

3.3 Decarbonize electricity

The largest potential for decarbonization of electricity currently is solar power. This utilizes established technologies for tapping solar energy for heating and conversion to electricity.

3.3.1 Solar heating and rooftop panels

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. Class 1 construction must pre-plumbed for solar water heating.
b. Building classes 2-9 should install renewable energy source to cover at least 25% of building usage. This measure is strongly recommended for non-residential buildings which are fully air-conditioned. The adoption of solar energy also contributes to enhancing the resilience of the building in extreme weather events.

3.4 Waste reduction

This section discussed the waste from building construction processes and also solid waste generated during the building operations.

Waste materials from construction, renovation and demolition processes are often reusable/recyclable in other projects.

3.4.1 Construction and demolition waste management

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. At least 50% of waste materials (by weight) from construction, renovation or demolition process should be diverted from landfill or incineration.
b. Prior to construction/major renovation/demolition, owner shall submit a **Waste Material Management Plan.** The Plan shall consist of:
   - Estimate of the materials and volume to be generated during project.

23 Fiji data from IFC EDGE app, referenced January 2022.

- Identification of what components/ materials that can be reused or recycled.
- Description of method(s) for material storage and segregation during construction/renovation/demolition.
- Description of method(s) for verification of plan.

3.4.2 Waste management during building operations

Individual dwelling	RECOMMENDED
Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

During the normal course of building operations, building occupants generate waste that is disposed of in numerous ways. Building design can support increased adoption of recycling through incorporation of the below features:

a. **Recycling area** – All buildings or development should have designated areas for the segregation, collection, and storage of recyclable materials such as cardboard, plastic, glass and metals. Where relevant, organic waste can also be collected for composting. Building managers should facilitate the recycling of materials through appropriate waste management companies.

b. **Awareness raising** – Noticeboards or other means of sharing information should be installed in common areas to raise awareness on waste reduction, segregation and reuse among building occupants.

c. **Hazardous waste** – Specific collection points should be designated for the disposal building components containing hazardous substances, including fluorescent light bulbs, alkaline batteries, rechargeable batteries and electronics. Adequate disposal of such materials should be facilitated through the building management, or a waste management company.

SECTION 4

INCLUSION AND WELLBEING

4.1 Universal accessibility (DD, ND, NDP3)

Universal Design is a design approach that ensures that buildings are innately accessible to as many people as possible. It goes beyond designing for disabled access. The principles for universal design are: Equitable use, flexibility in use, simple and intuitive, perceptible information, tolerance for error, low physical effort and size and space for approach and use.

Clauses in this section enable designers to consider the mobility, information and safety needs of different users – people with different abilities/disabilities, cultural backgrounds and needs or concerns. This section mostly pertains to public buildings, non-residential buildings as homes can be customized to fit specific needs of the occupants.

The dimensions for access cover the minimum across applicable buildings, but some buildings, e.g. healthcare buildings, childcare buildings, etc. may require additional measures or enhanced requirements to ensure accessibility for the building users.

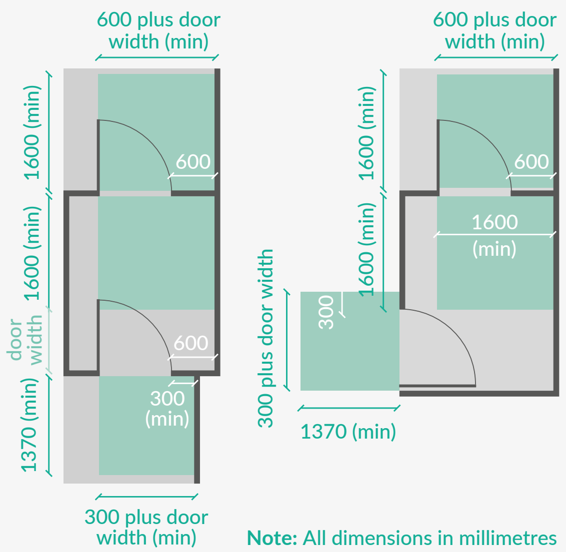
4.1.1 Building lobbies

Group dwelling	RECOMMENDED
Non-residential	MANDATORY

For non-residential buildings and group dwelling with a common-access lobby

a. There must be adequate space for maneuvering trolleys, bags, strollers, wheelchairs, etc. (Figure 17).
b. Lighting design in lobbies should be mindful of the transition from outdoor to indoor space.

FIGURE 17
Space requirements forbuilding lobbies



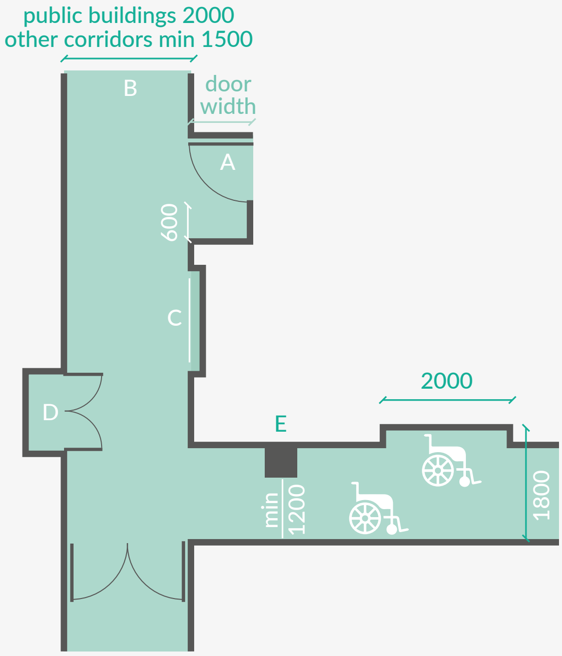
Note: All dimensions in millimetres

4.1.2 Corridors

Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. Main corridors in public access buildings should provide at least 2000mm clear width to enable 2-way pedestrian traffic.
b. For other buildings, a minimum of 1500mm clear width for corridors is recommended. Corridors less than 1800mm wide should provide recesses with clear width of 1800mm of at least 2000mm length at reasonable intervals.
c. Outward opening doors including to accessible toilets (Door A) to be recessed to equal depth as the width of the door, as in Figure 18.
d. Wall mounted fixtures and equipment need to be recessed (C in Figure 18).
e. Projections into the corridor such as column or pipe ducts must be clearly marked and visible (E in Figure 18).

FIGURE 18
Minimum dimensions for doors and corridors (mm)



4.1.3 Stairways (DD1, ND2)

Group dwelling	MANDATORY
Non-residential	MANDATORY

a. Stairways must be maintained without obstructions, even when not in use.
b. Steps must be regular in dimensions throughout a stair flight. Architectural requirements for irregularity require approval from the Engineer.
c. Continuous handrails are required one side for all stairs at 900-1100mm above pitch line. For stairs wider than 1000mm wide, continuous handrails shall be provided on both sides.
d. Internal stairs must be lit whenever in use. Lighting can be user-controlled or automatic.

4.1.4 Internal ramps for access (ND2, ND3)

Group dwelling	RECOMMENDED
Non-residential	MANDATORY

a. Internal ramps must not exceed a continuous ramp length of 9000mm.
b. Clear width of ramps to be at least 1500mm, with handrails at 900-1100mm above ramp.
c. Consecutive ramps must use the same gradient.
d. Immediate areas at the entrance and exit of ramps must be kept clear of obstructions at all times.

4.1.5 Glass screens and walls

Group dwelling	MANDATORY
Non-residential	MANDATORY

a. Where clear glazing is installed as a vertical barrier (whether internal or as a part of the envelop), there must be distinct and permanent markings at 850-1000mm and 1400mm to 1600mm above floor level.

Such markings should be continuous for the full width of wall and visible on both sides of the glass.

4.1.6 Wayfinding and signages

Group dwelling	RECOMMENDED
Non-residential	MANDATORY

a. Non-residential buildings must have clear signs to facilitate wayfinding. Minimally, these include information signs, directional signs, identification signs, and mandatory safety signs. Signages should be prominently placed and easily legible.
b. Warning signs for various forms of hazards must be prominently displayed.
c. Emergency escape routes and exits must always be clearly marked and unobstructed. (ND1)

4.1.7 Sanitation facilities

Group dwelling	RECOMMENDED
Non-residential	MANDATORY

a. Toilets should be conveniently located and easily located through signages.
b. Horizontal travel distance to a toilet in public buildings must be less than 40m, or less than 25m in schools.
c. In non-residential buildings for general public access, baby changing facilities accessible by men and women and nursing rooms must be provided.
d. In non-residential buildings for general public access, provide one accessible toilet on each floor or include one wheelchair accessible cubicle for male and female toilets on every floor.

4.2 Active mobility

As part of promoting the wellbeing of building users, spaces can be designed to support the use of non-motorised mobility within and around the buildings.

4.2.1 Use of stairs

Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. During building design or refurbishment, ensure staircases are designed and positioned to encourage usage for vertical connectivity.
b. Staircases should be clearly signposted and attractive to use. They should be well lit and designed to suit the main building occupants/users.

4.2.2 Use of non-motorized transit

Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. Building shall be linked by accessible walking and cycling routes to nearby amenities/blocks.
b. New workplaces and other relevant buildings shall be linked to walking and cycling networks.
c. Non-residential buildings should provide bicycle racks and shower facilities to promote cycling.
d. In compounds where there are multiple buildings, all buildings must be connected by a network of footpaths.

4.3 Access to nature

Connection to nature, through lighting and adequate views promote wellbeing of building occupants, particularly those who spend long hours indoors.

D3.1 Quality window view

Group dwelling	RECOMMENDED
Non-residential	RECOMMENDED

a. At least 75% of regularly occupied areas to have direct line of sight to vision glazing or open windows.

b. Window glazing or glass walls should have visible transmittance of at least 50%.

c. Views from windows/glazing to include (1) flora, fauna, or sky; (2) movement; and (3) objects at least 7.5 meters from building exterior.

KEY REFERENCES

For climate change adaptation:

1. National Construction Code of Australia (Volumes 1 and 2)
2. IFC EDGE User Guide Ver 3.0.a, EDGE Application
3. New Buildings Institute Energy Efficiency Report (2014)

On resilience to climate change:

1. IFC EDGE User Guide Ver 3.0.a
2. IFC Building Resilience Index
3. RELi project rating system RELi | C3 Living Design Project
4. Improving the Flood Performance of New Buildings (UK Communities and Local Government)

On climate change mitigation:

1. New Buildings Institute Energy Efficiency Report (2014)
2. IFC EDGE User Guide Ver 3.0.a, EDGE Application
3. National Construction Code of Australia (Volumes 1 and 2)
4. International green Construction Code
5. Pacific Appliance Labelling and Standards Programme

On inclusion and wellbeing:

1. Building for everyone, Centre for Excellence in Universal Design
2. International WELL Building Institute
3. Leadership in Energy Efficient Design ver4.0
4. Australian Network on Disability
5. AS 1657:2018 Fixed platforms, walkways, stairways and ladders – Design, construction and installation
6. Accessibility Design Guide: Universal design principles for Australia's aid program

TECHNICAL NOTES

Useful factors for understanding building thermal performance:

Thermal conductivity (U-value / U-factor) BS EN 673:1998 – This measures the insulating capacity of the glass (or glass assembly). The lower the U-value, the less heat passes through the glazing or wall. U-value is the inverse of the R-value (see equation). The unit is W/m^2K or $Btu/hr \cdot ft^2 \cdot °F$.

$$U = \frac{Q}{A \times TD_{eq}}$$

Q: Amount of heat transfer through wall or glazing (W)
A: Area of wall or glazing (m^2)
TD_{eq}: Temperature difference between the interior and exterior (K)

Simple method of calculating the U-value:

$$U - Value = \frac{1}{R_{si} + R_{so} + R_1 + R_2 + R_3\ etc}$$

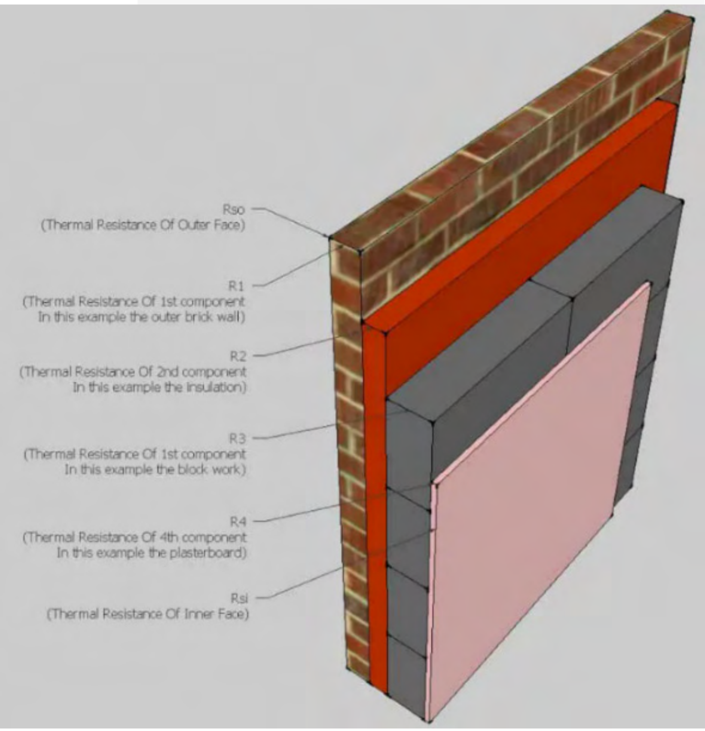
Where:
Rsi = Resistance of the air layer on the inner side of the roof (add constant of air)
Rso= Resistance of the air layer on the external side of the roof
R1, 2 etc. = Resistance of each material layer within the roof

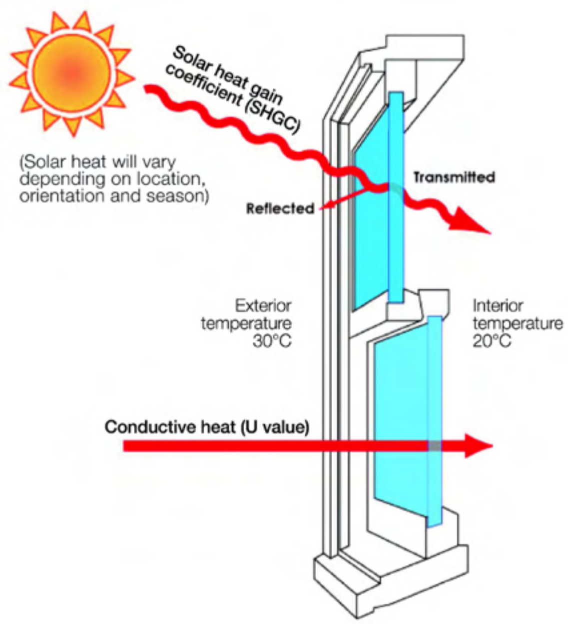
R-value: The R-value measures the capacity of a material to resist heat flow, hence it measures the effectiveness of insulation of a material. A higher R-value represents more effective insulation. R-values are additive, so the total thermal resistance of a wall or roof assembly is the sum of the respective thermal resistances of the various layers. (See Figure 19.)

$$R_{assembly} = R_{so} + R_1 + R_2 + R_3 + R_4 + R_{si} \qquad R = \frac{D}{\lambda}$$

The resistance of a roof material (Eq XX) where:
D = thickness of roofing material (m)
λ = thermal conductivity in W/m.K

FIGURE 19
Wall assembly with multiple layers





Solar heat gain coefficient, SHGC – This is the amount of heat from direct sunlight that passes through the glass as a proportion of the total amount solar energy hitting the glass surface. This is a value between 0 and 1.

Overall thermal transfer value (OTTV) ASHRAE 90A-1980 – This measures the heat transfer into a building through the envelope. The unit is watts/square metre (W/m^2).

$$OTTV = \frac{Q_{wc} + Q_{gc} + Q_{sol}}{A_w + A_g} = \frac{(A_w \times U_w \times \Delta T_s) + (A_g \times U \times \Delta T) + (A_g \times I \times \theta)}{A_w + A_g}$$

Q_{wc}: Amount of heat conducted through opaque wall.
Q_{gc}: Amount of heat conducted through glazing.
Q_{sol} : is the amount of solar radiation through glazing.

A_w: Area of opaque wall.
A_g: Area of glazing.

Energy Efficiency

Integrated Energy Efficiency Ratio
IEER is a weighted calculation of the unit's efficiency at four load points –100%, 75%, 50% and 25% of full cooling capacity.

The formula for calculating the IEER is:

IEER = (0.020*A) + (0.617*B) + (0.238*C) + (0.125*D)

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