



THE UNIVERSITY OF
SYDNEY

Roofing System Standard

**Design, Engineering, Planning &
Sustainability**

University Infrastructure

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1 Purpose

The Roofing Standard sets out the University of Sydney's minimum requirements for the design and construction of roofing systems to ensure the best outcomes following watershedding principles across new and existing assets.

In the context of this Standard roofing system and watershedding are defined as:

Roofing System – *External horizontal, above-ground surfaces requiring watershedding principles in its design. This includes roofs, podiums/terraces, balconies, and canopies. It is inclusive of all waterproofing and drainage elements necessary to achieve all the required performances.*

Watershedding – *Is the collection, re-direction, and drainage of water. It is a holistic approach based on working with gravity to shed water towards suitable outlets, without causing harm or inconvenience to people or property on the way.*

The standard will aim at:

- a. Identifying areas where requirements above the legal minimum requirements must be instated;
- b. For these areas, establishing more onerous performance requirements for the design, detailing, specification, procurement, installation, and testing of roofing systems;
- c. Identifying quality assurance (QA) procedures for contractors and builders to demonstrate compliance with the guideline's requirements (as well as compliance with relevant construction standards);
- d. Nominating documentation required at early design stages for submission for review (warranties, performance solution reports, dispensations etc);
- e. Identifying handover documentation on completion of works.

This standard requires compliance with both the NCC and relevant Australian Standards, as well as compliance with the more stringent performances established within this standard.

Where any ambiguity exists between this standard and the mandatory requirements then:

- a. The highest performance requirements complying with mandatory regulatory requirements must apply.
- b. Applicable requirements must follow this order of precedence:
 - i. Workplace Health and Safety legislation
 - ii. Safety in Design legislation
 - iii. Disability Discrimination legislation
 - iv. State Environmental Planning and Assessment legislation
 - v. All other Commonwealth and State legislation
 - vi. NCC
 - vii. AS/NZS standards
 - viii. Other relevant overseas standards and codes
 - ix. This standard and other University of Sydney standards

This standard requires that designers and contractors properly plan future works, and provide a basis for the construction and management of new and existing roofing system installations within the University of Sydney.

2 Scope

This standard describes minimum requirements for design, installation, and maintenance of roofing systems (roofs, podiums/terraces, balconies, and canopies) for buildings and spaces owned, operated, maintained and/or managed by the University of Sydney.

This standard:

- a. Applies to new and existing buildings;
- b. Applies to upgrades and large-scale repairs (> \$1M in fees) of existing buildings;
- c. Applies to heritage buildings (to be further developed in later revision of this Standard);
- d. Includes design principles for roofs, podiums/terraces, balconies, and canopies;
- e. Does not apply to internal waterproofing (e.g. bathrooms and other internal wet areas);
- f. Does not apply to external ground level waterproofing (e.g. courtyards);
- g. Does not apply to below ground waterproofing (e.g. basements);
- h. Does not apply to vertical facades.

The standard applies to all planners, architects, project managers, consultants, contractors, sub-contractors, tenants, managing agents and University staff involved in the design, construction and maintenance of existing, new and proposed university buildings and facilities.

The standard provides:

- a. A reference document to enable consistency with the design performance and principles developed across the University of Sydney assets;
- b. Details of the minimum performance requirements for planning, architectural design and maintenance;
- c. Support of the university vision for the built environment and best practice in construction.

The standard addresses key objectives including:

- a. Quality design which responds to, enhances, and complements the environment;
- b. The design of low maintenance buildings and environments;
- c. Longevity of construction approach to design;
- d. Value for money in all aspects of the project and ongoing operations for the entire lifecycle of the asset;
- e. Recognition of the heritage regulatory context and cultural history of the campuses. This includes the *NSW Minimum Standards for Maintenance and Repair* ([NSW Minimum Standards of Maintenance and Repair](#)) under the *NSW Heritage Act 1977* because the University of Sydney Camperdown Campus is listed as a heritage “item” on the State Heritage Register (Item 1974). Many of the buildings are also listed as items of local significance on various Local Environmental Planning instruments such as the City of Sydney Local Environmental Plan. Camden campus is on an interim list as a heritage item on the Wollondilly Shire Council Local Environmental Plan.
- f. Standardisation of key flashing and ancillary details;
- g. Flexible design, to future-proof building usage for expansion or adaption to new uses;
- h. Sustainability;
- i. Ensure safe and accessible roofs;
- j. Safety in design.

2.1 Conformance and Deviations

All roofing systems, products and services provided or specified by designers, consultants, staff and contractors must conform to this standard.

Where specific applications are not explicitly covered, or where ambiguity exists or a deviation is required, the intent of this standard must still be satisfied. In such cases a return design brief must be provided for review and approval by the issuer of this standard or their appointed delegate who must have relevant technical competence in the subject matter. Additionally, more stringent requirements may apply on a project-specific basis dependent upon risk management and insurance requirements.

3 Glossary of Terms

3.1 Abbreviations

The following abbreviations are used within this Standard.

AAMA	American Architectural Manufacturers Association
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AS	Australian Standards
AS/NZS	Australian and New Zealand Standards
ASTM	American Society for Testing and Materials
ATTMA	Air Tightness Testing and Measurement Association
BAL	Bushfire Attack Level
BIPV	Building Integrated Photovoltaics
BMT	Base Metal Thickness
BMU	Building Maintenance Unit
CAPEX	Capital Expenditure
CFC	Compressed Fibre Cement
COS	Central Operations Services
DA	Development Application
DBP	Design and Builder Practitioner
DBPA	Design and Building Practitioners Act
DLP	Defects Liability Period
DPI	Department of Primary Industries
ECI	Early Contractor Involvement
EFVM	Electric Field Vector Mapping
EP&AR	Environmental Planning & Assessment Regulation
EPA	NSW Environmental Protection Authority
EPD	Environmental Product Declarations
EVFM	Electronic Field Vector Mapping
EWP	Elevated Work Platform
FC	Fibre Cement
HB	Handbook
IFD	Intensity Frequency Duration – This is a calculated rain fall intensity graph created by the Australian Bureau of Meteorology
IPCC	Intergovernmental Panel on Climate Change
IRA	Industrial Rope Access
ITA	Independent Testing Authority
ITP	Inspection Test Plan
KEE	Ketone Ethylene Ester

NCC	National Construction Code
O&M	Operation & Maintenance
OC	Occupation Certificate
OPEX	Operational Expenditure
PBDB	Performance Based Design Brief
PC	Practical Completion
PCA	Plumbing Code of Australia
PMU	Pre-construction Mock Up
PUG	Project User Group or Project Working Group
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RBS	Registered Building Surveyor
RBS	Registered Building Surveyor
RH	Relative Humidity
RWO	Rain Water Outlet
SA HB	Standards Australia Handbook
SiD	Safety in Design
SRI	Solar Reflectance Index
SWMS	Safe Work Method Statement
SWOT	Strengths, weaknesses, opportunities, and threats
TQC	Technical Quality Control
TRG	Technical Review Group
UHI	Urban Heat Island
UI	University Infrastructure
USYD	University of Sydney
UV	Ultraviolet (radiation)
WH&S	Work Health & Safety
WSUD	Water Sensitive Urban Design

3.2 Definitions

The following definitions are included to provide explanation to key terminology used within this Standard. These definitions are sourced from various standards, codes, and literature, as listed in Section 19, and where relevant have been adopted to suit the context of this Standard.

Access Hatch	A device normally closed, but which can be opened, to provide access through a roof, platform, or other similar structure.
Anchor Point	Any single or multiple fixed anchor point or static line support point, whether part of a work positioning, abseiling or fall arrest system.
Balcony	An accessible open or covered platform attached to an upper floor of a building, projecting from or recessed into the face of the wall and protected by a railing or balustrade and accessible from an adjacent room.
Bioresistance	Resistance to degradation by biological attack
Building	Above ground enclosed envelope consisting of vertical and horizontal surfaces with primary and secondary drainage layers.
Canopy	Roof-like structure adjacent to or attached to a building, generally not enclosed by walls.
Design Life	The design (intended) life for a roof and/or waterproofing element is the minimum period of time for which the system is proposed to be used for its intended use (i.e. prior to replacement).
Downpipe	A pipe to carry water from gutters and roofing system catchments to drains or storage tanks.
Drainage	Natural or artificial means for the interception and removal of water from roofing systems.
Dry Joints	A joint between any two sections of material. A dry joint does not rely upon sealants such as silicone, solder, or electric welding to seal the joint.
Fall	Difference in level between two points in the direction of flow.
Flashing	Components used to weatherproof or seal the roof perimeters, penetrations, walls and other places where the roof covering is interrupted or terminated.
Gateway Paper	The UI project delivery process including concept, scoping, procurement, delivery and handover.
Gutter	Preformed or purpose-made channel for collecting and carrying away water from roofing systems.
Leak	Internal water entry through the primary and secondary drainage layers.
Mechanical Fixings	Fixings that utilise friction as the locking device.
Membrane	An impervious barrier to moisture, which can be sheet or liquid applied
Oil Canning	Minor elastic distortion in the form of waviness or out-of-flatness in a preformed sheet, normally caused by local buckling of the sheet metal
Podium / Terrace	Elevated outdoor area, often fitted with a balustrade.
Primary Drainage	Primary means of drainage of a roofing system that directs water to drainage outlets.
Roof	Construction that encloses a building or open area (e.g. plant) from above.
Roofing Systems	For this Standard, it is defined as an external horizontal, above-ground surfaces requiring watershedding principles in its design. This includes roofs, podiums/terraces, balconies, and canopies. It is inclusive of all waterproofing and drainage elements necessary to achieve all the required performances.
Root Resistant	Capable of preventing root penetration through a membrane.
Secondary Drainage	Secondary means of drainage if there is water entry through the primary drainage layer of a roofing system.

Service Life	Service life is the minimum time from installation during which a roof and/or waterproofing element, with normal routine maintenance and cleaning, continues to perform as specified (i.e. life to first maintenance).
Slip Resistance	The effective friction of a walking surface.
Slope	Inclination of a surface to the horizontal.
Sump	A collector of rainwater, generally of rectangular shape, in the sole of a box gutter and connected to a downpipe within the building perimeter, which is used to increase the head of water at the entry to the downpipe and thus increase the capacity of the downpipe.
Surface Mounted	Any anchor that is fastened (by means of friction, mechanically or “clipped”) to a roof sheet, eave, or batten.
Watershedding	Is the collection, re-direction, and drainage of water. It is a holistic approach based on working with gravity to shed water towards suitable outlets, without causing harm or inconvenience to people or property on the way.
Wet Joints	A joint between any two sections of material. A wet joint includes a substance such as silicone, solder or the use of electric welding to seal the joint.

4 Roles and Responsibilities

4.1 This Standard

This standard is issued by University Infrastructure (UI). It is approved and signed off by the Chief of University Infrastructure Officer. UI is responsible for maintaining the standard and keeping it up-to-date.

4.2 Designers and Contractors

This standard does not substitute the design judgement of both project designers and contractors during the pre and post tender stage, as the guidelines expressed in this Standard are required to be adapted and tailored for each project specific condition. Ultimately the design and construction responsibility remains with the appointed project Designers and Contractors.

A **roofing system** lead designer (architect or specialist waterproofing consultant) is required to coordinate all roofing systems, including interfaces with other disciplines, systems, trades. Refer to section 8.2.1 for more detailed information on design responsibilities.

5 Design Requirements

5.1 Design Principles

Roofing systems shall be designed and constructed to follow the watershedding principles. The underlying design will aim to collect, re-direct and drain water to prevent leaks and water ponding.

Where there is potential for water entry, a non-absorbent flashing shall be installed to re-direct the water out of the building envelope. Ventilation must be provided to remove water vapour from the building.

Roofing system design to consider the following key factors:

- a. Safety
- b. Durability
- c. Low maintenance
- d. High-quality waterproofing
- e. Resilience
- f. Redundancy
- g. Sustainability
- h. Responsible procurement

5.2 Design and Documentation

5.2.1 Design Approach

The University requires consultants and designers to provide designs that meet all requirements within this standard. Consultants, designers and installing contractors are to reflect the following priorities in their design documents:

- a. Provide roofing systems that meet or exceed the requirements listed in this standard.
- b. Take a long term and balanced view of capital costs, maintenance costs and longevity.
- c. As educational and research environments both evolve at rapid rates, usage of buildings and areas within buildings will be subject to multiple changes within the life of the building. Roofing systems must be designed to be flexible and adaptable for such changes.
- d. Design to consider mechanical plant and its influence on the waterproofing and drainage and any roofing system replacement. Mechanical plant to be installed such that roofing systems can be repaired or replaced with no need to remove plant.
- e. Ensure that assets and equipment are designed with access and visual impact taken into consideration.
- f. Ensure a comprehensive service and maintainability review has been conducted, led by the main contractor during the design stage and prior to construction. Process to align with 'Green Star Design and As Built Submission Guidelines_v1.3' - Services and maintainability review credit.

It is the designer's and the installing contractor's obligation to document and install systems, equipment and materials that are "fit for purpose" from both a Work Health & Safety (WH&S) and operational perspective. Any disputes with regard to the interpretation of this clause shall be referred to NSW Fair Trading and/or the UI/COS Project Manager for a final determination.

5.2.2 Documentation

Full details of all proposed roofing systems, including interfaces with other systems/trades and non-typical roofing system detailing, must be submitted to UI for approval, prior to any works commencing on site.

Explanatory reference details are included in subsequent Sections to identify key roofing system principles discussed within this Standard. The details are not intended for use for construction nor detract from the roofing system designer's detailing responsibility.

5.3 New Buildings

All new buildings are to have a roofing system package submitted as a fully coordinated document for approval.

For any works on new building the design process must:

- a. Include a wholistic analysis of viable options to maximise the value for the University.
- b. During Preliminary/Concept stage, in order to outline the most suitable project scope, the design report must include:
 - i. SWOT (strengths, weaknesses, opportunities, and threats) analysis;
 - ii. Gap analysis for interfaces between roofing system and other trades/systems (i.e. facades);
 - iii. Life cycle cost assessment (CAPEX/OPEX) to evaluate most appropriate design solution;
 - iv. Initial maintenance expectations for lifecycle cost impacts;
 - v. Return brief on how the design of the roof can adapt to future changes in the layout function of the building.
- c. Minimise complexity of geometry to reduce the risk of water leakages.
- d. Maximise slope to reduce the risk of leakages and water ponding.
- e. Allow for overland flow paths to be away from the building façade, skylights, hatches, etc. to reduce risk of water entry.
- f. Optimise site specific rainwater harvesting strategies, to make full use of the roof as catchment area. This must be done in coordination with architects and hydraulic engineers.
- g. Consider roof integrated photovoltaic panels with reference to existing and future conditions of the project and surrounding areas.
- h. Minimise Urban Heat Island effect.
- i. Depending on the delivery method (UI or COS delivery), it is the responsibility of the consultant/contractor to obtain the Gateway Paper or the project inquiry form from the Project Manager, to understand the scope of works in relation to the space and fit out requirements.

5.4 Existing Buildings

Detailed design and investigation into the existing roofing system is required to accompany any proposed design or modifications.

For existing buildings, with insufficient documentation, on-site investigations must be undertaken to gather sufficient data to determine the existing build-up, conditions, etc.

Existing heritage buildings are to be referred to the University's Heritage Architect for direction on refurbishment and installation of the roofing and waterproofing system.

For any works on existing buildings, including a retrofit, refurbishment or a new project within an existing building, the design process must:

- a. Take into consideration risks associated with asbestos and other hazardous materials and discharges.
- b. Include a wholistic analysis of viable options to maximise the value for the University.
- c. During Preliminary/Concept stage, in order to outline the most suitable project scope, the design report must include:
 - i. SWOT (strengths, weaknesses, opportunities, and threats) analysis;
 - ii. Gap analysis for interfaces between roofing system and other trades/systems (i.e. facades);
 - iii. life cycle cost/carbon assessment (CAPEX/OPEX) to evaluate most appropriate design solution.
- d. Assess the current age, condition and criticality of the existing drainage system and overland flow paths for surface water, and identify any areas where water is ponding or where there is a risk of water entry.
- e. Consider assets together with opportunities to upgrade the lifecycle and performance requirements of the roof including waterproofing, thermal and acoustic performance, replacing combustible materials, etc.
- f. Optimise site specific rainwater harvesting strategies, to make full use of the roof as catchment area. This must be done in coordination with the architect and hydraulic engineer.
- g. Consider roof integrated photovoltaic panels with reference to existing and future conditions of the surrounding areas.
- h. Minimise Urban Heat Island effect, refer to Section 7.1.13.
- i. Depending on the delivery method (UI or COS delivery), it is the responsibility of the consultant/contractor to obtain the Gateway Paper or the project inquiry form from the Project Manager, to understand the scope of works in relation to the space and fit out requirements.

5.4.1 Reuse of Equipment

- a. Reuse existing services where identified in the scope of works and the approved Return Brief.
- b. Existing equipment is to be assessed for its condition, capacity, and adequacy.
- c. Equipment must be suitable for the intended new purpose and life expectancy of the works, comply with current codes and achieve energy targets.
- d. Equipment must be cleaned, have consumables replaced, tested, relabelled and re-commissioned.
- e. Remove redundant pipework, equipment, and wiring, including inaccessible ceiling spaces, and make good of exposed surfaces before commencing the installation of new services.

5.4.2 Heritage Buildings

Existing heritage buildings are to be referred to the University's Heritage Officer for direction on refurbishment and installation of the roofing system. The University Heritage Officer will be guided by the regulations under the *NSW Heritage Act 1977* and any relevant Local Environmental Planning regulations. For example, the University of Sydney Camperdown Campus is listed as a heritage item on the NSW State Heritage Register. Subsequently, any works that we do to any of the buildings at the Camperdown Campus are subject to regulations such as:

- a. The NSW Minimum Standards of Maintenance and Repair under the Heritage Act 1977;
- b. Standard Exemptions and Site Specific Exemptions granted to us under Clause 57 (2) of the NSW Heritage Act 1977. Standard Exemption 10: Restoration of Fabric that forms part of the significance of the item (Significant Fabric) and Site-Specific Exemption 1.4: Building Interiors and Exteriors – Repairs to Significant Fabric can be applied by the UI Heritage Officer if the works qualify under the relevant standards and specified activities and works.
- c. The OCP Architects Roofing Study (2022) [Heritage Management Guidelines Slate and Terracotta Roofs] at [Heritage Management Guidelines: Slate and Terracotta Roofs](#). This document is very comprehensive and covers the standards for leadwork, slate, sarking membrane, and roof plumbing. It also covers all maintenance and conservation issues in every roof detail required. (This is attached as an Appendix to this Standard).
- d. A range of documents that prescribe the latest approaches to issues such as Climate Change and heritage building adaptability from the 2024 NSW Heritage Forum at [Heritage Forum 2024](#)
- e. Roof Safety upgrade studies
- f. A range of Conservation Management Planning (CMP's) documents for all of our heritage listed buildings. The UI Heritage Officer can provide specific guidance from these CMP's. These CMP's occasionally prioritise roofing repairs for the range of exceptional and high heritage buildings.
- g. Technical studies by NSW Heritage such as the slating-tiling-and-roof-plumbing-information-sheet at [Slate, tiling and roof plumbing for heritage buildings](#) and heritage-maintenance-corrugated-roofing-information-sheet at [Corrugated roofing for heritage buildings](#).

6 Technical Requirements

6.1 Roofing System Types

Table 6.1 lists the UI preferred roofing systems. Where a non-preferred roofing system is proposed, in particular for existing buildings, UI approval is required.

TABLE 6.1: PREFERRED ROOFING SYSTEM

	Roof	Podium/Terrace	Balcony	Canopy
Metal roofing with secondary drainage plane (Refer Section 6.1.2)	✓	✗	✗	✓
Concrete roofing with modified bitumen or reinforced single-ply membrane (Refer Section 6.1.3)	✓	✓	✓	✓

6.1.1 General Design Criteria

General design criteria apply to all roofing system types described in the subsequent sections of this Standard.

6.1.1.1 Materials

- a. Materials must be new and of high quality with no blemishes or damage and be readily available in the location being installed. Any materials that are found to be of inferior quality to be removed at the contractor's expense.
- b. The use of recycled materials must be approved by UI.
- c. All selected materials for all roofing system components must be compatible, including compatibility with interface systems/trades.
- d. Aspects such as building location (coastal, inland, near chemical fall out or industrial areas, bush fire prone areas), climate and classification of building (industrial, commercial or residential) are to be taken into consideration when selecting appropriate roofing materials and specifically highlighted in the submission.
- e. Acceptable materials for the typical conditions are identified in the subsequent sections for each roofing system.
- f. When in presence of exhausts from chemical laboratories or other special processes, an input from a material specialist and durability consultant must be included in the decision-making process, to ensure adequate measures are considered to avoid corrosion due to non-typical chemical reactions. Noting that exhausts from surrounding buildings need to also be included in this assessment.
- g. All materials must align to other clauses in this Standard including Section 7 – Performance Requirements.

6.1.1.2 Slope

- a. Roofing system slope and drainage layout must consider deflections due to dead loading from plant, equipment, solar panels whether part of the project or planned for potential future installation and allow for future-proofing.
- b. Roofing system slope design shall allow for:
 - i. Flow paths for surface water to direct water to the drainage systems.
 - ii. Prevention of water ponding on any surface.
- c. For all roofing systems, slopes must be considered after deflection.
- d. For concrete and timber roofing systems, a minimum 10-year deflection must be considered for slope and water ponding prevention.

6.1.1.3 Movement Joints

- a. The following joint types are to be nominated on all relevant drawings:
 - i. Construction Joints (CJ)
 - ii. Expansion Joints (EJ)
 - iii. Permanent Movement Joints (PMJ)
 - iv. Temporary Movement Joints (TMJ)
 - v. Building Joints (BJ)
 - vi. Articulation Joints (AJ)
- b. Movement joints within gutters are to be avoided. Where movement joints will be required, gutter lengths must be maximised to reduce number of joints. Joints within gutters must be formed along the highest point, form a ridge and use a UV stable proprietary joint system.

Building Movement

- c. All building movement joints to have a minimum 50mm high integral hob, continuity of control layers (drainage, air, thermal and vapour) where applicable to roof build-up and use a proprietary movement joints system.
- d. Details must be developed for all aspects of the joint, including horizontal, vertical and corner details and interface with other systems/trades.

Thermal Expansion

- e. Thermal expansion joints and minimum overlapping of materials must be designed and documented.

6.1.1.4 Penetrations

- a. Penetrations of the exposed roofing system must be avoided, where this is not possible penetration locations are to be approved by UI.
- b. Where a penetration is required, it must be located away from other “weak points” (e.g. movement joints, low points, etc.) and in areas of the roof that will require a minimal flashing detail.
- c. Penetrations for service pipework and electrical services must be designed to allow for:
 - i. Services (e.g. copper service pipework, electrical service cables, data service cables) to be grouped to minimise the number of penetrations required. Grouped services are to penetrate the roof through a dedicated service riser, the service duct riser is to have a sealed downleg of not less than 300mm;
 - ii. Future capacity to prevent need for additional penetrations.
- d. Service duct risers must have minimum 150mm vertical upturn and incorporate an over flashing.
- e. All penetrations are to be under-flashed using a compatible butyl flashing tape.
- f. A dilapidation report of the roof area directly affected by the installation must also be submitted, where penetrations will be required on existing roofing.

6.1.1.5 Step Down and Perimeter

- a. Minimum 70mm step down at sliding doors.
- b. Minimum 70mm edge/hob at roofing system perimeters.

6.1.1.6 Flashings

- a. Flashings are not to be used to support equipment or structures.
- b. Inter-connecting elements must have flashings that direct water to the drainage systems.
- c. Flashings are to be designed for all project specific parameters including building and thermal movements and wind and maintenance loads (where applicable).
- d. All flashings must be fixed with mechanical fixings and not solely rely on structural sealant.
- e. The vertical termination height of a flashing must ensure that in a flooded situation that surface water cannot overtop the vertical termination of the flashing and enter the building envelope.
- f. The minimum vertical termination height shall be in accordance with AS 4654.2.
- g. Where long run flashings are required, the minimum overlap between flashings shall be 50mm. This shall be increased to min 100mm for ULS wind speed greater than 50m/s.
- h. Flashings must be compatible with the adjacent roofing material to avoid risk of galvanic corrosion.
- i. Flashings must consider overland path direction to ensure water flow does not lead to corrosion from runoff from dissimilar metals.
- j. Where weep holes are required vermin proof shrouds must be used.

6.1.1.7 Parapets / Cappings

- a. All parapets to be sloped inward to prevent water ponding.
- b. Minimum 5 degrees slope.

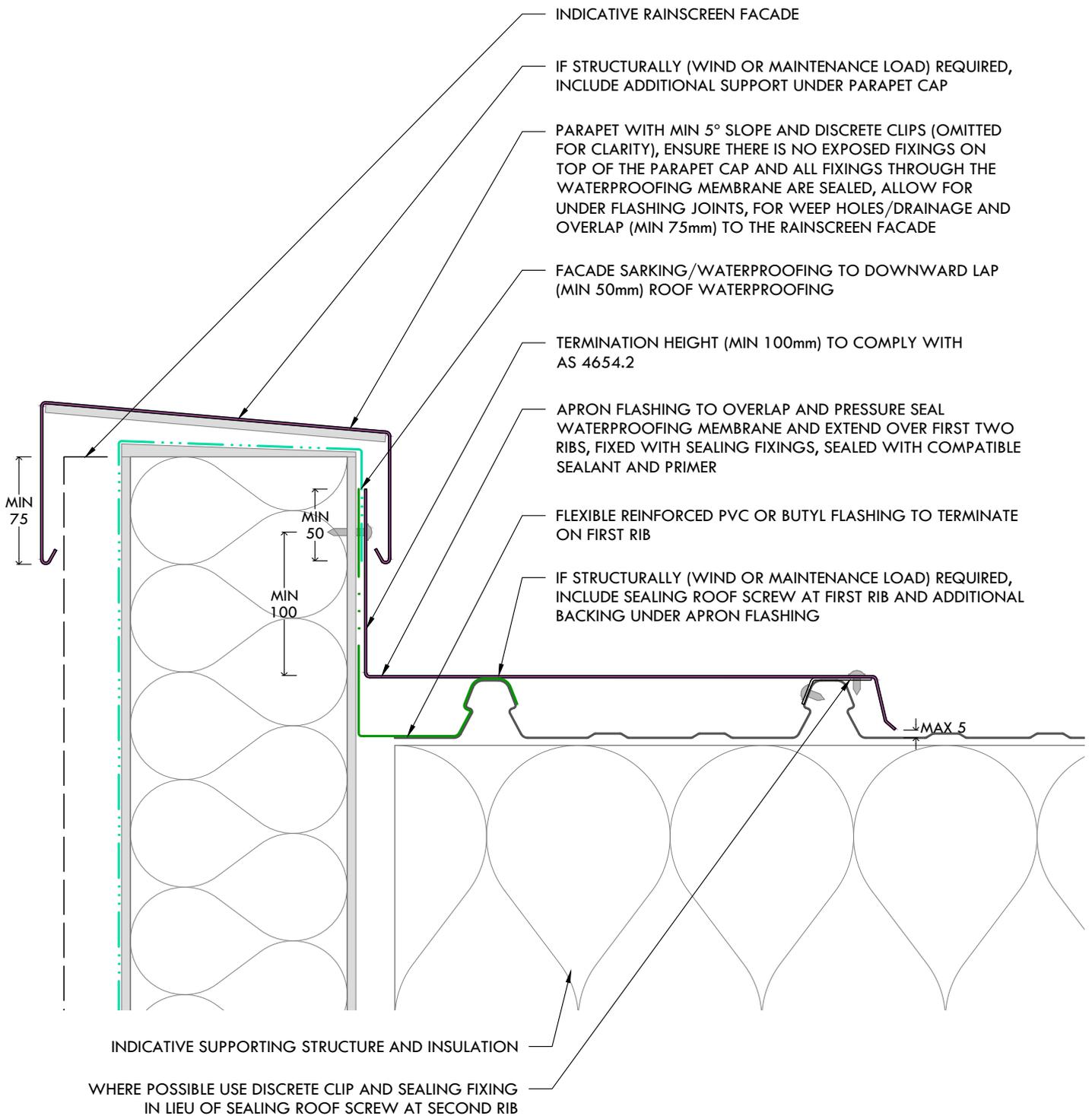


FIGURE 6.1: PARAPET INTERFACE

6.1.1.8 Jointing

- a. Only soft soldered, welded, brazed or lapped joints will be approved for use.
- b. If proven that a silicone joint is the only possible solution, full details of the joint must be submitted for approval by UI.
- c. Only expansion joints are allowed within gutters, refer Section 6.2.

Dry Joints

- d. This jointing detail allows movement between a number of materials. Dry joints do not depend on silicone or any other sealant as the waterproofing component. Dry joints can be adapted to any surface, component or structure.
- e. Dry joints can be used where material separation is not required for compatibility.

Wet Joints

- f. Wet joints must be used with a means of mechanical fixing. For mechanical fixings, a staggered pattern of the fixings must be adopted across the joint, and allow for thermal expansion. The mechanical fixings are to be installed then the jointing compound is to be sweated in and around the rivets.
- g. Where there is an overlap of surfaces (e.g. flashings), the depth of the overlap shall not be less than 75mm.
- h. Silicone is not to be used as a gap filler.
- i. All substrates are to be cleaned and primed prior to application as per manufacturer's requirements of the wet joint sealant.
- j. Jointing sealant to be UV stable, compatible and have satisfactory adhesion properties with both substrates.
- k. Wet joints sealants are to be protected from UV exposure by application of an overlaying flashing or compatible coating and be compatible with all substrates.

6.1.1.9 Access Hatches/Doors/Walkways

- a. For all plant and equipment installed at the University of Sydney, internal access is required.
- b. Where the plant or equipment is proposed to be installed on the roof, UI approval is required.
- c. Access hatches must be constructed with a steel or aluminium frame with either a frosted glass (only in non-trafficable areas) finish or finished with material suitable for the surrounding roof area.
- d. An access hatch must have a stair or step built underneath for ease of access. A platform or level area must be provided outside the hatch to provide safe access onto the roof. The access hatch must also incorporate a chain or metal strap fixed to the lid to securely prop the lid open. All access hatches are to be secured by means of a hasp staple and padlock. This padlock is to be keyed to the University Roofing Barrel.
- e. Removable access hatches are not permitted due to risk of being dislodged or left on roof unsecured.
- f. Access and maintenance strategy for plant or equipment is to be provided to UI and COS for approval.
- g. Maintenance pathways including those for major plant removal are to be determined and considered acceptable by UI and COS, in alignment with 'Green Star Design and As Built Submission Guidelines_v1.3' - Services and maintainability review credit.
- h. Must follow minimum penetration requirements as per Section 6.1.1.4.
- i. For metal roofing systems, pan flashings must be used as per Section 6.1.2.4.

Refer to the UI Hydraulics Services Standard for further information on access requirements.

6.1.1.10 Skylights

- a. The design must be one that incorporates a pressure equalised aluminium frame with secondary drainage system, with a minimum 5-degree slope.
- b. Skylight must not be face sealed.
- c. The glass must be designed to be trafficable and double glazed with adequate SHGC and U-value to meet the projects specified thermal performance requirements.
- d. Minimum slip resistance of the glass to be designed to comply with NCC and to address Safety in Design requirements.
- e. All skylights must be fixed, operable skylights are not permitted.
- f. Must follow minimum penetration requirements as per Section 6.1.1.4.
- g. For metal roofing systems, pan flashings must be used as per Section 6.1.2.4.

Refer to the UI Façade Standard for further information on skylight design.

6.1.1.11 Gutters and Leaf Guards

- a. Eaves gutters are preferred over box gutters. Where a box gutter is required, they must be placed in proximity to the edge of the facade, not towards the centre of the roof.
- b. Overflows to be minimum 50mm below high point of parapets, hobs or gutters.
- c. Overflows in rainwater heads to be minimum 30mm below box gutter floor.
- d. Location of leaf guards to all gutters and rainwater pipe, must be discussed and agreed during the Detail Design phase, with Architect and Hydraulic Engineer and approved by UI. The agreed layout must be documented for Tender.
- e. Leaf guards must avoid any fixing through the roof and gutters, in area that might lead to water leakages. Full details, including fixing points must be developed by the contractor in the construction documentation, and signed off by the Architect, Hydraulic Engineer and UI.
- f. Leaf guards are to be stainless steel. Where stainless steel is not compatible with existing gutter, an alternative detail is to be proposed for UI approval.
- g. Leaf guards are to be self-cleaning to prevent clogging of the drainage systems.
- h. In bushfire prone zones, leaf guards to be designed to the appropriate BAL rating, as per AS 3959 and NSW Rural Fire Service Planning for Bushfire Protection.

Refer to Section 6.2 for further information on drainage systems.

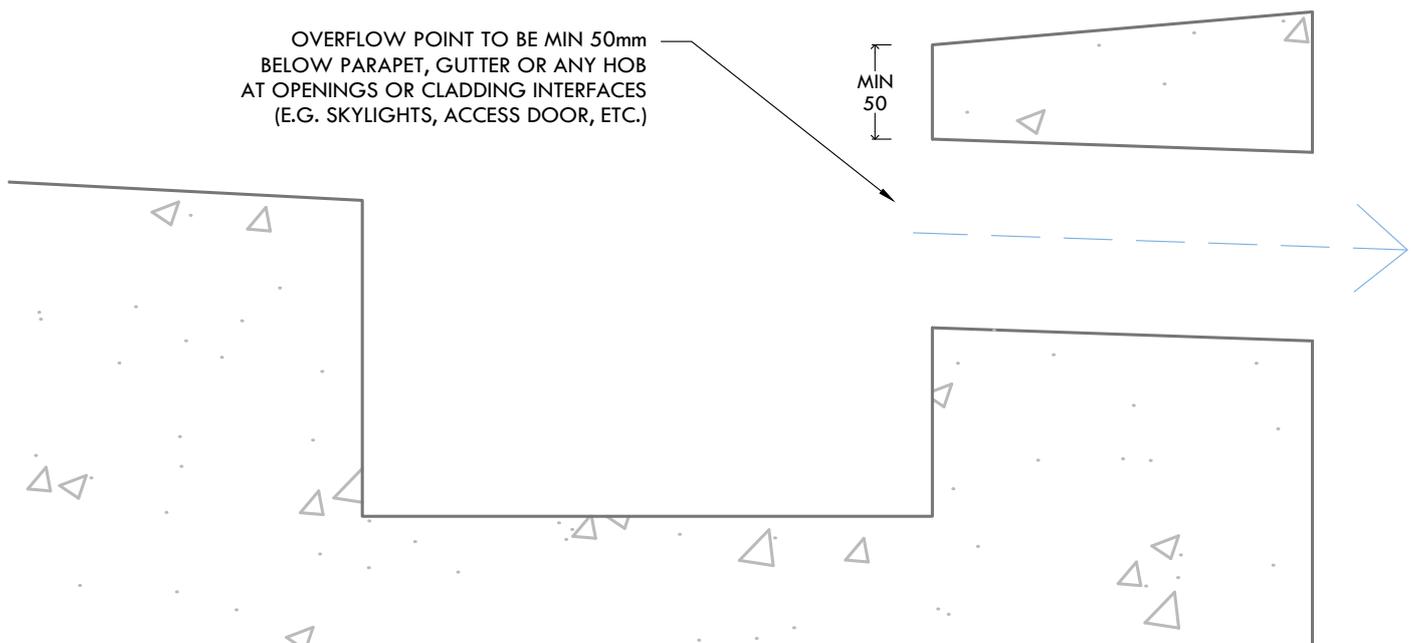


FIGURE 6.2: OVERFLOW

6.1.1.12 Plant

- a. All plant and equipment must be installed in a plant room, to reduce penetrations through the roofing system surface. Where an alternative arrangement is required seek UI approval.
- b. Where heavy duty plant is installed on the roof, the roof must be concrete.
- c. Unless approved by UI, concrete plinths are not to be installed under rooftop plant equipment. All plant is to be installed on an elevated plant platform.
- d. The platforms for plant and equipment must be constructed in such a way that the roof surface and plant equipment are easily accessible. The platform must be constructed of aluminium and is to be a proprietary prefabricated system.
- e. Maintenance pathways including those for major plant maintenance are to be approved by UI and COS, and be in alignment with Green Star Requirements.
- f. A minimum distance of 600mm must be provided between the roofing system surface and the platform. This distance also relates to the lowest point of any equipment installed on or below the platform. This clearance may be reduced for items which are liftable without mechanical assistance such as condenser units. Clear height is required for maintenance access for both waterproofing membrane and plant and equipment.
- g. Platforms are to be designed so that the sections of the platform can be disassembled to allow access for roof maintenance. This also reduces cutting of the material and hot works when installing.
- h. Incorporate sound attenuation mounts where flanking sound can be transferred through the roof.
- i. All platforms are to comply with the current version of AS 1657.

6.1.1.13 Communications Equipment

- a. The design of all communications equipment installations must not impair access for roofing system and façade maintenance or to other equipment located on the roofing system, and must not require shutdown for any roofing system and façade maintenance.
- b. All installations must be self-supporting and must not rely on any plant or equipment to support the device.
- c. The equipment must be fixed to a supporting structure, without causing any penetration on any element that is part of the weather barrier of the roof.
- d. Flexible conduits must not be used through a roof penetration.
- e. The roofing system design must be future-proofed with structural fixing points, cable trays and other relevant provisions, to reduce the number of additional penetrations on the roofing system, in particular waterproofing to be made during the lifespan of the building.

6.1.1.14 Redundant Equipment

- a. All redundant services (power, water, drainage, etc.) must be removed as part of the project. Building surfaces and finishes must be “made good”.

6.1.1.15 Product Support

- a. All materials and equipment are to be readily available in Australia and meet the relevant Australian standards and other legislative requirements.

6.1.2 Metal Roofing System

This section details the minimum requirements for metal roofing systems as required by the University, in addition to relevant NCC clauses, AS 1562.1 and other relevant standards and codes.

6.1.2.1 Metal Roofing System Types

Metal Roofing without Secondary Drainage Plane

- a. Suitable for use over plant areas and canopies.
- b. Standing seam metal roof with concealed fixings. Without a secondary drainage plane the metal roofing panel is the only layer of protection from water entry.
- c. Use of exposed fixings is not allowed without UI approval.

Metal Roofing with Secondary Drainage Plane

- d. Suitable for use over conditioned spaces.
- e. Standing seam metal roof with concealed fixings and a secondary drainage plane. The secondary drainage plane allows for redundancy in the roofing system in the event of water entry through the primary drainage layer.
- f. The secondary drainage plane can be a roof membrane or a metal deck.
- g. Use of exposed fixings is not allowed without UI approval.

Non-combustible Insulated Metal Sandwich Panel

- h. Suitable for use over a sports hall, plant area or canopy.
- i. Typical detailing does not include a secondary drainage plane.
- j. Use of exposed fixings is not allowed.

6.1.2.2 Materials (Typical Conditions)

For typical applications, the minimum values below shall apply:

- a. Steel
 - i. Roofing – minimum 0.55mm BMT, exposed metal roof may need to allow for thicker gauge for trafficability and hail resistance.
 - ii. Flashings – minimum 0.6mm BMT
 - iii. Gutters – minimum 1.2mm BMT
 - iv. All external exposed steel to be Colorbond ULTRA for main campus buildings. Use of an alternative needs to conform with AS 1397 and AS/NZS 2728 and be approved by UI. Consider use of Steel Magna Flow or Unicote Lux where high level of corrosivity is expected.
 - v. All external non-exposed steel within roof system to be Zinalume or equivalent.
- b. Aluminium
 - i. Roofing – minimum 1 mm BMT (AS 1562.1)
 - ii. Gutters and flashings – minimum 1.6mm BMT
 - iii. All exposed aluminium to have high performance coating conforming with AAMA 2604 or 2605.
 - iv. Aluminium roof with aluminium fixings is required when high level of corrosivity is expected.
- c. Colours to light coloured, cool roof colours in line with Green Star requirements – Surfmeister or equivalent for colorbond.
- d. The same material must be used for all metal roofing system components (e.g. movement joints, flashings, gutters, etc.). Where this is not possible, a compatible material with equivalent or superior durability must be selected to avoid durability issues (e.g. galvanic corrosion), and full details must be submitted for approval by UI.

6.1.2.3 Slope

- a. Metal roofing slope (post structural deflection) to be minimum 3 degrees (after deflection), and never less than the manufacturer's specifications. Any application of the roof with less than 3 degrees must be approved by UI.
- b. Selected metal roofing slope must allow for 25-year warranty.

6.1.2.4 Flashings

Pan Flashings

- a. The pan flashing is to cover at least one full rib either side of the penetration. The pan flashing must extend up to the ridge and minimum 600mm downslope. Where the pan flashing is within 500mm distance from the gutter, the pan flashing must extend to the gutter.
- b. All pan flashings that exceed two ribs in width shall have a rigid support provided under the pan to prevent damage.
- c. Pan flashings are to have a folded turnup on the uphill and side slope on the sides of the penetration. There are to be no pierced lap seals within 300mm of the upslope side of the penetration.

Ridge Flashings

- d. The ridge flashing must extend and have a minimum 300mm overlap to the adjacent metal roof sheet and have a minimum 5 degree slope.
- e. Must be under-flashed using a compatible butyl flashing tape.

Silicone Boot Flashings

- f. Penetrations requiring a silicone boot flashing are to be under-flashed using a compatible butyl flashing tape and a 316 stainless steel hose clamp.
- g. Silicone boot flashings may only be used when fastened to a pan flashing.
- h. Only silicone boot flashings with a tolerance to temperature of between -50°C to 200°C are to be used on penetrations.
- i. To prevent multiple penetrations through the roof structure, the provision of a 100mm hard pipe with a turn down is to be installed where future penetrations may be required. This is to be sealed around the protruding cabling or pipework.
- j. Multiple pipes are not to be flashed by one silicone boot flashing component. Each service or piece of equipment will have its own dedicated silicone boot flashing.
- k. Silicone boot flashings are to be installed on the diagonal so that water does not pond on the uphill side of the penetration.
- l. Dektite is the preferred silicone boot flashing.

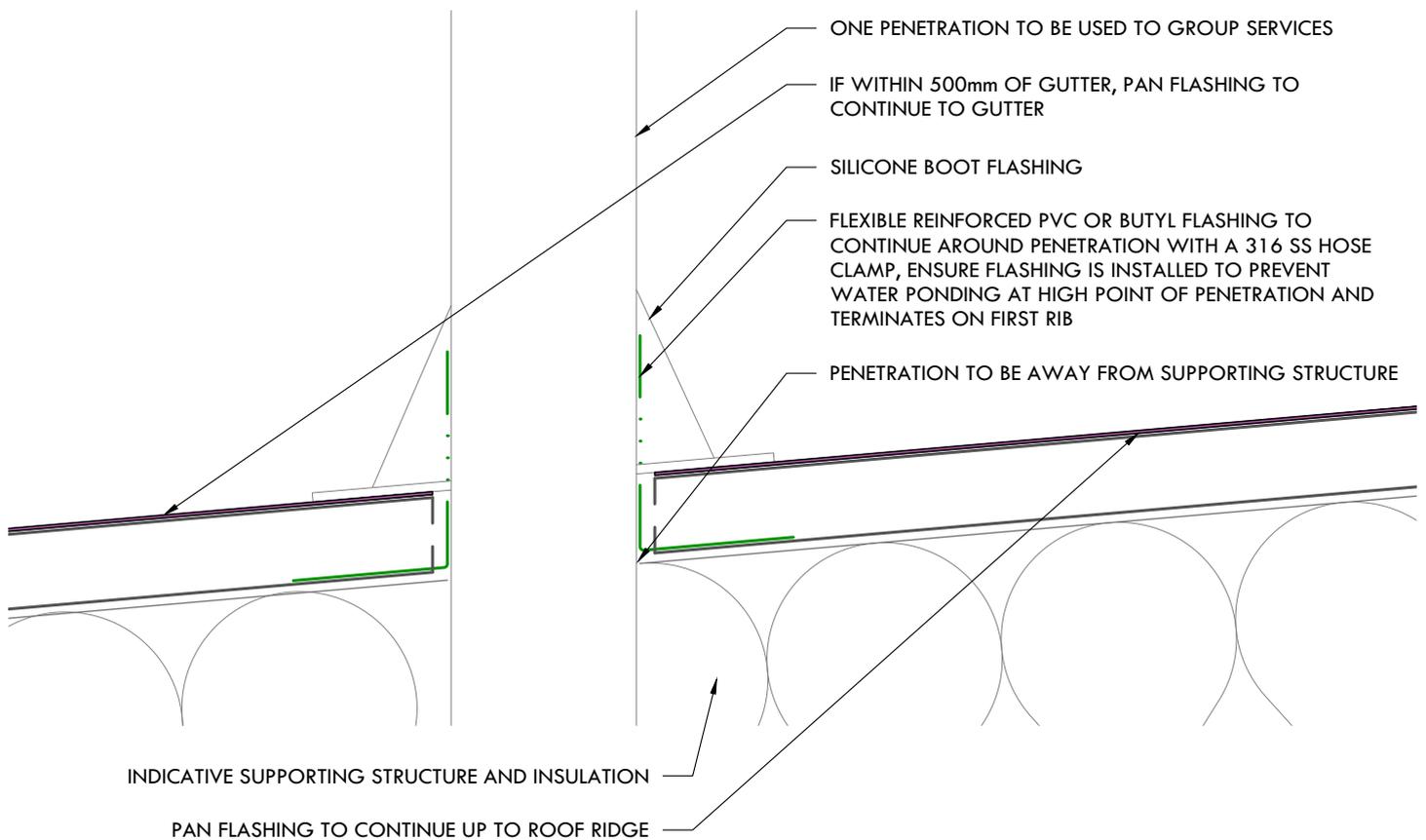
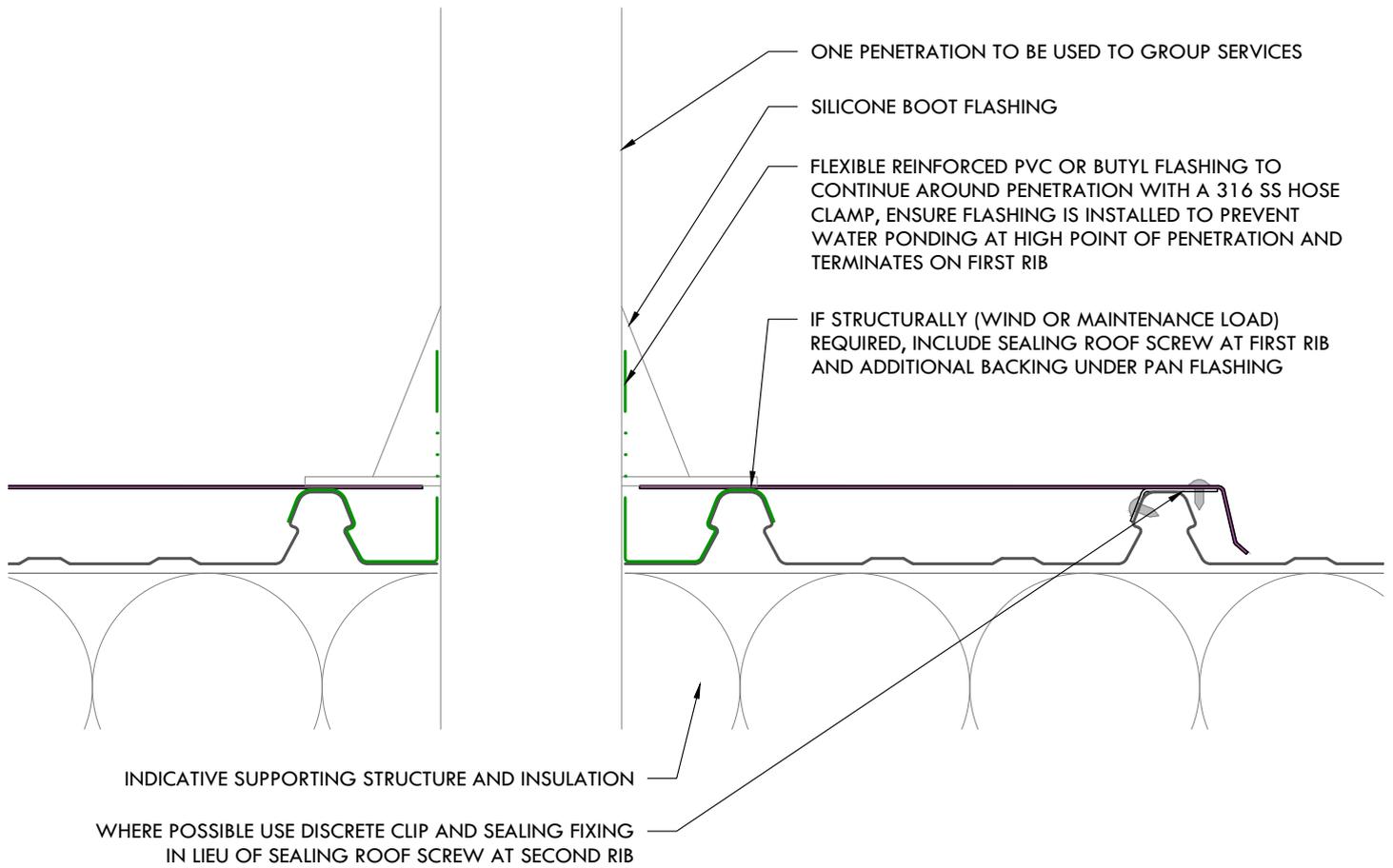


FIGURE 6.3: METAL ROOF PENETRATION

6.1.2.5 Fixings

- a. Use of exposed fixings is to be limited to where hidden fixings cannot be used. All exposed fixings to have EPDM washers. Details of exposed fixing locations to be provided to UI for approval.
- b. All construction detailing, including junctions and connections between panels and the supporting structure, or between panels and other elements of the roofing system must be scrutinized by the installer for point of fixity to allow for thermal expansion. For example, a fascia break detail fixes the panel at the point of the break. To fix it again at its opposite end would constitute double pinning.
- c. Where fixings are not specified for project specific conditions (e.g. corrosion zone) by the product supplier, fixings are to be selected which are compatible with the roofing system materials, appropriate for the project specific corrosion zone and have supplier approval for use.

Refer to Section 7.1.11 for information on corrosion.

6.1.2.6 Roofing System Extras

- a. All roofing system extras (solar panels, walkways, etc.) must not rely solely on the metal roofing panels and be supported by the roofing system structure. Where required design loads must be coordinated with the Structural Engineer, in particular for additions to existing buildings.
- b. For standing seam roof panels, roofing system extras must be fixed with non-penetrating clamps. Clamps must avoid double pinning of the roof panels to allow thermal movement, and be installed minimum 200mm away from hidden clips to not restrict thermal expansion of the roof panels.

6.1.2.7 Testing

- a. All selected metal roof systems must be tested in accordance with current version AS 4040.

6.1.2.8 Details

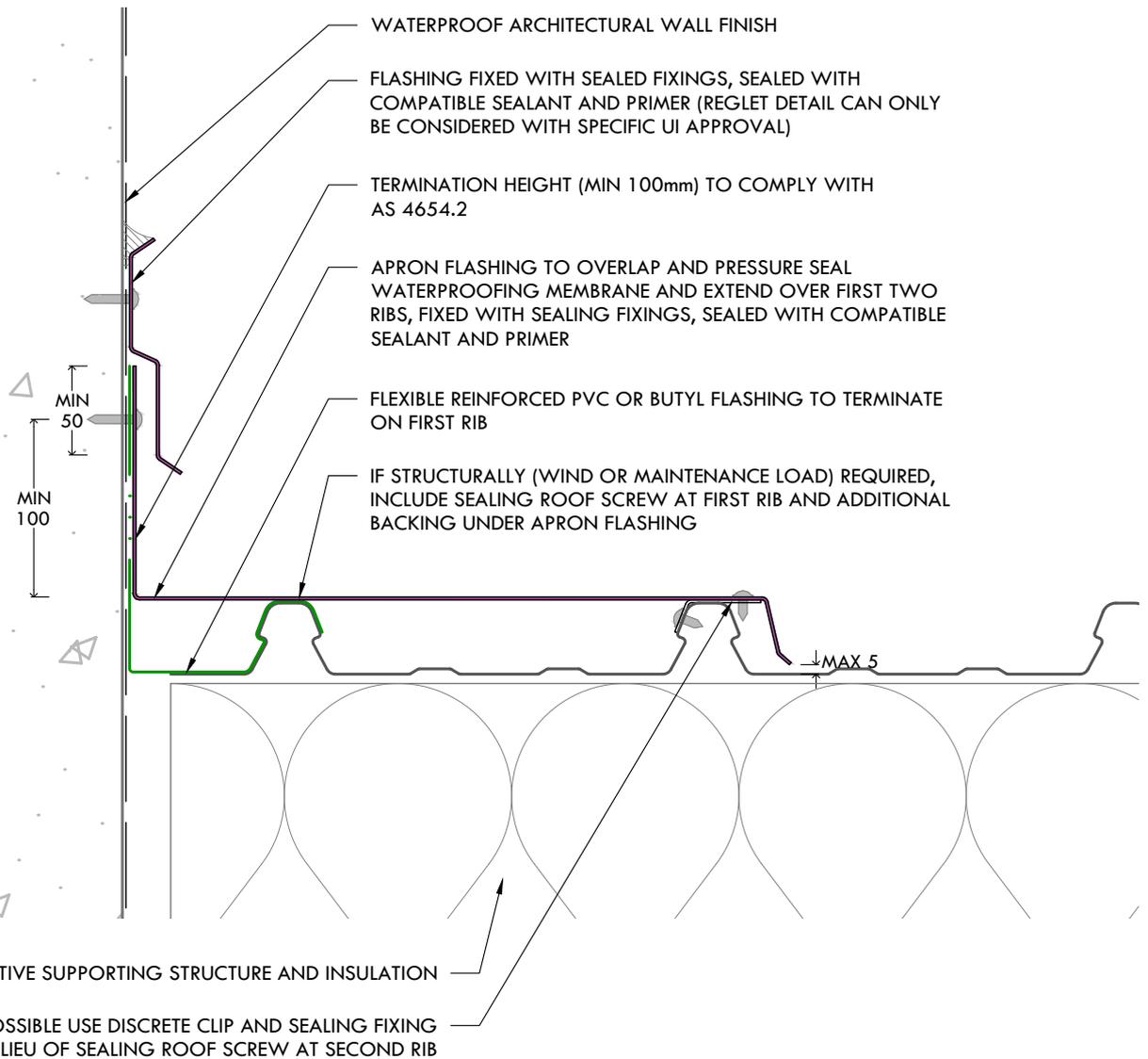


FIGURE 6.4: METAL ROOF TERMINATION AT VERTICAL WALL

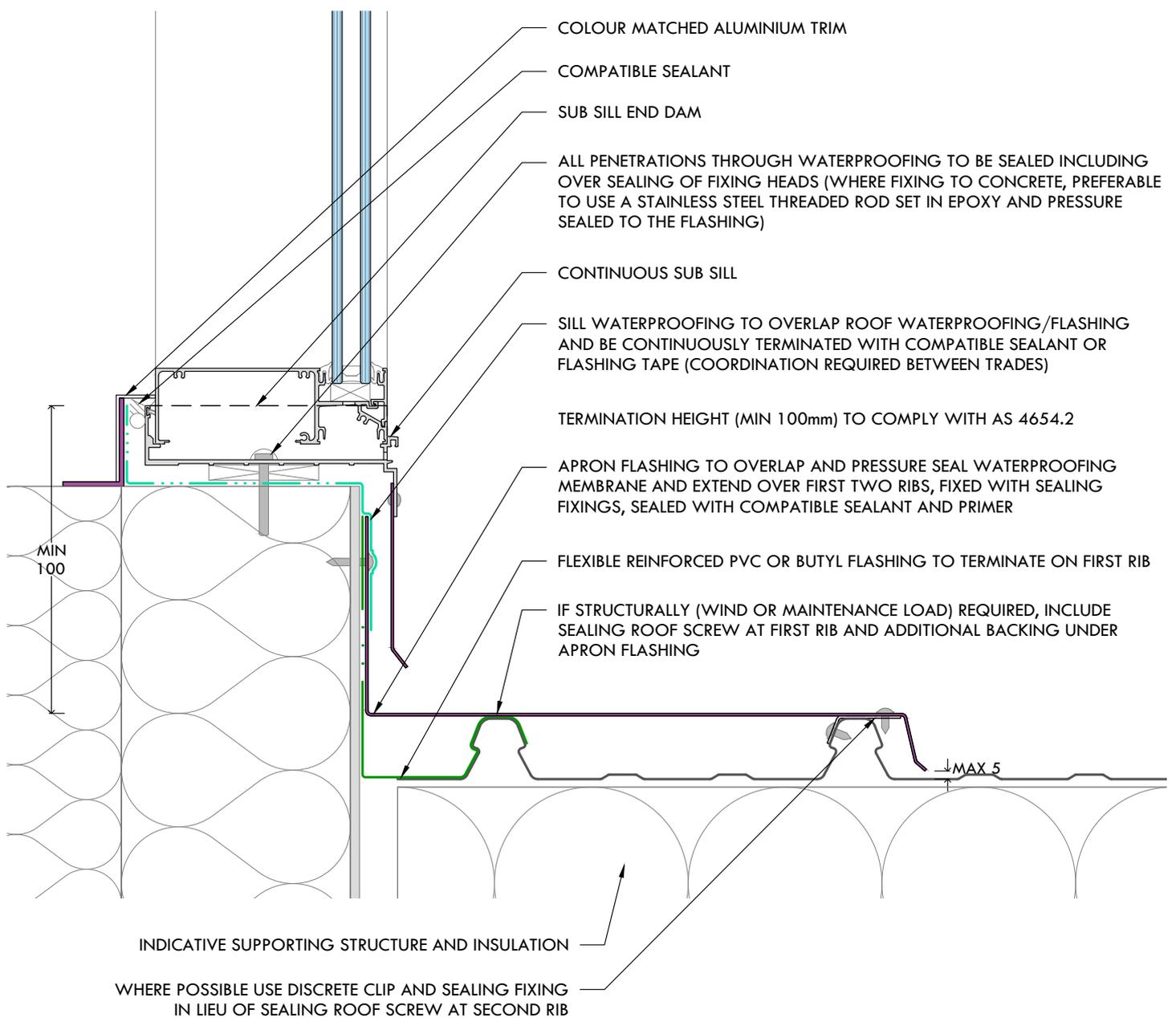


FIGURE 6.5: METAL ROOF TERMINATION AT WINDOW SILL

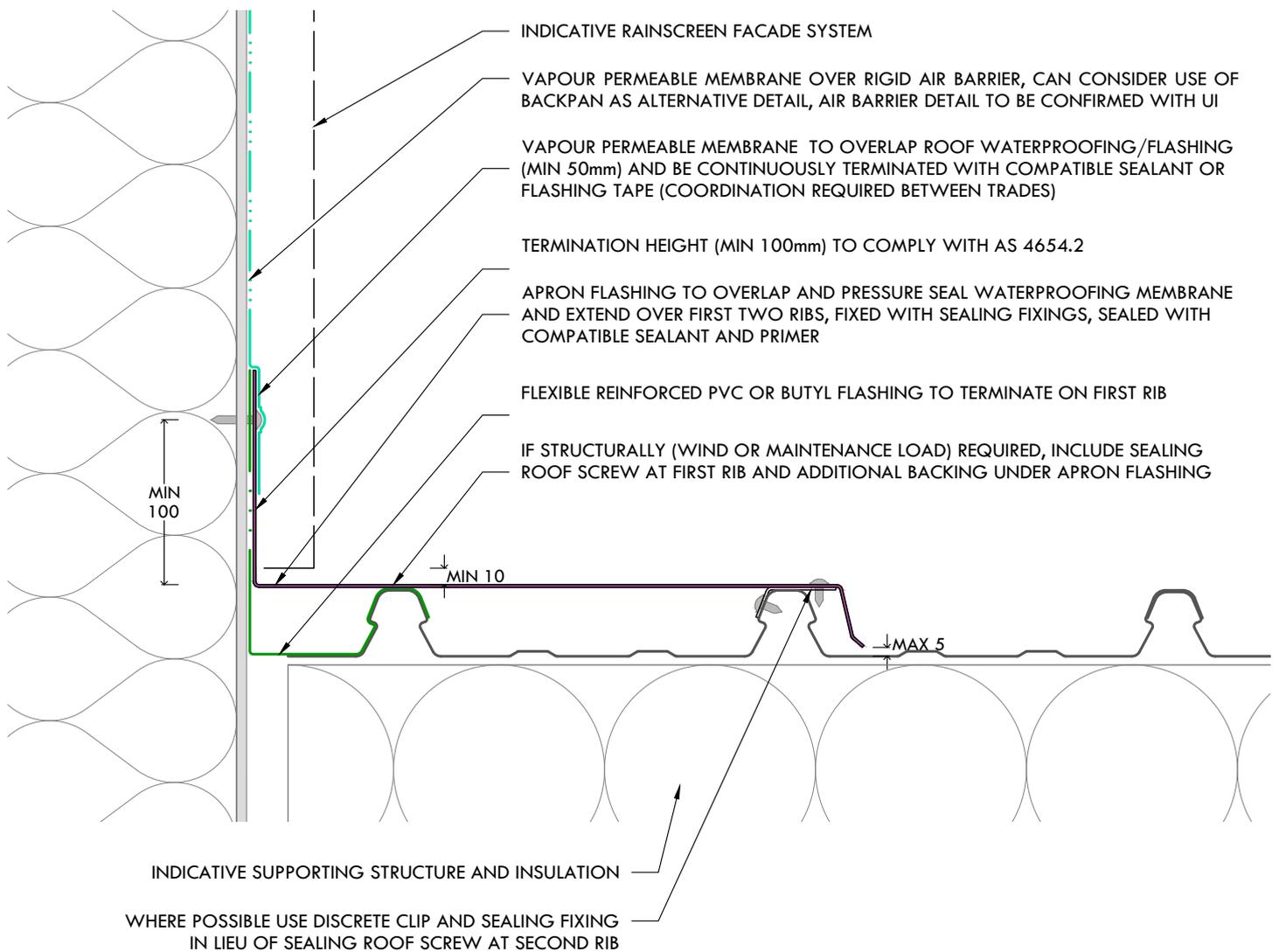


FIGURE 6.6: METAL ROOF TERMINATION AT RAINSCREEN FAÇADE

6.1.3 Concrete Roofing System

A concrete roofing system is inclusive of waterproofing membrane. This section details the minimum requirements for concrete roofing systems as required by the University, in addition to relevant NCC clauses, AS 4654 and other relevant standards and codes.

Concrete roofing systems are the preferred choice of roof system where:

- a. Low slopes are required;
- b. There will be high foot traffic;
- c. The roof will have heavy plant or equipment.

For applications where proposed waterproofing membrane is installed on a structural deck (e.g. FC or CFC), the structural deck must follow the concrete design criteria principles described below and specific approval from UI is required.

Warm roof systems are not allowed.

6.1.3.1 Concrete Design Criteria

- a. Riser and downpipe placement must be decided prior to finalising concrete shape.
- b. Concrete must have a minimum uniform fall of 1:80 to the drainage outlets. The fall must be calculated after deflection (minimum 10-year deflection).
- c. Concrete slab must be checked for final deflected shape for the roof slab for factors such as long term deadload deflection, creep, etc. that is part of the structural engineering design. As a minimum 10-year deflection map to be provided identifying areas of maximum hogging and sagging, and drainage outlets to be placed at the bottom of 10-year deflection.
- d. Architect, structural engineer and hydraulic engineer to coordinate spacing required for drainage outlets and drainage planes.
- e. Balconies must be designed without the requirement for construction, expansion and pour joints. On large balconies where an expansion joint is required it must be placed at the ridge of falls with a 50mm hob on either side of the expansion joint and UI approval is required.
- f. Hobs and step downs must be designed without construction, expansion and pour joints.
 - i. At the perimeter hob must be minimum 70mm.
 - ii. At sliding doors step down must be minimum 70mm.
- g. Structural engineer to design concrete to eliminate cracking by considering the following and noting all information on structural drawings:
 - i. Crack control reinforcement design;
 - ii. Curing method design;
 - iii. Concrete mix design.

6.1.3.2 Waterproofing Membranes

- a. Sequencing of membrane installation must take into consideration drainage direction to prevent water ponding.
- b. Selection of the membrane type must take into consideration the lap build-up at interfaces (e.g. door openings, hobs, penetrations, etc.)
- c. Selected membranes to be light coloured, cool roof colours in line with Green Star requirements.
- d. Must be designed to withstand uplift wind load, refer Section 7.1.2.
- e. All the penetrations must be sealed with a compatible sealant and have an over flashing.
- f. All proposed waterproofing membranes require full documentation including relevant test reports, details and O&M manuals to be submitted for UI approval.

Modified bitumen membrane (preferred option)

- g. Must be electronic hot air welded or peel and stick installation. Use of an open flame is not permitted.
- h. Minimum 2 layers to be used.
- i. The bottom sheet must be a vented sheet if there is a likelihood of residual moisture in the substrate.
- j. The top sheet must include a mineral chip (or equivalent) layer to achieve low heat gain, durability and reduce Heat Island Effect.
- k. When protective coating is required, the coating system must last 5-years without maintenance.

Reinforced single-ply membrane (preferred option)

- l. Must be a class II or class III membrane.
- m. Membrane can be PVC, KEE or Butynol, alternate material selection requires specific UI approval.
- n. Membrane can be adhered and/or mechanically fastened.

Liquid applied membrane

- o. Can only be used for existing buildings subject to UI approval.
- p. Only proven two-part polyurethane/polyurea waterproofing systems that are supported by a 25-year manufacturer's warranty are to be used.
- q. Minimum thickness must be tested as per manufacturer's installation QA requirements.
- r. All areas need to be accessible for maintenance.
- s. Where UV protective coating is required, it must be installed as per manufacturer's requirements.

6.1.3.3 Durability

- a. Waterproofing membranes are to be selected to be resistant to temperature, UV, roots, biological agents, cyclic movement, puncture, tear, and chemicals to achieve the required design life.
- b. UV protection shall be installed in accordance with manufacturer's instructions.
- c. Waterproofing membranes to be tested in an approved facility according to AS 4654.1. Elongation at break to comply with Pass/fail criteria in Appendix A.
- d. The minimum warrantable life of a membrane is to be 25-years.
- e. Where a membrane or its components requires maintenance, ensure that the membrane is accessible and provide a maintenance schedule at the time of tender for UI approval.

6.1.3.4 Installation

- a. Prior to commencing works allow for workshop(s) with architect, structural engineer, hydraulic engineer, waterproofing consultant and membrane supplier to review project specific detailing, to identify any challenging areas and hold points.
- b. Waterproofing membranes are to be installed with adequate overlaps in the direction of the roof slope to reduce risk of water ingress and prevent water ponding.
- c. There must be minimum 28 days of curing period of the concrete substrate before membrane is installed.
- d. Moisture content of the concrete substrate shall be less than 4.5% when measured with a concrete moisture meter.
- e. Membranes must **not** be installed where one or more of the following conditions is met:
 - i. Concrete temperature is less than 10°C;
 - ii. Relative humidity (RH) greater than 75%;
- f. The manufacturer must provide written sign-off that the slab is ready to receive the membrane.
- g. Drainage outlets must be compatible with the proposed concrete roofing system and shall be recessed into the concrete substrate.
- h. For concrete roofing system with slopes greater than 10°, above the horizontal, a fully bonded membrane must always be used.
- i. Waterproofing membranes are to be protected from damage during installation and after testing to project handover. If damaged, waterproofing membrane is to be replaced or repaired prior to completion of works.
- j. It is the responsibility of the main contractor to ensure that the waterproofing membrane is protected after the installation and QA testing until project completion and handover.
- k. The waterproofing membrane subcontractor/installer must demonstrate minimum 10-years local experience with the selected waterproofing membrane.

6.1.3.5 Ballast

- a. Use of ballast is not allowed on new buildings.
- b. Ballast can only be used on existing buildings with UI approval where:
 - i. It is required to hold down a loose laid single-ply membrane;
 - ii. Additional UV protection is required;
 - iii. Siphonic drainage is not used.
- c. Drainage cell wrapped with filter fabric shall be provided under ballast laid on a waterproofing membrane.
- d. The concrete roofing system slope shall remain consistent to allow for even distribution of the ballast, and must not exceed 9° to prevent the ballast from sliding or shifting.
- e. Ballast is to be designed for wind uplift in accordance with ANSI SPRI RP-4.

6.1.3.6 Verification and Testing

- a. Waterproofing membrane visual inspection regime must be included in waterproofing membrane system O&M manual.
- b. All new buildings and where it can be introduced in existing buildings, are to allow for EFVM system to be included in the concrete roofing system design. EFVM testing is beneficial in pinpointing exact locations of waterproofing membrane breaches and is a non-destructive form of testing.
- c. Flood testing is to be used on existing building where EFVM testing cannot be conducted, and must be undertaken to a recognised standard such as ASTM D5957.
- d. At the completion of successful testing, waterproofing membranes must be protected to prevent damage to the installed systems prior to Practical Completion.
- e. When necessary, the following complementary test methods can be implemented.
 - i. Identifying location of wet insulation in roofing system using thermal imaging following ASTM C1153.
 - ii. Probe testing/visual inspection of waterproofing membrane in particular to inspect quality of joints.

6.1.3.7 Details

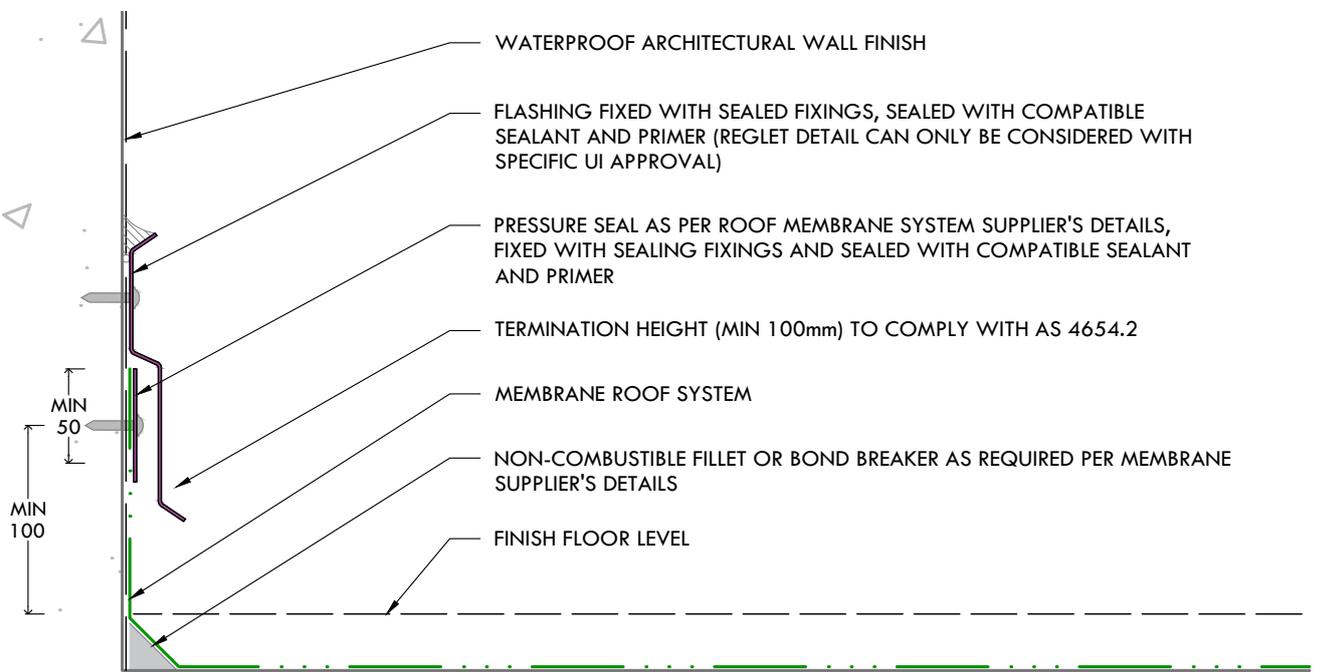


FIGURE 6.7: MEMBRANE ROOF TERMINATION AT VERTICAL WALL

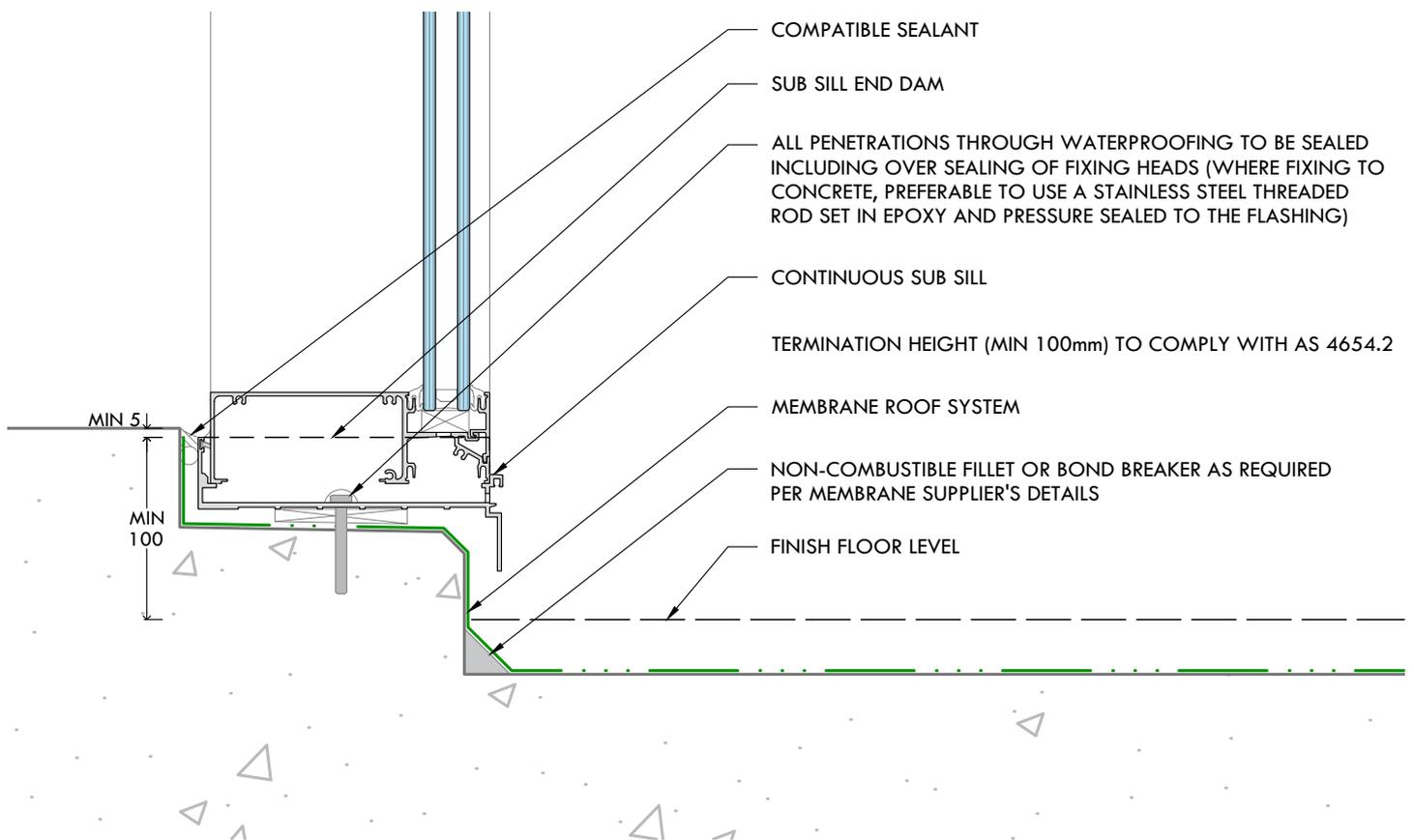


FIGURE 6.8: MEMBRANE ROOF TERMINATION AT WINDOW SILL

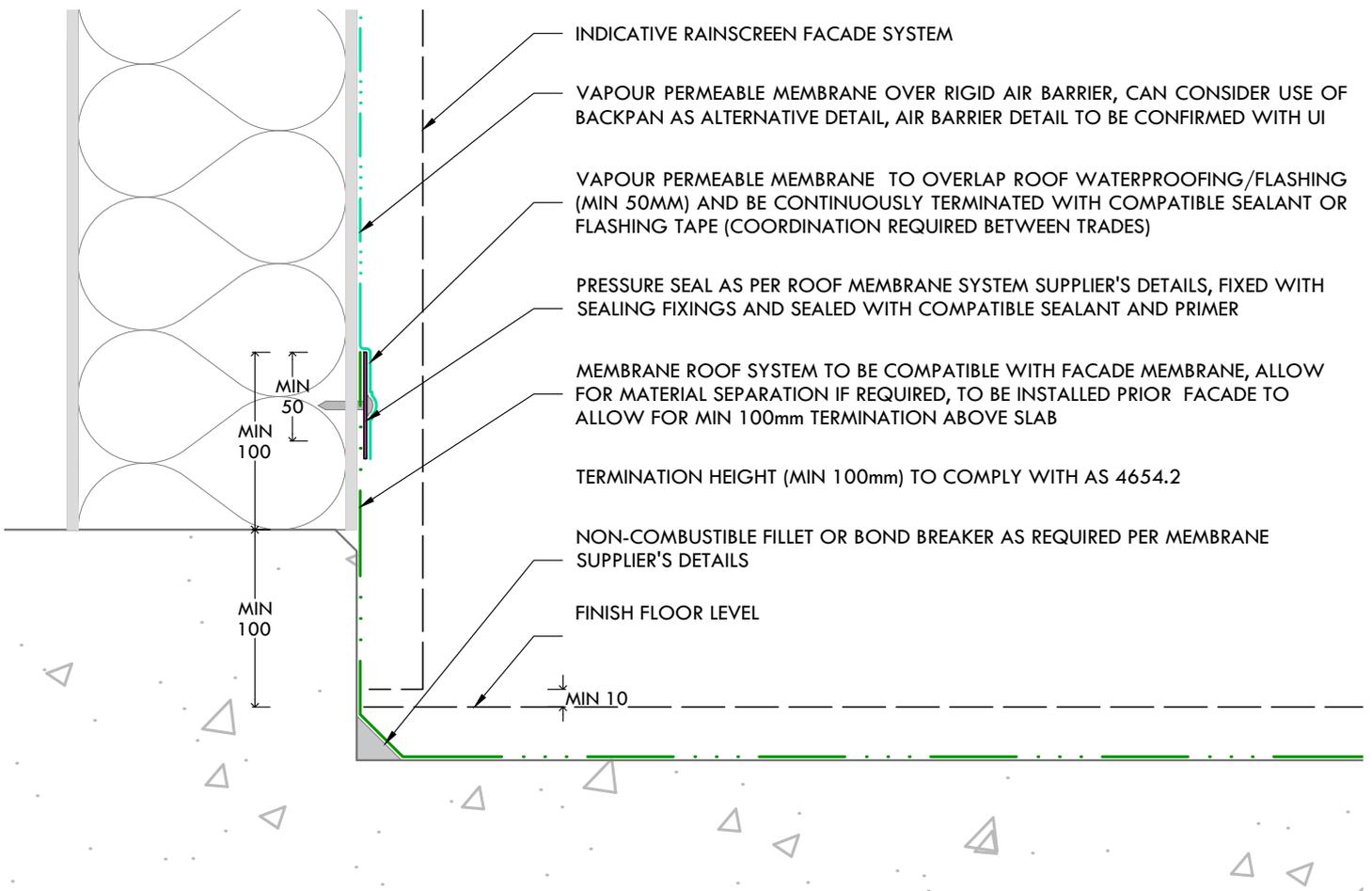


FIGURE 6.9: MEMBRANE ROOF TERMINATION AT RAINSCREEN FACADE

6.1.4 Green Roofing Systems

Green roofing systems are not preferred at roof level and will only be considered by exception by UI.

Where a green roofing system is proposed, a proprietary system is preferred, a landscape architect must be included as part of the design team and a fire engineer must be consulted to confirm any performance solution requirements.

This section identifies key considerations for green roofing systems for the University, and it is recommended the MBA Waterproofing Guide for Planter Box Waterproofing is referred to for detailed guidance.

It should be noted that green roofing systems only applies to areas defined as roofs according to this Standard.

6.1.4.1 Green Roofing System Build-up

A green roofing system is typically divided into two parts, the substrate and the greenery system.

Substrate

- a. The substrate must be a concrete roofing system inclusive of a waterproofing and drainage system, refer to Section 6.1.3.
- b. Concrete roofing system design must be coordinated with the Structural and Hydraulic Engineer to allow for additional weight of a green roofing system.

Greenery System

- c. Is a system that caters to all the requirements for the vegetation to thrive and is inclusive of waterproofing and drainage system.
- d. Consists of a structure that holds the growing media, root resistance membrane, filter fabric, drainage layer and waterproofing.
- e. The structure can be fixed, modular or hybrid.
 - i. Fixed – permanently fixed to the substrate.
 - ii. Modular – flexible structure that allows for greenery system to be maintained within each module and access to substrate without needing to remove the greenery system.
 - iii. Hybrid – combination of a modular and fixed structure.
- f. The system can be traditional or soil-less.
 - i. Traditional – method of growing plants using soil types suitable for the vegetation to thrive.
 - ii. Soil-less – method of growing plants using nutrient-rich water solutions. This technique allows plants to grow faster and more efficiently by providing them with direct access to essential nutrients. This system is lighter in weight and reduces the structural load to the roof when compared to a traditional greenery system.

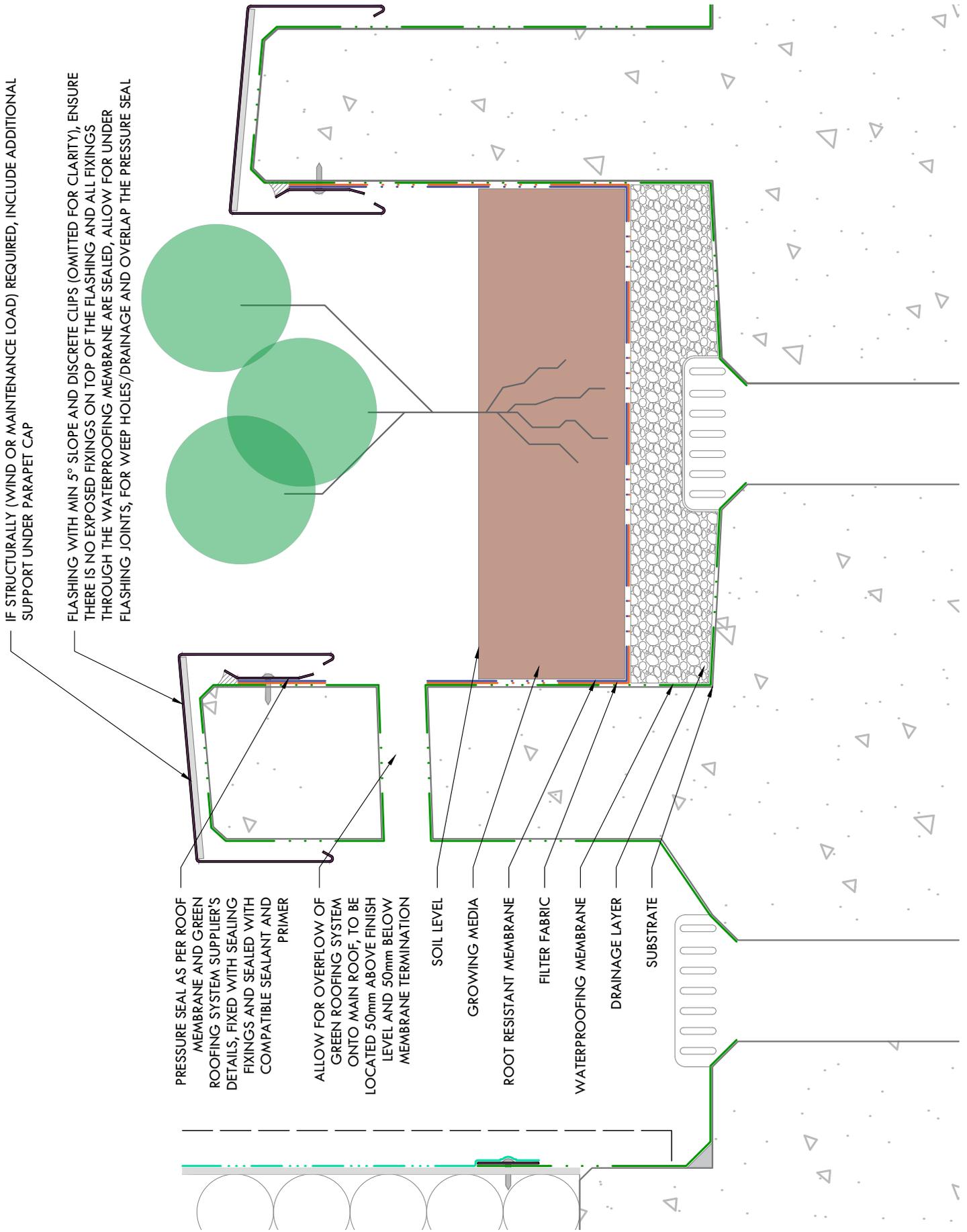


FIGURE 6.10: GREEN ROOFING SYSTEM BUILD-UP

6.1.4.2 Green Roofing System Locations

- a. Can only be installed in areas where no special access will be required for maintenance.
- b. The greenery system must not be installed to abut an external wall. There must be a minimum 50mm gap between the greenery system and external wall.
- c. The greenery system must not be continuous over a movement joint.
- d. Must only be located where space below is external or is a circulation space within the building.
 - i. Cannot be installed above functional spaces (e.g. lecture theatre, classrooms, offices, laboratory, etc.)
- e. Must not be installed where location coincides with building drainage system overflow points.

6.1.4.3 Membrane Requirements

- a. The membrane waterproofing principles identified in Section 6.1.3 also applies to green roofing systems.
- b. The membrane must be tested to AS 4654.1.
- c. The membrane termination height must be minimum 100mm above the finish level.
- d. All areas must be fully flood tested prior to installation of growing media.
- e. The waterproofing layer part of the concrete roofing system must be installed with an EFVM leak detection system.
- f. Where the selected membrane does not have sufficient root resistance for the selected flora, two membranes can be used. The two membranes must be compatible, and the root resistance membrane must be above the waterproofing membrane.

6.1.4.4 Flora Selection

- a. Flora selection requires input from the landscape architect and system supplier to ensure the flora selection is fit for purpose.
- b. Selection of flora must consider the following:
 - i. Use of native species
 - ii. Resilience to climate change
 - iii. Impact to local flora and fauna
 - iv. Maintenance requirement
- c. Must provide flora specific biodiversity impact and lifecycle analysis.

6.1.4.5 Irrigation

- a. Irrigation requirements for the green roofing system must be planned to reduce number of penetrations through the primary waterproofing layer.
- b. Green roofing system cannot solely rely on portable water for irrigation. There needs to be access to a consistent water supply to ensure the regular irrigation intervals are met for the selected flora.

6.1.4.6 Drainage

- a. The drainage principles identified in Section 6.2 also applies to green roofing systems.
- b. Drainage system must be designed for extreme weather conditions of past 100-year events.
- c. Overflow must be at least 50mm above soil level and 50mm below membrane termination height.
- d. Overflow drainage system must not be connected to primary drainage of the green roofing system.
- e. The drainage system must be fully tested prior to the installation of the growing media.
- f. Drainage system must be designed to not allow any solid particles into the drainage system and must be serviceable without spoiling the integrity of the green roofing system.

6.1.4.7 Maintenance

- a. Maintenance intervals must be agreed with UI and COS prior to finalising the green roofing system design.
- b. O&M manual must include requirements for irrigation system and selected flora.

6.1.5 Tiled Roofing Systems

Tiled roofing systems includes materials such as terracotta and slate.

6.1.5.1 Tiled Roofing System Requirements

- a. Tiled roofing systems must allow for a secondary drainage plane.
- b. Roof slope must be as per tile manufacturer's recommendations to allow for runoff and avoid water ponding at tile joints.
- c. Must use a proprietary penetration system.
 - i. Base sheet flashing must extend below tile above penetration and continue over tile below penetration.
- d. Where system specific details cannot be followed, system supplier/expert must be consulted to resolve project specific details.

6.1.5.2 Existing Buildings

- a. UI must be informed where:
 - i. Requirements (e.g. allow for a secondary drainage plane) cannot be met.
 - ii. Large scale damage or leaks are found.
- b. Where like-for-like replacement is not required alternative roofing systems (e.g. a metal roofing system) can be proposed.

6.1.6 Specialised Roofing Systems

Specialised roofing systems requires design input from specialist consultant, contractor and system supplier. It is recommended Early Contractor Involvement (ECI) is considered where any specialised roofing system is to be used.

Specialised roofing systems includes:

- a. Copper and lead roofs
 - i. Heritage buildings
- b. Tanked roofs
 - i. Only allowed on existing buildings.
- c. ETFE/PTFE roofs
 - i. Canopy or cover for sporting area
- d. Prefabricated roofs
 - i. Sheds and farm structures
- e. Glass or polycarbonate roof
 - i. Greenhouses and sheds
 - ii. Must have fire engineer sign-off.

Skylights and canopies are outside the scope of this Standard, refer UI Façade Standard for further information.

6.2 Roofing System Drainage

This section includes, but is not limited to, the minimum requirements for the design, supply and installation of fully functional stormwater drainage systems applied to new and existing buildings.

6.2.1 General Design Criteria

- a. The rainwater drainage system shall be designed in accordance with the performance requirements of this document, the NCC, applicable Australian Standards and Codes, best practice industry guidelines, and other University of Sydney standards.
- b. The rainwater drainage work that complies with the provisions of AS/NZS 3500.3 are deemed-to-satisfy for the performance requirements of the NCC.
- c. Performance Solutions can be used if they meet the performance requirements of NCC and are accepted by UI.
- d. Conventional gravity drainage systems shall be used for all drainage systems.
- e. Where conventional gravity drainage system is not feasible, siphonic drainage system can be proposed with UI approval as per subsequent sections.
- f. All components of the roofing system drainage, including gutters, sump, rainwater pipe, overflows and overflow pipes must be located to allow replacements and maintenance.
- g. Material selection must be compatible with the roofing and building materials and where exposed be suitable for direct sunlight exposure and temperature exceeding 80°C, for all components of the roofing system drainage, including gutters, sump, rainwater pipe, overflows and overflow pipes.
- h. Drainage system shall be sized to suit latest Bureau of Meteorology statistics or AS/NZS 3500.3 requirement whichever is the most onerous plus climate change resilience allowance of 20% above the rainfall intensities data.
- i. The roof drainage designer shall hold the necessary registration for certification of the building roof drainage recognised by NSW Fair Trading.
- j. All special conditions must be identified, discussed and agreed with UI.

6.2.2 Gutters

6.2.2.1 Eaves Gutter Systems (preferred option)

- a. Eaves gutter systems must be designed for minimum 5% AEP plus climate change resilience allowance of 20% above the rainfall intensities data.
- b. Eaves gutter systems, including downpipes, shall be designed and installed so that water will not flow back into the building, and have a fall greater than 1:200 including tolerances.
- c. Eaves gutters shall have support systems to allow longitudinal thermal expansion without impacting the gutter or accessories.

6.2.2.2 Valley Gutter System

- a. Valley gutters must be adequately supported by valley boards running the entire length of the gutter.
- b. Joints in valley gutters must be lapped.
- c. No welding or sealing of joints is permitted.
- d. Weathering of the valley gutters must include a supported “turn up” of at least 10mm.
- e. Where valley gutters are adopted, the following shall apply as per AS/NZS 3500.3:
 - i. The catchment area shall not exceed 20m²
 - ii. Roof slopes shall not be less than 12.5 degrees
- f. The nominal valley gutter side angle must not be less than 16.5 degrees
- g. Valley gutters must have a minimum 300mm overlap on either side of the valley and include closer strips to match the profile of the roof.

6.2.2.3 Box Gutter System

- a. Use of box gutters is to be avoided and box gutters must not be installed without specific approval from UI.
- b. Box gutters must be provided with overflows
- c. Box gutter systems must be designed for minimum 1% AEP plus climate change resilience allowance of 20% above the rainfall intensities data.
- d. To avoid ponding and consequently corrosion, box gutters shall be built with a minimum fall of 1:200.
- e. Minimum depth of box gutters must be 150mm and the box gutter sump depth must not be less than the box gutter depth due to issues surrounding hail causing flooding.
- f. Minimum clear width of box gutters must be 400mm for ease of cleaning.
- g. Outlets to have guards/protection to prevent blockages.
- h. Sumps are to be fitted to the underside of the box gutter floor.
- i. Box gutter design must eliminate/minimise the number of required expansion joints, and where this is not possible expansion joints to be provided as per AS/NZS 3500.3.
- j. For metal roofing systems, box gutters must incorporate a box gutter flashing under the roof sheet with closer strips to suit the profile of the roof.
- k. Box gutters must be stainless steel 316, alternative material selection requires specific approval from UI.

6.2.3 Rainhead

- a. Rainheads are acceptable and encouraged to be used as when constructed correctly, offer exceptional fail-safe qualities.
- b. Rainheads are to be constructed from materials compatible with the roofing and building materials.
- c. A slotted overflow no less than three quarters of the length of the rainhead must be included in the design. The overflow must be installed no less than 100mm from the end of any ancillary product supplying the rainhead. The capacity of the overflow is to be no less than 1 ½ times the size of the gutters/downpipes supplying the rainhead.

6.2.4 Downpipes

- a. Rainwater shall be directed by guttering, downpipes and drains to the respective stormwater drainage system in accordance with local codes, the NCC and Australian Standards, and discharged to the nearest suitable civil stormwater drainage system.
- b. Downpipes are to be sized to suit latest Bureau of Meteorology statistics or AS/NZS 3500.3 requirement whichever is the most onerous plus climate change resilience allowance of 20% above the rainfall intensities data.
- c. Drainage pipework must be located external to rooms containing electrical equipment susceptible to water damage including computers, communications equipment, servers, switchboards, and transformers.
- d. As a minimum downpipe size to not be less than: Ø100mm or equivalent 100mm x 75mm rectangular downpipe.
- e. Downpipes must not be sized to be less than overflows.
- f. Downpipes are not permitted within structural columns.
- g. Design and installation of the downpipes and material selection must be compatible with the roofing and building materials and where exposed be suitable for direct sunlight exposure and temperature exceeding 80°C.
- h. Internal downpipes are not recommended. If internal downpipes are to be designed, failsafe components must be submitted to UI for approval.
- i. Rodding access is to be provided for all above ground pipework with a specific rodding point located at finished floor level and in an easily assessable location.
- j. The overflow pipework shall be not less than Ø100mm or the size of the primary outlet/downpipe, whichever is greater.

6.2.5 Overflow and Spitters

- a. All roofing systems, including gutters shall be provided with overflow or spitters to allow for adequate redundancy in roofing system drainage and prevent damage to the building fabric.
- b. Locations of overflows and spitters in all roofing systems, including gutters must be designed to accommodate the potential for blockages of downpipes or during intense storm events.
- c. Roofing system, including gutter overflows suitable to relieve runoff from a 200-year average recurrence interval (ARI) storm event.
- d. The overflow system shall be provided as per AS/NZS 3500.3 and discharge over a pit separate to the discharge point of the primary down pipe and be in a safe visible location above ground floor level, which provides a readily visible indication of a failure or blockage of the main drainage system.
- e. Overflows shall be positioned to discharge in an area capable of accepting the additional volume without creating localised flooding and having a known overland flow path.
- f. Position of overflows to be reviewed to ensure they are not located over entrances, egress paths, areas with trapped overland flows or onto other roofs without sufficient overflow capacity.
- g. Slot-shaped, minimum 300mm wide x 90mm, overflows through the façade are preferable as they reduced the risk of blockages.
- h. When the overflows are integrated with the façade, the façade shop drawings must be reviewed and approved by the Hydraulic Engineer.
- i. The overflow pipework shall be not less than Ø100mm or the size of the primary outlet/downpipe, whichever is greater.

6.2.6 Siphonic Drainage System

- a. Siphonic drainage system must only be used where there are no other options, and with UI approval.
- b. Prepare a performance solution for approval by UI as required.
- c. Siphonic drainage system shall be designed in coordination with the following contractors:
 - i. Syfon Systems Pty Ltd.
 - ii. Geberit Syphonic System
- d. The entire siphonic roof drainage system comprising box gutter size, roof inlets, piping, support system and installation are considered an alternate solution to NCC Volume 3; and must be designed and certified by an expert person as defined in the NCC.
- e. The design shall incorporate a primary siphonic system relevant to the local Rainfall Intensities (RFI) and 20% climate change resilience allowance.
- f. The roof membrane shall be sealed to the siphonic drainage system with a pressure seal.
- g. The calculations for the size and position of roof gutter siphonic inlets, horizontal and vertical pipe work, including bends, branches, junctions and their connections to any associated underground pipe work will be prepared by an approved siphonic specialist.
- h. Calculations to be based on detailed architectural and hydraulic engineering drawings of the project. Also, local rainfall intensities as mentioned above.
- i. The pipework system shall be sized to convey the design roof water flow from the siphonic inlets through the system to the point(s) of discharge via the most efficient possible direction.
- j. The minimum velocity shall be 1.0 m/s for self-cleansing purposes.
- k. The maximum negative pressure in the system shall not exceed 8.0m water column – (-800 mbar)
- l. All pipes and fittings shall be manufactured predominantly from High Density Polyethylene (HDPE), pressure rated.

6.2.7 Noise and Vibration

- a. Stormwater pipework shall be acoustically insulated where located within occupied spaces, or sensitive areas. Liaise with the acoustics engineer to confirm requirements.
- b. All pipework support shall be isolated in such manner to reduce transmission of hydraulic pipe noise and vibration to the building structure.
- c. Stormwater pipework must be routed away from any noise-sensitive spaces.

6.2.8 Durability

- a. The roofing system drainage components including gutters, downpipes and overflows shall be designed and commissioned to provide a minimum service life of 25 years.
- b. Drainage structures, tanks and inaccessible pipe systems shall have a minimum design life of 50 years.
- c. All inlets will incorporate leaf guards when installed in box gutters.

6.2.9 Testing and Commissioning

- a. The Contractor must undertake the testing and commissioning of the drainage system in accordance with the requirements outlined under Section 10 of this Standard.

6.2.10 Hold and Witness Points

- a. The Contractor's Project ITP shall nominate Hold and Witness Points. As a minimum the following main aspect of the roofing system shall be witnessed and sign-off:
 - i. Roof gutter size to match the design drawings.
 - ii. Roof gutter slope to achieve minimum stipulated grade.
 - iii. Confirm number of downpipes outlets are installed as per design documentation.
 - iv. Flood test the gutter and confirm no leaks or ponding and overflow operates as per intended design.
 - v. Confirm number and size of overflows are installed as per AS/NZS 3500.3
 - vi. Confirm material of gutter as per design drawings.
 - vii. Confirm no dissimilar material are in contact.
 - viii. Confirm all installation requirements are done to avoid corrosion of gutter system.
 - ix. Confirm joints are undertaken in accordance with AS/NZS 3500.3
 - x. Confirm gutters and rainheads/sumps have the required freeboard as per design documentation.
 - xi. Confirm expansion joints have been installed as per design documentation.
- b. The above minimum witness points shall be documented, recorded including photographic records and include the as-built submission.

6.3 Roofing System Auxiliary Materials

6.3.1 Insulation

- a. All internal insulation must be non-combustible.
- b. Where insulation is fixed at the purlins, insulation must continue over the purlins.
- c. If required to demonstrate thermal performance, thermal bridging calculation must be provided.

6.3.2 Thermal Breaks

- a. Thermal bridging calculation to be provided where it is not possible to install continuous insulation.
- b. If required, non-combustible thermal breaks must be used to meet thermal performance requirements.

6.3.3 Air Barrier

- a. The following materials are acceptable for air barriers:
 - i. Aluminium
 - ii. Zinalume
 - iii. Non-combustible roof membrane
- b. The air barrier shall be attached to the supporting structure by sealing and securing it with continuous clamps according to product specific details. The clamps shall be sufficiently stiff and shall be fixed with fasteners sufficiently close together to maintain a complete seal and sufficiently strong to resist the design wind load on the air barrier.
- c. Where non-combustible sarking is used the air barrier is to be fixed such that the risk of tearing or damage due to wind loading is eliminated.
- d. If required, aluminium alloy sheet or CFC/FC is to be used for wider gaps where support is required to prevent flapping/tearing under wind loading.
- e. All air barrier joints are to be fully lapped and sealed.

6.3.4 Vapour Control Layer

- a. Vapour control layers must be continuous and non-combustible.
- b. The use of foil faced insulation is not considered as a suitable vapour control layer.

6.3.5 Sealants

- a. Sealants should not be used as the sole waterproofing barrier.
- b. All sealants used are to be compatible with and will not stain the surfaces with which they are in contact and no leakage or contamination from run-off water will occur.
- c. Compatibility and adhesion testing reports must be provided for all project specific applications of sealants.
- d. Silicone sealants must be used for long-term durability. Where an alternate sealant type is required data sheets and warranty information shall be submitted to UI for approval.
- e. Sealants must only be used with manufacturer's approved primers and applied as per the manufacturer's requirements.

6.3.6 Hazardous Materials

- a. For existing buildings:
 - i. Prior to commencement of works, UI to provide information on hazardous materials and risks to general contractor
 - ii. If not present, specialised contractor to provide to UI a hazardous materials register, including safety and design risk mitigation strategies.
- b. For both new and existing buildings the use of hazardous material must be avoided, including materials containing silica.
- c. Refer to UI Contractors Handbook for more information.

7 Performance Requirements

7.1.1 Thermal Efficiency / Comfort

Thermal efficiency is to be included in designing any roofing system or ancillary product, and be included in any maintenance work completed within the University.

Thermal performance must meet or exceed those outlined in Section J of the NCC, project specific sustainability performance requirements (e.g. Green Star) and the UI Building and Architecture Standard.

All roofs and podiums/terraces must consider any comfort issues for users of neighbouring buildings that may be impacted (e.g. reflectivity).

All conditioned spaces must consider the following performance requirements:

- a. Consider the use of ventilated roofing system where possible, to reduce the heat transfer to the internal environment in summer.
- b. The design must assess and minimise the thermal bridges to maximise the energy efficiency and optimise the use of insulation. Remaining thermal bridges must be subject to 2D condensations analysis.
- c. In case the roofing system employs steel purlins with thermal insulation between purlins, the design must specify and include the use of thermal breaks on the upper part of the purlins to reduce the thermal bridges. Thermal breaks compliance with NCC, to be reviewed by building certifier and fire engineer.
- d. All roofing systems to include dedicated air barrier and vapour control layers to optimise energy performance and minimise risk of condensation.
- e. The external finish must be a natural patina or light in colour if painted/powder coated (Surfmist or equivalent from Colorbond). No black/dark colour is allowed. This has numerous benefits including:
 - i. Reduce the risk of Urban Heat Island (UHI) – refer to section 7.1.13 for more information.
 - ii. Reduce the heat transfer to the internal environment in summer.
 - iii. Reduce the thermal expansion on the roof metal panels.

All balconies and canopies must consider the following performance requirements:

- f. The connection with the main structure must include the use of thermally broken system (e.g. Schoeck) where possible. It is noted that thermally broken systems available on the market may require performance solution to fire as they may employ the use of materials considered 'combustible' by the NCC Deemed to Satisfy Solution.
- g. The design must employ the use of adequate air barrier and vapour control layers, and air tightness testing.

7.1.2 Wind

- a. Uplift wind conditions must be taken into consideration during the decision-making process and material selection.
- b. For projects that include wind testing, the test must include pressure points in correspondence of the main roofing system areas to validate the wind calculation assumptions.
- c. All roof panels, auxiliary elements (including planter boxes, mechanical services, etc.) are to be mechanically retained to avoid dislocations due to wind uplift.
- d. Considering cyclic wind positive/negative pressures, all roofing system membranes must be applied to a rigid substrate design to take full wind load.

7.1.3 Thermal Expansion

- a. External elements to accommodate minimum thermal movement for 90°C change in temperature. Specific temperature differences must be assessed for every project.
- b. If a specific roofing system design requires greater or different allowance, advise during the design phase and incorporate into project specifications.

7.1.4 Fire Performance/Combustibility

- a. All elements in the roofing system must comply with the requirements for non-combustible building elements in NCC 2022 clause C2D10 (or equivalent clause in later revisions of NCC) unless otherwise agreed in writing by the University subject to a performance-based fire safety engineer assessment.
- b. The roof covering must be non-combustible where photovoltaic panels are, or could reasonably be expected to be installed on the roof.

7.1.5 Bush Fire

- a. The design of the roofing system must comply with AS3959 where applicable.
- b. The design of the roofing systems and facades must consider air tightness design and testing to reduce ingress of smoke and lowering of air quality.

7.1.6 Air Tightness

- a. Adequate airtightness targets and airtightness testing must be established, designed, priced and considered for every project since the early stages, especially when air quality and energy efficiency are a major design factor.
- b. Air tightness targets and tests to be in accordance with Green Star Building Air Tightness guidance for best practice outcome for specific building type.

7.1.7 Moisture Management/Condensation

- a. The design of the roofing system must consider the climate zone, the orientation, the ventilation, the insulation (and thermal bridging) and the vapour permeability of the build-up. The design must align with the best practices described in the NCC Condensation in Buildings Handbook.
- b. The minimum scope of work shall include:
 - i. Schematic Design: A point-by-point narrative describes how condensation is addressed, including these leading concerns:
 - High interior relative humidity levels, particularly in susceptible areas like bath and laundry rooms and below-grade spaces.
 - Air leakage which could wet either exposed interior materials or interstitially “hidden” materials.
 - ii. Detail Design pre-tender phase: Designers to identify all high risk areas that require further condensation risk studies.
 - iii. Construction documentation – post-tender phase: Condensation analysis with transient conditions using WUFI or equivalent software. Condensation analysis in alignment with AIRAH DA07 (minimum 1D transient on typical build-ups + 2D analysis on main thermal bridges).
- c. The roofing system build-up must include a vapour control layers to comply with Australian standard AS/NZS 4200.2.
- d. All thermal bridges to be addressed to avoid condensation.

7.1.8 Durability

- a. Minimum design life to be 50 years unless noted otherwise for all structural elements and roofing system layers that cannot be easily maintained and replaced.
- b. All materials exposed to solar radiation, to be UV stable (for both structural integrity and colour retention) or employ a UV protection layer.
- c. The contractor's submission must include a compatibility report to include all sealants and interface materials.
- d. The main walkways located in the roof must employ a permanent protection in high foot or maintenance vehicular traffic situations.
- e. For foot traffic:
 - i. Metal Roofing: Lightweight walkway system clamped to roof metal panels with standing seams. All connections to avoid penetrations on the metal panel.
 - ii. Concrete/Membrane Roofing: Protective membrane (sacrificial) layer or walkway system, in alignment with supplier's system/details. Sacrificial layer to be nominated on the drawings and walkway highlighted on site.
- f. Roofing system design and construction must allow the ability to inspect, maintain and replace all components with a design life of less than 50 years, without compromising the overall roofing system integrity and functionality.
- g. The roofing system areas in proximity of cooling towers or kitchen and laboratory exhaust systems (or other type of exhaust with high temperature or chemically reactive compounds) must be subject to:
 - i. Detail investigation to avoid early corrosion or failure of the roofing system (e.g. metal panel, membrane).
 - ii. Fire safety review for high temperature areas only.
 - iii. Consideration of any issues for comfort for nearby buildings.
 - iv. Consideration of chemical compounds in the air from adjacent buildings.
- h. The design must avoid areas where the roofing system is sheltered or unwashed by natural rainfall, as these will be subject to faster degradation and might not be covered by product warranty.

7.1.9 Dissimilar Metals

- a. Contact between dissimilar metals is to be avoided to reduce risk of galvanic corrosion. Where contact between dissimilar metals cannot be avoided, suitable galvanic separation materials must be placed between those metals to eliminate direct contact. Separation materials must be weather resistant, UV stable, durable and chemically inert.
- b. Paint/powder coating is not considered a separating layer.
- c. Dissimilar metals must not be installed where runoff from a more noble metal to a less noble metal will occur.
- d. Fixings such as pop rivets, roof screws, astragals and fittings must also abide by this rule.
- e. Galvanic separation is to comply with AS/NZS 3500.3 and SA HB 39.

7.1.10 Parapets

- a. All parapets to be designed as rainscreen cladding consisting of:
 - i. External cappings (rainscreen) with sealed horizontal joints. Minimum 5° inward slope. If aluminium, minimum 3mm thick.
 - ii. Internal weather proofing barrier sealed against the roofing system and façade weather barriers, and all seals to be concealed by the external coping and protected from UV and designed to prevent water ponding and allow for drainage.
- b. As a minimum, to be designed to withstand wind and maintenance load.
- c. In case of abseiling, the access and maintenance strategy must consider davit arm or other means to avoid the transfer of the abseiling load through parapets.

7.1.11 Corrosion

- a. Corrosion category to be selected in accordance with AS 4312 and ISO 9223
- b. Air chemical composition from exhausts, kitchen exhaust, cooling towers and within plant area must be checked to ensure there is no chemical composition that could cause higher or accelerated rate of corrosion.
- c. Venting from kitchen exhausts to be monitored for high temperatures and particles that could lead to cause higher or accelerated rate of corrosion for metals, breakdown of membranes in particular membranes with bituminous composition or fire safety risk. Areas subject to kitchen exhaust discharge to be easily accessible for monitoring, cleaning and maintenance.
- d. All selected materials to be suitable for design corrosion zone.

7.1.12 Sustainability and Traceability of Materials

- a. The design shall evaluate the availability, use and cost of:
 - i. Highly durable and resilient systems, build-up, materials
 - ii. Low carbon product alternatives
 - iii. Locally produced materials
 - iv. Recycled and recyclable materials
- b. The contractor must provide Environmental Product Declarations (EPDs) for all products part of the major elements that are part of the roofing system.
- c. Material passport must be requested for all the main products. All product and materials must be traceable and avoid supply chain with risk of modern slavery.
- d. The design must evaluate the use of building integrated photovoltaics (BIPV) with reference to:
 - i. High performance products (above 20% efficiency)
 - ii. Life cycle assessment with consideration to current and future overshadowing
- e. The roofing system design must be suitable to allow rainwater re-use.
- f. The roofing system must avoid materials included in the red list from ILFI (<https://living-future.org/red-list/>). Where impossible or impractical, the designers/contractors must notify University Infrastructure for acknowledgment and sign-off on the use of the specific materials included in the red list.

7.1.13 Reflectivity and Emissivity

- a. Minimise the Urban Heat Island (UHI) effect by specifying light coloured materials with Solar Reflectance Index (SRI) in alignment with Green Star Buildings – Submission Guidelines – Heat Resilience Credit – Indications for Roofing materials. Black or dark roofs must be avoided.
- b. Qualitative assessment of possibility of reflectivity issues must be provided, including any impact on critical areas (e.g. streets, neighbouring buildings).
- c. Where there is a greater reflectivity concern conduct a reflectivity study during design phase. The reflectivity report must focus on the highly reflective materials present on the roofing system, including BiPV, metals, skylights etc.
- d. Reflectivity and emissivity to be selected in accordance with the projects Green Star Requirements.

7.1.14 Trafficability and Slip Resistance

- a. In presence of exposed external membrane, in correspondence of the main maintenance pathways / highly trafficable areas, the roofing system design must include:
 - i. Sacrificial layer in correspondence of the main maintenance pathways, to reduce the risk of punctures due to maintenance.
 - ii. Slip resistant layers designed with Safety in Design criteria and in alignment with AS 1657.

7.1.15 Future-Proofing for Climate Change

- a. The roofing system shall be designed with consideration to the worst-case scenario from IPCC. with reference to:
 - i. Increased rain event – + 20% capacity, refer to Roofing System Drainage (Section 6.2)
 - ii. Increased temperature – taking into consideration CSIRO projected weather files for building energy modelling.

7.1.16 Hail Resistance

- a. All metal panels must be tested for hail impact in accordance with Texas Tech University NWI DIF Horizontal Hail Impact Standard 2.1.2015 (variation on ANSI FM 4473: Test Standard of Rigid Roofing Materials by Impacting with Freezer Ice Ball by the American National Standard Institute) or an equivalent alternative.
- b. Thin gauge metal (steel or aluminium) panels must consider resistance to hail.
- c. All zinc/copper and other thin gauged panels must include a structural substrate under them due to susceptibility to damage from hail.

7.1.17 Noise and Vibration

- a. In presence of onerous conditions where insulation from noise and vibrations is required:
 - i. The project team must include a noise and vibration consultant.
 - ii. The roofing system must be concrete.
- b. For metal roofing acoustic insulation is required on the underside of secondary drainage plane and/or metal panel to reduce drumming noise from rain and hail.

7.1.18 Seismic Design

Where roofing system supporting structure requires seismic design:

- a. Structure to be designed in accordance with latest AS 1170.4 revision and other relevant mandatory standards.

Where seismic joints are required:

- b. Only use a proprietary seismic joint system.
- c. Pre-Tender: Details to be included in the architectural/structural tender set and reviewed/signed-off by architect, hydraulic engineer, structural engineer and façade engineer (for any façade interfaces).
- d. Construction Documentation: System to be fully documented and signed-off by the contractor, subcontractors, proprietary seismic joint system supplier and product supplier of any interfacing systems (e.g. roofing system, facade, etc.). The documentation must be reviewed and signed-off by UI, architects, hydraulic engineer, structural engineer, waterproofing consultant and facade consultant.

7.1.19 Maintenance Load

- a. Maintenance pathways along a roof must have permanent protection.
- b. Design for maintenance must allow for maintenance activities to occur without the use of temporary protection (e.g. ply sheets).

8 Documentation and Records

Prior to commencing construction on new or existing buildings, the consultant/contractor must fully investigate and document the requirements for each roofing system required, including waterproofing and drainage services to be installed, altered or modified as part of the project works.

8.1 Design and Construct Contract

8.1.1 General

This section outlines the extent of the services to be provided by the contractor under a Design and Construct contract.

The contractor shall be fully responsible for the complete design and installation of the roofing system, including the selection, sizes and quantity of materials and equipment. The contractor shall provide calculations, drawings and other documentation as necessary to demonstrate conformance with the design parameters, industry practice, UI requirements, codes, regulations and standards. This includes all calculations required to confirm that existing infrastructure is sufficient to support the proposed roofing system.

The contractor shall allow to fully co-ordinate the documentation with the architect, structural engineer, hydraulic engineer, façade consultant, waterproofing consultant and all other services consultants/contractors.

Compliance for proposed works to be agreed with Registered Building Surveyor (RBS) and Registered Certifier.

8.1.1.1 Existing Buildings

Whilst every endeavour is made to comply with current NCC regulations during refurbishments and upgrades, it is unlikely that the full extent of the building regulations can always be met.

Within any building proposed for refurbishment, the Standard of Performance for all existing systems must be reviewed by the consultant/contractor for compliance with the current NCC and Australian Standard requirements. The details of this review together with a proposed roofing system upgrade strategy must be submitted to UI for approval during the initial design development.

8.1.2 Experience

Provide details of existing examples in Australia of the proposed roofing systems. Provide contact details of an independent person knowledgeable about each example.

Submit details and experience of all subcontractor and supplier firms demonstrating their continuous experience with the systems, required roles and/or specified products for the stated continuous time periods. The Representative nominated by the Principal reserves the right to reject any of the parties below who in their opinion cannot demonstrate sufficient experience in this type of work and as a minimum as listed below:

- a. Roof Contractor – Not less than 10 years
 - b. Designer and Draftsmen – Not less than 10 years
 - c. Installer – Not less than 10 years
 - d. Qualified and experienced Consultants – Not less than 10 years (refer Section 8.1.3)
 - e. Sealant Manufacturer – Not less than 15 years
 - f. Membrane Manufacturer – Not less than 35 years
 - g. Supervisor and Technical Quality Control (TQC) – Not less than 10 years
 - h. Independent Testing Authority (ITA) – Not less than 15 years
- All specialist subcontractors (installers) to be manufacturer-approved applicators.

8.1.3 Calculations

As part of the contractor’s design, it is expected that, as a minimum, the following design calculations, provided by relevant qualified and experienced Consultants, are to be produced for UI review and approval prior to finalising the design:

- a. Stormwater drainage calculations, inclusive of roof, gutters, sumps, downpipes, in ground drainage, overflows, rainwater harvesting, on site detention, permitted site discharge and water quality.
- b. Wind calculation, with focus on wind uplift. Alternatively, wind tunnel test report.
- c. Structural calculation/simulation (including 10years deflection for all roof systems structures).
- d. Hygrothermal calculations inclusive of condensation risk analysis, in particular for student accommodation, in alignment with Table 8.1.
- e. All other calculations necessary to illustrate equipment reticulation and components have been selected fully in accordance with the project requirements and this standard.

TABLE 8.1: MINIMUM DESIGN DOCUMENTATION REQUIREMENTS

Document/ Certification	Provided By	Requirements
Condensation Risk Analysis (1D)	Designer/ Contractor	1D transient on typical build-ups in alignment with DA07
Condensation Risk Analysis (2D)	Designer/ Contractor	2D transient on typical details, in presence of systemic thermal bridges
Weather Performance (NCC 2022 F3P1)	Contractor	To cover full building envelope including roofing systems.

¹ Or equivalent NCC clause for weather performance in later revisions of NCC.

8.1.4 Documentation and Submissions

The consultant/contractor shall provide design, construction, and as-built drawings, which may be either design drawings produced by the consultant/contractor or project specific shop drawings produced by system manufacturers.

The design consultant (pre-tender) and contractor (post-tender) are responsible for producing all design and as-built documentation for UI approval, including, but not limited to:

- a. Concept Design documentation (as required).
 - i. Return Brief defining the systems proposed and any deviations from this standard.
 - ii. Design report to include information as described in Section 5.3 New Buildings and 5.4 Existing Buildings.
 - iii. General outline of systems and products being proposed. Including maintenance requirements, warranties (including any maintenance to maintain warranties) and design life to allow University of Sydney early review of design options.
 - iv. Where NCC Deemed-to-Satisfy solutions cannot be followed, provide list of proposed items which will require performance solutions.
 - v. Gap analysis report to be provided, to include any discrepancies between NCC, Design Brief and/or UI Standards or areas where no performance requirements have been provided.
 - b. Detailed Design – Tender documentation, including:
 - i. Layout and detail drawings to include all systems' details and interfaces.
 - ii. Specifications of all systems including testing and commissioning procedures.
 - iii. Membrane supplier sign-off for integration of EFVM leak detection system with their membrane system.
 - iv. Design report to show compliance with Sections 6 and 7 of this Standard.
 - v. Updated Return Brief defining the systems proposed, and any deviations from this Standard.
 - vi. Updated gap analysis report.
 - vii. Schematics, including a Basis of Design Statement for each service.
 - viii. Safety in Design report
 - ix. Provision of a NCC Compliance Design Report to include F3P1 Performance Based Design Brief (PBDB), or equivalent clause in later revisions of NCC.
 - x. Provision of Fire Engineered Performance Solution Report (where applicable).
 - xi. Calculations and selections of the roofing system, including relevant hygrothermal calculations.
 - xii. Calculations to be provided on the sizing of the pipe work. Any future allowances are to be included in these calculations/sizing.
 - xiii. Budget calculations.
 - xiv. Requests for all variations to this Standard submitted using the USYD Request for Dispensation Form (USYD-ENG-F001).
 - c. Construction documentation (Post Tender) – Issued for construction, including:
 - i. Updated detail drawings to include all systems' details and interfaces.
 - ii. Updated gap analysis report.
 - iii. Full description of the roofing systems inclusive of all relevant technical datasheet, calculations, warranties (including Terms and Conditions and maintenance requirements) for all products, in compliance with roof design specifications.
 - iv. Updated Safety in Design report
 - v. Test reports for review and approval
 - vi. Updated Return Brief defining the systems proposed and any deviations from project specifications and from this standard.
 - vii. F3P1 design report, or equivalent clause in later revisions of NCC.
- NOTE: The construction documentation must be reviewed and signed off by UI and all relevant discipline consultants, prior to the contractor proceeding with the procurement and installation of the roofing systems.*

d. Handover

- i. As Built drawings and BIM model (LOD 300), including system schematics and detailed drawings demonstrating the as installed system (in both PDF and CAD format).
- ii. Commissioning test results and certificates of compliance
- iii. Roof Safety System Certification
- iv. Product manufacturer's specific information
- v. Warranties for all systems and equipment
- vi. Warranty schedules for all major items of equipment.
- vii. Operations and Maintenance manuals
- viii. Training manuals
- ix. Certification of compliance to the design standard by completing and submitting the UI Project Design Certification Form (UI-PROJ-F001).

All documentation shall be maintained and kept up to date using revision numbering throughout the check, review and approve process.

Submissions to use the University of Sydney standard documentation format. The documentation must be provided by the consultant/contractor in electronic format and approved by UI at the end of each stage and prior to Practical Completion being granted.

UI review and approval is required prior to ordering any materials and/or any works being carried out. It is not acceptable to complete works not in accordance with the University standards, and request dispensation after the fact.

8.1.4.1 Basis of Design Statement – Return Brief

A Basis of Design Statement is to be provided for each service present on the schematic layout. The statement shall identify how the service works, basis of design, any departures from Australian or UI standards and all substantial information are required to review the adequacy of the design intent.

8.2 Design Responsibilities

The following responsibilities are a minimum expectation for the roofing system design for the University of Sydney and do not take away the overall responsibilities of the Designers/Contractors and from the requirements from the NCC, Australian Standards, NSW legislations, DBPA, etc.

8.2.1 Lead Designer / Architect / Specialist Waterproofing Consultant

- a. The roofing system lead designer can be the architect or the specialist waterproofing consultant and is responsible for the overall design and coordination of the water shedding and waterproofing performance of the roofing system.
- b. The lead designer must integrate the requirements of all other relevant disciplines into the roofing system design and take a lead role in resolving coordination issues, resolving conflicting requirements, etc. Where different coordinated roofing system design solutions are considered, the lead designer is to present these back to the Technical Review Group (TRG) for review and endorsement of a preferred solution.
- c. The lead designer must develop, coordinate and update a 'gap analysis' report from the early stages of the projects, to identify, monitor, coordinate and resolve the interfaces between the roofing system and other trades.
- d. For all new buildings and large-scale repairs (> \$1M in fees) of existing buildings, a specialist waterproofing consultant is to be appointed to advise, review and sign-off on all documentation relevant to waterproofing.
- e. Lead designer to provide selection and specification of roofing systems, inclusive of design life, warranty and minimum maintenance requirements.
- f. As a minimum architect to provide the following drawings:
 - i. 1:50 concrete slab cross section(s). Sufficient cross sections to describe the complete topography of the roof must be provided.
 - ii. 1:100 concrete slab profile plan.
 - iii. Detailing of specific system elements (e.g. penetrations, interfaces) at 1:20, 1:10, 1:5 or 1:2. Scale of detailing to be selected based on complexity of detailing being resolved.
 - iv. Falls to rain water outlets (RWOs) are to be clearly documented on design drawings by labelling with relative levels (RL).
- g. Coordination of any penetrations, services, anchors, interfaces, etc.
- h. Update any drawings if required for as-built documentation, including highlighting any weak points or specific areas for maintenance inspections.
- i. Weather performance compliance to NCC 2022 F3P1 (or equivalent clause in later revisions of NCC):
 - i. Pre-tender, F3P1 Performance Based Design Brief (PBDB), provided in conjunction with full building envelope including facades (façade section to be provided by façade consultant).
 - ii. Post-tender, F3P1 Report, provided by the Contractor, in conjunction with full building envelope compliance including facades (façade section to be provided by façade contractor).
- j. Review ITP provided by Contractor, to ensure it addresses all aspects of the works and to identify inspection hold points.
- k. Undertake inspections to confirm that work is being constructed with the plans and specifications.
- l. Coordination with Structural Engineer, Hydraulic Engineer, Façade Consultant and Waterproofing Consultant
- m. Identify hold point inspections.
- n. Review and assess any variations to the work.
- o. Lodge a Regulated Design (if required)
- p. Issue a statement of design compliance with this document before work commences.
- q. Issue a certificate of compliance with the plans and specification on completion of the work.

8.2.2 Structural Engineer

- a. Design of supporting structure including support for auxiliary items (e.g. photovoltaics)
- b. Design and coordinate the structure to ensure the roofing system aligns with the post-deflection roof slope requirements, including providing calculation to show minimum 10-year deflection.
- c. Undertake inspections to confirm that work is being constructed with the plans and specifications.
- d. For existing buildings, inspect and assess structural integrity of existing building and suitability for proposed work.
- e. Issue instructions during construction as necessary.
- f. Provide a certificate of compliance on completion of the work.
- g. All shop drawings relevant to structure must be formally approved by the Structural Engineer.

8.2.3 Hydraulic Engineer

- a. Design of guttering and drainage systems.
- b. Coordination of outlet and overflow points with roofing system geometry.
- c. All façade/roofing system shop drawings relevant to hydraulics must be formally approved and signed-off by the Hydraulic Engineer.
- d. Undertake inspections to confirm that work is being constructed with the plans and specifications.
- e. For existing buildings, undertake an inspection of the existing hydraulic services to determine adequacy and any deficiencies.

8.2.4 Sustainability / ESD Consultant

- a. To provide assessment against Section J thermal performance requirements.
- b. To provide condensation risk analysis.
- c. To provide climate change and UHI analysis.
- d. To provide reflectivity study report, where required.
- e. To provide assessment Green Star or other relevant certifications.

8.2.5 Main Contractor

- a. To have responsibility of design and installation of roofing systems.
- b. To take responsibility of coordination between all project works consultants, subcontractors and trades, including submitting construction design packages for UI approval prior to procurement and installation.
- c. Identify, co-ordinate and document all hold point inspections and allow for all hold point inspections in construction plan.
- d. Provide a PMU of specific elements (e.g. flashings, cappings, penetrations, etc.) where requested for sign-off by UI prior to commencement of the roofing system installation.
- e. Provide ITP for the work with critical hold points identified before the work commences.
- f. Collate all ITPs on completion of the work and submit to UI.
- g. Construct the work in accordance with this document using materials that are fit for purpose.
- h. Construct the work using materials and methodologies to provide the required service life for the warranted period.
- i. Identify any variations necessary to achieve compliance before signing contracts and before commencing the work.
- j. Provide protection to installed and/or tested systems whilst not in use.
- k. Issue a final certificate and report on completion of the work.
- l. Prior to the handover of the project, coordinate inspections and system testing to confirm that it complies with this document, relevant Australian Standards and manufacturer's instructions and warranty requirements.
- m. Coordinate all drawings from all consultants and trades to show 'as-built' structure at completion of the Works.
- n. Maintenance Manual including specific methodologies for each system installed on the project.
- o. Provide general warranty (minimum warranty duration and inclusions as per Section 13)

- p. Provide the sign-off/endorsement of the roofing system installed for all penetrations and interfaces with other trades.
- q. Ensure that all hold point inspections are documented.
- r. Ensure assets have access for maintenance and replacement and where possible ongoing operational risks are designed out.
- s. Undertake periodic Safety in Design meetings to monitor and mitigate the main risks in construction and operation phases.

8.2.6 Specialist Subcontractor (Installer)

- a. Sign-off on project details including all non-standard conditions, dispensations, performance solutions, penetrations, etc.
- b. Identify any deficiencies in the design, allowing for hold point for Designer, UI input/review prior to works progressing.
- c. Co-ordinate and ensure all hold point inspections are allowed for in construction plan.
- d. QA/QC/ITP records of all works.
- e. Relevant testing as required to verify installation.
- f. Provision of shop drawings where non-typical system details are required
- g. Compatibility reports, in particular for sealant and adhesive flashings
- h. Provide manufacturer's design and installation compliance statement on completion of the work.
- i. Provide installation warranty (minimum warranty duration and inclusions as per Section 13)

8.2.7 Roofing System Supplier

- a. Provide typical details to the Architects, to include in the Construction Documentation.
- b. Certification of system for meeting project performance requirements (e.g. coatings, combustibility, durability, etc.)
- c. Provide installation requirements, specifications, evidence of compliance to relevant AS and O&Ms.
- d. Sign-off the construction documentation and all non-typical conditions.
- e. Provide calculation to demonstrate the roofing system in particular membranes can withstand project specific wind load (including uplift wind), thermal expansion, differential movement, etc.
- f. Identify hold point inspections and provide hold point report.
- g. Undertake hold point inspections and provide documentation identifying any issues.
- h. Overview the installation, QA/QC/ITP and testing of the roof to confirm the product has been used within the Terms and conditions of the product warranty.
- i. Provide supplied system warranty including all project specific instances.
- j. Provide product warranty (minimum warranty duration and inclusions as per Section 13)

8.2.8 Other Product/System Suppliers (Plant or Equipment)

- a. Certification of system for meeting project performance requirements (e.g. coatings, combustibility, durability, etc.), and compliance with Australian standards.
- b. Provide installation requirements, specifications, evidence of compliance to relevant AS and O&Ms.
- c. Sign-off on project details to confirm system is used as intended.
- d. Identify hold point inspections and provide hold point report.
- e. Undertake hold point inspections and provide documentation identifying any issues.
- f. Provide supplied system warranty including all project specific instances
- g. Provide product warranty (minimum warranty duration and inclusions as per Section 13)

9 Safety

Roof safety is to be achieved through the provision of permanent edge protection such as handrails, balustrades or parapets.

Persons wanting to use a roof safety system for access must be suitably qualified and have approved Permit and Safe Work Method Statements (SWMS). Documents are located on the University Contractors page. (<https://www.sydney.edu.au/about-us/working-with-the-university/contractors.html>)

Preference is to have a parapet or handrail that will be compliant as a fall prevention measure, negating the need for height safety systems. Where height safety systems are necessary, these are to be designed prior to construction with the aim for highest level of safety, most cost effective solution and ability for ongoing recertification.

9.1 Provisions for Safe Roof Access

Safe access provisions are to be provided to all areas of roofs and other elevated areas for inspection, repairs, and maintenance.

9.1.1 Roof Access for Maintenance

Roof access may also be required to facilitate maintenance of:

- a. Plant and equipment or roof fixtures
- b. Solar panels
- c. Planters
- d. Skylights
- e. Box gutter and sump cleaning

Provisions may include, in no particular order:

- a. Guardrails
- b. Elevated catwalks or platforms or bridges
- c. Walkways
- d. Permanent ladders or stairs
- e. Hooks for portable ladders
- f. Fall-arrest anchorages such as:
 - i. Anchor points
 - ii. Rigid rails
 - iii. Safety lines
- g. Roof hatches
- h. Gates, doors or access hatches.

9.1.2 System Design

Generally, the overall system design should also aim to minimise number of different access systems needed across a building, wherever practical, in particular for regular maintenance such as cleaning.

9.1.3 Roof Access Method

The roof access method should be selected using the Safe Work NSW hierarchy of risk controls for the prevention of falls as a guide.

TABLE 9.1: HIERARCHY OF CONTROL FOR THE PREVENTION OF FALLS, MODIFIED FOR ROOF ACCESS

Level	Description	Examples
Level 1	Work on the ground or a solid construction Eliminate the need for working at height	<ul style="list-style-type: none"> – Cleaners stand on ground and use cleaning poles or gutter vacuum equipment – Move items requiring maintenance to a safer location
Level 2	Use a passive fall prevention device	<ul style="list-style-type: none"> – Guard railing – Elevating work platform (EWP) – Step platform (platform ladder) – Scaffold
Level 3	Use a fall restraint or work positioning system	<ul style="list-style-type: none"> – Travel restraint system (not fall-arrest) – Industrial rope access system
Level 4	Use a fall arrest system	<ul style="list-style-type: none"> – Safety harness system / Fall-arrest (not travel/fall restraint) system
Level 5	Use a fixed or portable ladder, or implement administrative controls	<ul style="list-style-type: none"> – Fixed or portable ladder – Hazard warning signage

9.1.4 Guard Rails

Guardrails (Level 2 risk control) are to be employed for all fall hazard edges unless advised otherwise by the University of Sydney or if not possible due to planning and approval restrictions.

9.1.5 Walkways

- a. Walkways shall be provided for all known routine maintenance pathways over roofs or surfaces that are:
 - i. Raised rib metal deck or similar
 - ii. Slippery, including when wet, or
 - iii. Otherwise difficult or hazardous to walk on.
- b. Walkways should follow the safest practical route away from roof edges or other hazards.
- c. Walkways over gutters shall feature removeable or lift-out sections over sumps for maintenance access.

9.1.6 Waterproofing

Waterproofing and protection of membranes shall be considered when selecting and installing roof access provisions and determining maintenance pathways. The roof safety system design for new buildings shall be fully co-ordinated with waterproofing specialists. Roof safety system installation contractors are to be appropriately managed such that installation is completed in a manner to achieve best possible waterproofing outcomes.

9.1.7 Portable Ladders

Portable ladders are to be used only when:

- a. Permanent provisions are impractical or invite unauthorised access or have a major impact on the building aesthetic.
- b. The change in height is less than 4.0 metres.
- c. There are ladder hooks or equivalent provision for securing the ladder.

Where portable ladders are not used, access between levels shall be via stairs or an inclined ladder with flat stair treads. Vertical rung ladders shall only be used where stairs or inclined ladders are not possible due to difficulties in carrying materials and equipment up a vertical rung ladder. Fall-arrest vertical rails that feature a non-detachable rail grab device shall be provided for vertical rung ladders where practical and appropriate.

9.1.8 Anchor Points

- a. Cast-in, Grade 316 stainless-steel fixings are to be used when fall arrest anchors are mounted to concrete and the pull-out component of the loading is more than half of the shear component of the loading. This means the anchors do not need annual load testing. Annual inspection is still required.
- b. Fall-arrest Anchors, rail and safety lines mounted to metal deck roofing on new buildings shall be fixed directly to a purlin or other secondary structure, passing through the roof sheet, and with the approval of the project structural engineer. They shall not be fixed to a roof sheet.
- c. Fall-arrest provisions shall be suitable for use by operators using a standard, 2.0-metre-long fall-arrest lanyard. Systems which rely on adjustable length ropes or lanyards are to be avoided where possible and only used by persons with industrial rope access training.

9.1.9 Roof Hatches

Roof hatches shall be surrounded by guardrails on 3 sides to prevent a fall into an open hatch.

9.1.10 Skylights

- a. Skylights and glazed awnings for new buildings are to be suitable for maintenance personnel to stand on, both in terms of load capacity and slip resistance.
- b. Skylights and glazed awnings for existing buildings which have an unknown load capacity shall be provided with fall risk controls such as perimeter guardrails, nets, mesh or appropriate fall-arrest provisions.

9.1.11 Roof-Mounted Provisions related to Façade Access

- a. Safe access provisions are to be provided for all facades, soffits or ceilings above a single floor in height for routine cleaning, inspection, and light maintenance where it may be required. The roof design may be influenced, to:
 - i. Provide support for façade access or glass handling equipment,
 - ii. Provide improved access for façade access operations, or
 - iii. Allow glass or façade element replacement.
- b. As well as façade access, roof-mounted provisions may also be required for maintenance of:
 - i. planters
 - ii. light fixtures, security cameras or similar fixtures
 - iii. skylights
 - iv. smoke vents
 - v. sprinkler systems (both fire and for planters)
 - vi. canopies or awnings
 - vii. signage
 - viii. green walls
 - ix. artwork or advertising banners
- c. The façade access method should be selected using the Safe Work NSW hierarchy of risk controls for the prevention of falls as a guide. The method shall be practical and consider the architectural intent.
- d. Generally the overall system design should also aim to minimise number of different access systems needed across a building, wherever practical, in particular for regular maintenance such as cleaning.
- e. The roof-mounted façade access system design for new buildings shall be fully co-ordinated with waterproofing specialists. Façade access system installation contractors are to be appropriately managed such that installation is completed in a manner to achieve best possible waterproofing outcomes.

9.1.12 Building Maintenance Units

- a. Roof-mounted BMU's generally have a major impact on roof design. Type A and Type B Building Maintenance Units as defined by AS1418.13 are to be installed on new buildings only if specified by the project Façade Access Consultant and subject to the approval of the University of Sydney. Refer to the consultant's specifications for the particular requirements related to the BMU(s).
- b. Type C BMUs as defined by AS1418.13 use either a temporary suspension rig or self-powered cradle (hoists in the cradle) which is hired and not dedicated to the building. These may be used only for unscheduled works such as refurbishment or major repairs or re-furbishing facades. These are not to be used for routine façade maintenance or inspection activities.

9.1.13 Industrial Rope Access (RA)

- a. Where the façade is too high for cleaning poles or Aerial Work Platforms, and a BMU is not specified by a Façade Access Consultant, then RA is to be the primary method of façade access used, subject to a specific risk assessment. RA provisions generally impact on the design of roof areas.
- b. Suspension methods may include, in no particular order:
 - i. Portable davits in permanent davit bases or sockets
 - ii. Portable needles, either anchored or counterweighted
 - iii. Anchor points
 - iv. Rigid rails or Monorails
 - v. Portable suspension rigs which are anchored to the building
- c. Temporary suspension rigs are not to be used for routine façade access.
- d. Rigid rails and monorails shall be installed with provision for regular inspection of each rail support bracket and its fixings. This may include openable sections of soffit or cladding adjacent to each support bracket, or open slot on either side of the rail between the rail and the adjacent façade, soffit or cladding. Provisions shall allow, as a minimum, an endoscope to be inserted for inspection by an operator. The operator may need to be suspended from the rail during the inspections. Inspection openings shall be large enough to accept a 100mm diameter sphere. Inspection slots shall be minimum 30mm wide.
- e. Safe egress provisions are required at the ground or lower roof or level at the bottom of all operator work positions (or 'drops') for operators to return to ground or other safe level, and including a safe pathway back to their suspension anchorage provisions. If landing on another roof, that roof may need provisions and access for this purpose.
- f. Where ropes are to be diverted by parts of the building, the risks of damage to the ropes shall be considered. The diverting edges are to have sufficient capacity to survive operational rope loads resulting from a rope tension of 300kg. In addition, the edges shall not release the load should the rope carry the anchor ultimate design load of 12kN. The edges may be damaged from this load, but there shall be no additional risks created, such as falling debris, sharp edges or other hazard to the integrity of the ropes. This can be an issue for design of roof gutters, parapet capping, façade panels or features, balustrades, sunshades, canopies, awnings, and the like.
- g. The launch procedure for RA operators shall be considered in the roof design. RA personnel typically need to stand or sit on parapets or climb over balustrades during the transfer from the roof to suspension by their ropes. Operator safety needs to be considered, and the roof elements need to be capable of carrying the applied loads during this transfer. Operator harnesses and equipment can also scratch or damage some surfaces.
- h. Cast-in, Grade 316 stainless-steel fixings are to be used when rope anchors are mounted to concrete and the pull-out component of the loading is more than half of the shear component of the loading, including fixing of davit bases and monorail supports. This means the anchors do not need annual load testing. Annual inspection is still required.
- i. Anchors mounted to metal deck roofing shall be fixed through the sheet to a purlin or other secondary structure and with the approval of the project structural engineer. Anchors shall not be fixed to a roof sheet where there is no other structure below.
- j. Anchors intended for rope access shall also be rated for fall-arrest design loading where there is the possibility of a fall by a person connected to that anchor.
- k. Portable façade access equipment elements shall be lightweight for safe manual handling, transport, assembly and disassembly by a maximum of two persons. Davits are not to be used where there is no effective guardrail at the roof edge.

9.1.14 Roof-Mounted Provisions related to Façade Element Replacement

- a. Consideration of the method of replacing glass panels and other façade elements is to be made for all new buildings during the building design phase, and these can impact on roof design. Replacement of glass panels from the inside of the building is preferred where it is practical to do so. If this is not practical, the glass replacement process may involve the roof areas, and may include:
 - b. Transport of replacement panels across a lower roof to a suitable location for lifting to the façade above,
 - c. Temporary suspension rigs on the roof for lifting materials,
 - d. Positioning personnel during work on the façade to facilitate glass replacement, or
 - e. Temporary removal of other façade elements or roof features, (eg. balustrade panels) to allow for set up of a temporary suspension rig or other lifting equipment.
 - f. Provisions on the roof may include:
 - i. Additional suspension provisions at roof level (eg. Extra davit base for glass suspension with two RA operators suspended from adjacent davits).
 - ii. Additional load capacity of roof areas to support suspension rigs for lifting materials

9.2 Safety in Design

The contractor must consider risk during the design. A design safety report must be submitted to the relevant UI Project Manager for every design project. Contractors must confirm, so far as it is reasonably practicable, that the works are without risks to health and safety.

Design risks must be considered for the asset lifecycle covering construction, operational and maintenance, refurbishments, and decommissioning.

The design safety report must include the following:

- a. Description of design element.
- b. Description of potential risks and hazards associated with the design element.
- c. A low/medium/high risk assessment considering likelihood and consequence.
- d. Proposed measures to eliminate risks where practicable.
- e. Control measures to mitigate and manage design risks.
- f. Nominating responsibilities for managing the design risks.

This may be provided as a design risk register where appropriate and must include results of any calculations, testing and analysis etc.

Project specific items shall be discussed and included in the register during Safety in Design (SiD) meetings (at least 2 SiD during design and 2 SiD during construction).

TABLE 9.2: TYPICAL SAFETY IN DESIGN ITEMS FOR ROOFS

Hazard Reference	Activity/Process/ Material/Element	Hazard	Stage of Work
1	Use of new systems or unusual/bespoke components that have not been tried before.	Use of unfamiliar materials of which there is limited local experience that may lead to failure if incorrectly designed.	Design
2	Spread of fire	Risk of fire spread; combustible materials, fire stopping between floors/walls not properly considered, etc.	Design
3	Unknown procurement/supplier	Non traceable materials might be sourced in areas/companies subject to modern slavery.	Procurement
4	Installation of heavy/large elements	Injury to installers and/or bystanders	Construction
5	Risk of failure if roof components are incorrectly transported/lifted/installed	Manual handling / lifting of heavy elements - risk of falling objects to levels below during installation	Construction
6	Installation activities on roof	Fall from height	Construction
7	Maintenance of roof	Activities above public spaces, and hence a possibility of injury due to items being dropped from cradle/EWP etc.	Operations
8	Temporary support/propping	Requirement for temporary support during installation leading to risk of failure and injury in temporarily supported case.	Construction
9	External features	External feature (e.g. external bead, fin, etc.) or components dislodging and falling from height leading to risk of human injury.	Construction
10	Maintenance of roof	Working from height, high risk work activity - potential for fall from height during façade element replacement.	Operations

10 Commissioning and Testing

Comprehensive pre-commissioning, commissioning and quality monitoring must be specified by the consultant/designer.

A project specific commissioning plan is to be developed and provided to the University for review and approval.

Detailed testing and commissioning records must be provided for each system and each component as appropriate. All such records must be witnessed and verified by the project consultant/head contractor prior to witness commissioning by Specialist Waterproofing Consultant, UI Engineers and COS representatives.

Project handover plan must be developed by the consultant/designer to allow the system to be handed over to The University. A 12-month building tuning process will commence at project handover with systems monitored monthly, reported and assessed quarterly, and include assessment of feedback from the occupants.

All roof components must be subjected to testing with independent oversight before Practical Completion is awarded. A site visit from the UI Engineer and COS representative must be organised during the testing. Detailed testing report and commissioning records, including photo evidence must be provided for each system and each component as appropriate. All such records must be witnessed and verified by the project consultant/designer and Specialist Waterproofing Consultant.

Below are the minimum testing requirements for commissioning includes:

- a. New and existing membrane roofs, including green roofing systems – these roofs must allow for Electric Field Vector Mapping (EFVM) system into the membrane roof design. All membrane roofs are to be tested following EFVM methodology. All identified leaks must be repaired and re-tested until no leaks are detected. Test reports to be provided including identification of areas where repairs were required and methodology of repair.
- b. Existing membrane roofs, where EFVM system cannot be conducted – these roofs must be flood tested to a recognised standard (ASTM D5957). Flood testing shall be performed in a manner to test the operation of the overflows. All membrane roofs are to be tested after the first and last layer of membrane is applied. Bungs used to block the sumps/outlets are to be of the manufactured type or rags bundled with electrical tape. All bungs are to have rope or wire attached so it cannot be lost down the outlet. The wire or rope must be securely fastened to a nearby structure. Testing must include all critical penetrations, and take place for at least 24hrs. Flood testing methodology must be coordinated with Structural Engineer to ensure existing roof is structurally adequate.
- c. Metal roofs – to allow for static water pressure head test in accordance with ASTM E2140-01, as well as visual inspection of installed roof system. Test to include all critical penetrations.
- d. Box gutters – must be flood tested so the highest point of the box gutter has at least 10mm coverage of water and to ensure the overflows operate. Bungs used to block the sumps/outlets are to be of the manufactured type or rags bundled with electrical tape. All bungs need to have rope or wire attached so it cannot be lost down the outlet. The wire or rope must be securely fastened to a nearby structure. All testing must take place for at least 24hrs.
- e. Roof plumbing- the entire above ground stormwater system must be placed under a hydrostatic test. All rain heads and sumps must undergo hydrostatic testing. All testing must take place for at least 24hrs.

- f. Mechanically Fastened Safety Systems – This type of safety system includes steel or concrete as the base material. Load testing must be conducted to confirm the safety system supports the designed load. Documents confirming the test results must be signed by the consultant/contractor. A structural engineer’s certification for all anchor points and the entire safety system, must be included in the Operational and Maintenance manuals.
- g. Clamped/Braced Safety Systems – This type of system includes timber as the base material. Load testing must be conducted to confirm the safety system supports the designed load. Documents confirming the test results must be signed by the consultant/contractor. A structural engineer’s certification for all anchor points and the entire safety system, must be included in the Operational and Maintenance manuals.

Refer Section 6.1.3.6 for complementary testing methods for membrane roof systems.

11 Maintenance and Cleaning

11.1 Maintenance and Cleaning Regime

- a. All roofing systems must be designed to reduce the required maintenance and cleaning regime. All required maintenance and cleaning regime must be included in the issued for construction design package in addition to the O&M and be approved by UI and COS.
- b. Any maintenance and cleaning regime must have not less than an annual frequency and any mandatory condition of the warranty must be approved by UI and COS.
- c. Specific requirements for warranty maintenance must be identified and approved by UI prior to procurement of product.
- d. Where areas of the designed systems are not accessible, the roofing systems must be designed to meet design life requirements without any maintenance or cleaning.
- e. When protective coating is used on modified bitumen membrane, maintenance and re-coating must be planned in alignment with the product durability. Contractor to include durability of coating and required maintenance in the O&M manual.

11.2 Operations & Maintenance Manual

Consultants/designers must include in the project specification detailed requirements for operation and maintenance manuals, including system description, operation procedures, testing and commissioning records, maintenance instructions, product support information and recovery protocols for any computer related systems. Contractors must provide these to the satisfaction of the consultant/designer. Providing a collection of manufacturers' brochures and catalogues is not acceptable to the University.

The O&M manuals must be submitted in the format outlined in Operation and Maintenance Manuals Standard. The O&M Manuals Folder Template must be used to submit the final O&M manuals. O&M manuals must be provided electronically in the zip folder via a USB and a large file downloadable link or platform. O&M Manuals Review Checklist must be submitted with O&M manuals package. For more information refer to the Operation and Maintenance Manuals Standard.

Contractors must submit the university designed Asset Management Master Asset Data Capture Spreadsheet (COS-ASSET-F001) designed for recording operational and maintenance activities including materials used, test results, comments for future maintenance actions and notes covering asset condition. Completed logbook pages recording the operational and maintenance activities undertaken for Practical Completion and during the Defects Liability Period must also be provided. For more information refer to the COS Asset Identification and Labelling Standard.

Facilities Maintenance must establish, document and implement procedures for operation and maintenance of the Roofing Systems, plant and equipment to ensure they are fit-for-purpose, provide secure, efficient, safe and reliable electrical power, and comply with requirements of this Standard.

12 Design and Service Life

All roofing systems must achieve design and service life periods specified. Identify and classify each material and component of the Works in the following categories under normal service conditions:

- a. Non-maintainable – items will meet the Service Life of the roof/building (without loss of performance below those specified) but are inaccessible for servicing and maintenance.
- b. Maintainable – items will meet the Service Life (without loss of performance below those specified) but require routine service and maintenance to do so. Provide comprehensive recommendations for the maintenance tasks and frequencies of these items.
- c. Replaceable – under normal service conditions, these items cannot meet the specified Service Life. Design these elements to be replaceable and provide details of the method and frequency of replacement.

12.1 Minimum Requirements

All primary/main structure of the building must be designed to comply with AS 1170 and all other relevant standards and provide a 100-year design life unless otherwise approved. Refer to USYD Building and Architecture Design Standard.

All roofing system elements are to be designed for 50-year design life and 25-year service life (life to first major maintenance). A maintenance project is considered major when the cost of maintenance is above 50% of the project value.

All materials shall retain colour integrity and consistency for 25 years.

13 Warranty

Warranties are to be provided as certificates as part of the issued for construction design submission package in addition to the O&M from all system suppliers.

It is the responsibility of the installation Contractor to ensure all maintenance and servicing required for the equipment is provided, to ensure warranties are valid at the end of the project DLP.

Selected products must not have unreasonable or onerous maintenance and cleaning regimes. Any maintenance and cleaning regime must have not less than an annual frequency.

Written supply and installation warranties must be provided for all building components, materials and systems including but not limited to items listed in Table 13.1.

TABLE 13.1: MINIMUM WARRANTY PERIOD REQUIREMENTS

	Warranty Period (Minimum number of years from Practical Completion)
Metal roofing system	25 from both product supplier (product) and subcontractor (installation)
Membrane system	25 from both product supplier (product) and subcontractor (installation)
Equipment	1
Gaskets	10
Sealants and Adhesives	10
Structural Silicone	10
Aluminium Finish: polyester powder coat	20
Aluminium Finish: PVF2 coating	20
Aluminium Finish: Fluoropolymer Powder coating	25
Gutter System	20 from both product supplier (product) and subcontractor (installation)

13.1 Warranty Inclusions

Provide against the following in the warranties for any portion of the Works under the specified conditions:

- a. Penetration of water or air under conditions equivalent to, or less severe than, those specified;
- b. Lack of rigidity, unsuitability and excessive deflection of any elements or members;
- c. Being inadequate to withstand wind loads;
- d. Failure or defects of any kind resulting from selection, quality or application of materials, and movement under all conditions;
- e. Fading, non-uniformity of colour, discolouration, lifting, peeling, pitting, corrosion or loss of bond with substrate of any of the finished surfaces;
- f. Latent or patent defects or cracking arising from any cause;
- g. Sealants staining and bleeding onto adjacent surfaces;
- h. Failure of operation of any assemblies, controls or hardware;
- i. Warranty direct from structural silicone supplier for the design and fabrication of the structural silicone;
- j. Warranty direct from the metal roof or roof membrane manufacturer and supplier for the design and installation of roof covering, including full roof build-up.

Throughout the period of the warranty:

- a. Rectify and make good any defect or deterioration of the Works which are not in accordance with the Contract Documents and make good any work of other trades which may be damaged as the result of such defects or deterioration of the Works, and/or;
- b. Be involved in the rectification whether renewal, replacement, repair or addition of items of material and work or otherwise as may be required to maintain the Work to completely perform to the Contract Documents;
- c. Where warranty works are completed during the existing warranty period that warranty is to be maintained or provide and additional warranty.

14 Assets

Assets are to be tagged in accordance with the COS Asset Identification and Labelling Standard for the purpose of maintenance and operation of University Assets. For refurbishment projects the project manager is to provide the existing asset list to the contractor to ensure modified and redundant equipment are captured in the contractor's submitted asset list.

Each asset required to be collected can be found in the Form COS-ASSET-F001, each asset required to be coded will be identified by a unique equipment code.

The equipment code will be one of the three following types:

- a. Virtual asset (This is a concatenation Building Code - Floor - Room number)
- b. Item count asset (This is a concatenation Building Code - Floor - Room number)
- c. Unique bar code asset (Unique bar code in the million series number affixed to the asset)

Asset lists are to be submitted prior to practical completion of the project for review and approval by COS.

15 Authorisation of Variations

Project managers, consultants, contractors, commissioning agents and facilities maintenance personnel must ensure compliance with these requirements is achieved.

Variations to this standard must only be considered where:

- a. The University Standard's requirement cannot physically or technically be achieved.
- b. The Performance solution delivers demonstrated and proven superior performance for the same capital and life cycle cost or better.

Consultants and contractors must identify and justify requirements of the standard that do not apply to the project or which need to be varied and these which must be approved by the issuer of this standard. Formal requests for all variations to this Standard must be submitted using the Request for Dispensation Form (CIS-ENG-F001). The issuer of this standard or their delegated authority must review and consider requirements of stakeholders from clients, projects and facilities management before deciding whether to approve variations. Their formal sign-off is required for acceptance of any non-compliances and departures from this standard's requirements.

16 Quality Control

16.1 Design Standard Compliance

Compliance with requirements of this standard must be checked throughout the design, construction and commissioning phases of projects by UI's services consultant. Any issues or deviations from this standard must be reviewed and approved in writing by the issuer of this standard.

Competent UI consultants and representatives must check compliance with this standard during design reviews and formal site inspections. Any non-conformances with requirements of this standard must be documented and provided to the UI Project Manager for issue to contractors and their consultants.

Project Managers must maintain a formal register of non-conformances and manage close out of outstanding non-conformances. Contractors and their consultants issued with non-conformances must take appropriate corrective actions. The UI Project Manager must ensure:

- a. Proposed corrective actions are implemented;
- b. Close out of non-conformances in relation to this standard is formally approved and signed off by the author of the standard or their delegate.

16.2 Design Standard Certification

Contractors and consultants must certify compliance to the design standard by completing and submitting the CIS Project Design Certification Form (CIS-PROJ-F001) to the UI Project Manager at each of the following project phases:

- a. Design and Documentation;
- b. Tender;
- c. Construction.

Notwithstanding UI's internal quality control processes, contractors and their consultants must implement their own robust quality assurance and control procedures to ensure compliance with requirements of this standard.

16.3 Construction Compliance

Consultants and contractors are expected to include check sheets for each system component detailing each item that needs to be checked, tested and verified during the installation process. Such check sheets must be completed and verified by the project consultant/contractors, including the identification of any defects and the closing out of such defects.

16.4 Acceptance

The University will only accept projects as complete when all of the above have been carried out, submitted and verified.

The above standards are not an exhaustive list of the relevant requirements. The consultant/contractor must incorporate all relevant standards and Authorities requirements into project specific design, documentation and installation.

Consideration must be given by the consultant/contractor to the original standard of performance relevant to the construction date of the Roofing System.

17 Defects and Liability Period

Consultants/designers must include in the project specification detailed requirements for the defects and liability period following completion of the roofing and guttering system installation.

The contractor must include and allow for recommissioning of all major plant and equipment in the last month of the 12-month defects and liability period and confirm they achieve the original design requirements. In addition, all commissioning must be witnessed by UI Engineering staff with commissioning reports/results formally submitted to UI Engineering

17.1 Maintenance and Testing

For roofing systems installed as part of a refurbishment project of an existing buildings or new buildings, regular statutory maintenance and testing must be carried out by the University maintenance contractor during the Defects Liability Period (DLP). The installation contractor must provide a comprehensive handover and the required completion documentation at Practical Completion.

All defects arising from regular statutory maintenance and testing performed during the DLP will be documented and passed onto the installation contractor for rectification. The installation contractor must be responsible for all defect rectification works identified during the DLP.

For new buildings, the installation contractor must provide statutory maintenance and testing of all roofing and waterproofing systems for the building, throughout the DLP. Prior to the completion of the DLP, the installation contractor will perform all annual maintenance procedures in the presence of the University maintenance contractor and provide documentation confirming the provision of all statutory maintenance has been performed during the DLP.

Any details which will affect the future performance of the new or upgraded systems must be supplied by the installation contractor at Practical Completion.

Prior to completion of the DLP, a final inspection of the installed systems will be carried out by the: installation contractor, appropriate UI staff, and University Hydraulic services maintenance contractor, in order to reconcile the performance of the equipment during DLP to produce a final list of project defects.

All project defects identified must be rectified by the installation contractor prior to finalisation of the DLP.

18 Access and Operations

Access to all roofing systems within the University is controlled by a University of Sydney roof access permit. This permit must be submitted at least 3 business days before the start of works.

This permit provides the University with vital information about the applicant. Permits are to be submitted to the University delegate. The University delegate will review risk assessments and SWMS before access is granted.

Access to roofs must be through a plant room, stairwell or roof space. Access must not be situated in an area freely accessible to the public. Roof spaces used to access roofs are to be fitted out with walkways and lighting.

If you require University Security patrol to give you access to a roofing system area, you must submit a Service Request in Campus Assist Online (ask your UI or COS representative if you don't have access to Campus Assist Online) on the preceding business day and at least 24 hours before the requested time. You must attach the authorised Permit to Work to the Service Request.

19 References

Design and documentation utilising this standard is to incorporate the requirements of the following current standards and requirements as a minimum:

- ANSI SPRI RP-4 Wind Design Standard For Ballasted Single-Ply Roofing Systems
- AS 1397 Continuous hot-dip metallic coated steel sheet and strip - coatings of zinc and zinc alloyed with aluminium and magnesium
- AS 1530.1 Methods for fire tests on building materials, components and structures Combustibility test for materials
- AS 1562.1 Design and installation of metal roof and wall cladding – metal
- AS 1657 Fixed platforms, walkways, stairways and ladders – design, construction and installation
- AS 1684 Residential timber framed construction
- AS 2436 Guide to noise and vibration control on construction, demolition and maintenance sites
- AS 3700 Masonry structures
- AS 3958.1 Guide to the installation of ceramic tiles
- AS 4040 Methods of testing sheet roof and wall cladding
- AS 4200 Pliable building membranes and underlays
- AS 4312 Atmospheric corrosivity zones in Australia
- AS 4349 Inspection of buildings
- AS 4654.1 Waterproofing membrane systems for exterior use, Above ground level, Materials
- AS 4654.2 Waterproofing membranes for external above-ground use, Part 2: Design and installation
- AS 4773.2 Masonry in small buildings, Part 2: Construction
- AS/NZS 1891 Personal equipment for working at height
- AS/NZS 2311 Guide to the painting of buildings
- AS/NZS 2589 Gypsum linings – application and finishing;
- AS/NZS 2728 Prefinished/prepainted sheet metal products for interior/exterior building applications - performance requirements
- AS/NZS 3500.3 Plumbing and Drainage
- AS/NZS 4488 Industrial rope access systems
- AS/NZS 5532.2 Manufacturing requirements for single-point anchor device used for harness-based work at height
- City of Sydney Local Environmental Plan
- Code of Practice Safe Work on Roofs 2009 (Work Cover)
- Corrugated roofing for heritage buildings
- Green Star Buildings
- Guide to Standards and Tolerances
- HB 50 Glossary of building terms
- HB 161 Guide to Plastering
- Heritage Forum 2024
- Heritage Management Guidelines: Slate and Terracotta Roofs
- ISO 9223 Corrosion of metals and alloys
- MBA Waterproofing Guides
- National Construction Code (NCC)
- National Dictionary of Building & Plumbing Terms
- NCC Condensation in Buildings Handbook
- NSW Minimum Standards for Maintenance and Repair
- NWI DIF Horizontal Hail impact Standard 2.1.2015
- NZ Code of Practice for Torch-on Membrane Systems for Roofs and Decks
- NZ Metal Roof and Wall Cladding Code Of Practice

- SA HB 39 Installation code for metal roof and wall cladding
- SA HB 84 Guide to concrete repair and protection
- Slate, tiling and roof plumbing for heritage buildings
- Technical Specification – Watershedding for Balconies
- WELL Building Standard
- Wollondilly Shire Council Local Environmental Plan

The above standards are not an exhaustive list of the relevant requirements. The Designer/Contractor must incorporate all relevant standards into project specific design and documentation.