Blue Roofs – Design and Installation

Blue roofs are becoming more popular as property developers and building owners seek ways to manage rainwater runoff, and achieve Environmental, Sustainability and Governance (ESG) aspirations.

Whilst offering clear benefits, such systems present a number of risk exposures that require careful management. This Loss Prevention Standard provides useful guidance on reducing the risks associated with blue roofs during the design and installation stages.

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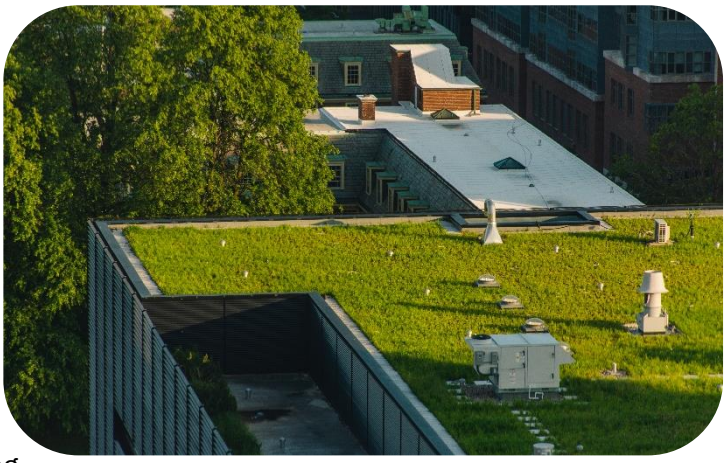
Introduction



A blue roof is an engineered roof system, typically associated with green or living roofing, which supports controlled attenuation of rainwater collected during periods of rain.

The blue roof system will typically store rainwater and then release it in a controlled manner, which can help prevent pluvial flooding and overwhelmed sewage systems, mainly in urban areas, and can also be used in non-potable arrangements such as irrigation systems, toilets, feeding green roofs or other landscaping, or redirected to watercourses, drainage and sewer systems.

Whilst helping to reduce the potential for localised flooding, these systems require careful management during the design and installation phases to help prevent the system from leaking or failing; being overwhelmed during periods of prolonged rainfall or sudden downpour events, or damaged as part of installation works, particularly as average rainfall associated with storm events is increasing.

This Loss Prevention Standard outlines the main areas of concern and provides useful guidance on minimising the risks associated with blue roofing systems during the design and installation stages. Loss Prevention Standard **Blue Roofs - Ongoing Care**, provides useful guidance on inspecting and maintaining the structure post installation. This Loss Prevention Standard does not discuss living/green roof systems. Aviva Loss Prevention Standards – **Living Roofs - Design and Installation, Living Roofs - Ongoing Care and Living Walls and Roofs - 12 Top tips** provide further guidance.

Note: This document relates to blue roof systems and is focussed on property loss prevention and related risk management guidance. It is not intended to address liability exposures. The presumption is that all regulatory requirements, such as Fire Risk Assessments and compliance with local building regulations, codes, or standards, have or will be met.

Understanding the Risks

There are two basic blue roof designs.

- **Passive**. These systems operate without mechanical components and comprise:
  - ✓ Ponding systems which allow water to collect on the roof and drain slowly
  - ✓ Below surface voids or modular tray systems which utilise polymer trays/crates, both of which hold water and release gradually.

  Note: Both systems use flow restriction devices to slow water release.
- **Active**. These systems manage water capture and release, via sensors and automated valves. They can be interlocked to Building Management Systems and predicted weather information to control water retention and release.

Both passive and active types can be utilised with green and living roof technology.

The main risks associated with blue roof systems include, but are not limited to:

- **Leaks**. Whether due to failure of the waterproofing layer, blocked drainage or general wear and tear, leaks from the blue roof system can lead to water penetrating buildings and causing structural damage, particularly to any timber construction materials present.
- **Fire**. Many of the components to create the roof system are plastic and therefore combustible, increasing the fire load. Water can escape and leak onto electrical components or equipment potentially leading to electrical fires.
- **Structural Damage**. Incorrectly specified equipment, that exceeds the load bearing capacity of the building, can lead to structural stress or even potential partial collapse.
- **Drainage**. Drainage systems can be blocked, or systems underspecified, both of which lead to backing up and localised flooding of plant rooms, or water ingress into the building etc.
- **Insulation**. Exposure to moisture can degrade insulation systems which can lead to increased energy costs and condensation issues.
- **Condensation**. Condensation can accumulate affecting air handling systems, promote mould growth, cause damp and also leading to corrosion related damage.
- **Mould and damp**. Mould and damp can affect structural integrity and building finishes and can be very expensive to remedy. Such conditions can also lead to earlier deterioration of system components.
- **Freezing**. Any standing water can freeze in cold weather, potentially damaging the system and membranes, blocking drains and outlets, etc. Freezing water expands and so can cause some structural issues or challenges to other services, especially when any frozen systems thaw and the potential for escape of water or water ingress can occur. The weight of ice combined with any associated snow can lead to structural faults.

Refer Aviva Loss Prevention Standard **Weight of Snow** for guidance.

General Design Considerations

Assessing the likely risk exposures during the design stage can help mitigate the main risk related concerns.

Business Impact Assessment

An assessment of the anticipated financial losses, for both the material damage and income/business interruption exposures, in the event of a significant or catastrophe loss incident relating to the blue roof should be undertaken to ensure the risk controls are proportionate and reflective of the potential loss estimates.

Designer Competence

Ensure competent and experienced blue roof designers and installers are utilised.

- The structural integrity of building and roofing systems should be compatible with the weight loading imposed by the blue roof and any living roof systems.
  - ✓ Compliance with appropriate National Standards, Regulations and Codes should be confirmed, such as:
    - **BS 6229: Flat roofs with continuously supported flexible waterproof coverings. Code of practice,**
    - Approved Document A of the Building Regulations, Scottish Building Standard Technical Handbooks and Technical Booklets in Northern Ireland.
    - **BS EN 1991-1-1:2002 Eurocode 1. Actions on structures - General actions - Densities, Self-weight, Imposed Loads for Buildings** in the United Kingdom.
- Systems and components should be reputable and suited for the type and size of the installation.
- Early engagement with experienced designers, architects and installers for more complex projects can help ensure the project is designed and built to comply with regulatory building requirements, standards or codes.

Management of Change

Where the blue roof is being installed to an existing structure, ensure the works are managed under a formal Management of Change programme and all relevant stakeholders are involved in design, planning and installation discussions.

- Close project management can help reduce the potential for errors, delays, expensive rectifications, and unplanned changes.

Refer Aviva Loss Prevention Standard **Managing Change – Property** for guidance.

Self-Inspection and Housekeeping

All works should be subject to regular self-inspection during the construction phase to ensure housekeeping standards and rules are being appropriately followed.

- The works areas should be checked daily and formally inspected at least weekly during the construction works.
- Waste materials should be removed from work areas daily to appropriate receptacles located at least ten metres from buildings or other valuable assets.
- Blue roof components and other materials should not be stored in or near the work area, other than items needed for the day's activities. Materials should be stored in a secured compound or other location at least ten metres from buildings or other valuable assets.

Refer Aviva Loss Prevention Standard **Self-Inspections** and **Housekeeping** for guidance.

Integrity

Ensuring the integrity of the roofing system and its suitability for supporting the blue roof is critical.

- The design should clearly state the intended life cycle of the blue roof system and its components.
  - ✓ Membrane systems in particular may be more vulnerable to age and wear related damage and end-of-life replacement process should be clearly understood and documented.

- A structural engineer should be engaged early in the design to ensure the weight of the system will not lead to structural or other associated damage to the property, including during cold weather periods where snow and ice may accumulate.
- In the United Kingdom weight loads should be calculated in accordance with:
  - ✓ **BS EN 1991-1-1 Eurocode 1. Actions on structures - General actions - Densities, self-weight, imposed loads for buildings**
  - ✓ **BS EN 1991-1-3:2003+A1:2015 Eurocode 1. Actions on structures - General actions. Snow loads**
  - ✓ **BS EN 1991-1-4:2005+A1:2010 Eurocode 1. Actions on structures - General actions - Wind actions**
- Ensure the total allowable rainwater discharge for the property/site has been agreed at the planning stage, and the system design is capable of meeting those requirements.
- The roof fall is critical and needs to be carefully considered by designers to ensure system compatibility.
- Positive fall roofs, i.e., roof designed with a slope to direct water to drainage systems, are preferred when installing blue roof systems.
  - ✓ This helps prevent ponding and damage to roofing membrane systems, flotation issues, e.g., lifting of other components, as well as providing improved drainage.
  - ✓ Positive fall roofs can however increase water depths within the roof, and lead to loading issues with water being stored unevenly across the system. This risk should be considered in the design specification.
- Zero fall roofs, i.e., roof systems with no intentional slopes, should be engineered to prevent back falls, (water unintentionally directed away from drainage systems); provide improved resilience to pooling; and be certified as waterproof.
  - ✓ Use of enhanced strength waterproof membranes can help increase system life and reduce the potential for damage and water ingress into other building areas.
  - ✓ The material should also be resistant to damage caused by freezing/thaw cycles, particularly in cold weather locations.
- Waterproofing should achieve a detailing height of at least 150mm over the finished surfaces of the roof.
  - ✓ A post-installation waterproofing certificate should be obtained and retained.
- Ensure design calculations reflect any amenity spaces, e.g., potential pedestrian or vehicular access such as terraces and car parks.
- Inverted roof systems should ensure the surface provides sufficient ballast to avoid insulation flotation.
- Condensation can occur where warm, moist air meets cold surfaces, and can lead to structural damage over time. The risks of condensation should be minimised.
  - ✓ Continuous vapour layers should be installed on the warm side of the insulation.
  - ✓ Insulation materials should also be continuous, to help avoid thermal bridging and resistant to condensation.
  - ✓ Installing insulation above the waterproofing layer can help reduce the condensation risks.
  - ✓ Ensure joints and gaps are minimised to help prevent warm air entering chambers and roof voids.
  - ✓ Integrated moisture detection should be considered where humidity and moisture levels in the location are likely to be detrimental to the blue roof system.

- Membrane systems should meet national building regulations, standards and codes, such as **BS 6229: Flat roofs with continuously supported flexible waterproof coverings – Code of practice** in the United Kingdom. Other standards include:
  - ✓ **EN 13956 – Flexible sheets for waterproofing – Plastic and rubber sheets for roof waterproofing – Definitions and characteristics**.
  - ✓ **EN 13707 – Reinforced Bitumen sheets for roof waterproofing – Definitions and characteristics**.
  - ✓ **EN 1928 – Waterproofing – Determination of watertightness**.

Accessibility

The blue roof should be designed to be as accessible as possible for maintenance, inspections and repairs.

- Key components such as inlets/restrictors, dams, ponded areas and drainage outlets should be accessible from the roof for routine checks, debris clearing, etc.
- Safe access will need to be provided including protection against falls and platforms for maintenance at height.

Property Insurer and Broker

Engage with your Property Insurer and broker as soon as possible, ideally at concept stage. They can provide guidance on enhancing the building resilience.

Construction

Whether installed with a hard surface, or as part of an 'inverted' roofing system and/or in conjunction with green or living roof systems, the substrate supporting the blue roof system should be concrete, and should be compatible with other construction elements, such as the external and loadbearing walls, building frame, etc., and have an adequate fire resistance rating (insulation and integrity).

- A fire resistance rating (insulation and integrity) of at least 90 minutes is recommended, or installed in accordance with national building regulations, standards or codes where higher fire resistance ratings are required.

Note: National building regulations, standards and codes typically focus on life safety. The use of construction products with improved fire resistance ratings provides enhanced property resilience.

- In the United Kingdom, **BS EN 13501-2. Fire classification of construction products and building elements - Classification using data from fire resistance and/or smoke control tests, excluding ventilation services,** provides further detail.

Other blue roof components, such as membranes, liners, substrates and insulation layers with no designated fire resistance rating should be non-combustible, where achievable, and ideally achieve a rating of A1 or A2 under **BS EN 13501-1. Fire classification of construction products and building elements - Classification using data from reaction to fire tests**.

Polymer materials are typically used for drainage and retention components. These should be fire-retardant in nature, ideally achieving a rating of at least B under **BS EN 13501-1**.

Note: The fire performance of roofing materials should always be checked with your Property Insurer and Broker for suitability.

Rainwater Management

- The drainage system should be in accordance with national building regulations, standards and codes.

  Note: In the United Kingdom **BS EN 12056-3: Gravity drainage systems inside buildings - Roof drainage, layout and calculation** applies to all gravity drainage systems including blue roof elements, however, may not be fully compatible with the blue roof design. Ensure the system designer has taken this into consideration within the design specification where achievable.

- Incorporate multiple drainage routes and inlets into the attenuation/storage area to ensure even distribution of rainwater across the system and help avoid wear to individual areas.
- Ensure sufficient debris traps and inspection chambers are incorporated into the inlet design.
- Care should be taken to minimise the penetrations through the waterproofing layers.
- Hydraulic design calculations should reflect the size of the roof system/roof area and local rainfall levels with allowances for future climatic conditions over the anticipated life of the blue roof system, e.g., 20% to 40%.
- Consideration should be given to installing a system that allows for retrofitting of additional storage if required, subject to other structural design criteria being met.
  - ✓ This allows for system expansion should the building use change or the property extended.
- The system should be designed to evacuate water over a 24-hour period after the maximum rainfall period and at least 50% over a 12-hour period.
- At least one emergency overflow should be installed per drainage zone in addition to normal drainage outlets, making allowances for further expansion of the system via added capacity. Emergency overflows should discharge to an area that is assessed as being able to safely handle the maximum expected volume of water.
  - ✓ Automatic leak detection devices, designed to provide early warning of escape of water events, should be installed to drainage systems and other vulnerable areas.
  - ✓ These could also be coupled with automated valving and piping systems that stop or redirect water flows to ‘lower exposure’ areas.
- Ensure the blue roof system is capable of being manually bypassed during an emergency event or during maintenance, with rainwater diverted to normal rainwater drainage. The use of temporary covers over inlets is not recommended for extended periods.

Cold Weather Conditions

- Drainage components should be freeze-resistant to help ensure normal operation during cold weather events.
- The use of trace heating to drainage systems, whilst not common or necessary in all jurisdictions, should be considered in cold weather locations.

Electrical Equipment

Electrical installations, including any outlets and electrically powered monitoring equipment installed in proximity to the blue roof should be suitably rated for use in or near such systems.

- Advice should be sought from a qualified and accredited electrical contractor/company.
- All replacement electrical parts should be similarly rated for use in potentially wet environments, where applicable.

Hot Works

The Aviva Loss Prevention Standard **Hot Work Operations** should be followed where hot works are unavoidable during installation works, and thermographic cameras used throughout the process and during fire watches.

- Fire watches should be undertaken for up to 240 minutes after the hot works, and only reduced where supported by a specific risk assessment.
  - ✓ A minimum fire watch period of 120 minutes should be enforced.

Smoking

Smoking and the installation of smoking shelters should not be permitted on, or within 10 metres proximity of the blue roof system.

- There should be no cigarette waste receptacles provided, and sufficient warning signage erected.

Lightning

Ensure lightning protections extend from the property to the structure and any blue roof components as necessary.

- The lightning risk assessment should be reviewed by a competent person or company, preferably a member of a recognised quality scheme or body. Such as The Association of Technical Lightning and Access Specialists (ATLAS) in the United Kingdom.
- Any new lightning protection systems should be installed in accordance with relevant standards, such as **BS EN 62305 pts 1 to 4 - Protection Against Lightning i**n the United Kingdom.
- Ensure lightning protection systems are adequately separated from the blue roof.
  - ✓ Terminals, conductor cables and associated fixings should be mounted to non-combustible building elements only and not placed or mounted within or beneath the blue roof system.

Refer Aviva Loss Prevention Standard **Lightning Protection** for further guidance.

Solar Photovoltaic (PV) Systems

Solar PV systems can be installed on blue roof systems, however careful management is necessary to reduce the potential for loss or damage of either system. In summer months the blue roof may at times be dry/partially dry and more vulnerable to ignition. This is also when solar PV panels generate the greatest power output and therefore present an increased potential ignition source.

- Ensure Microgeneration Certification Scheme (MSC) accredited designers/installers, with experience in installing solar PV systems on blue roofs are utilised.
- Solar PV panels should be mounted to avoid penetrating waterproof membranes.
- Framing should be permanently affixed to the roof structure rather than ballast mounted where possible.
  - ✓ Ballast can work loose and is not as structurally reliable as permanent fixings.
- New solar PV installations should be fitted with voltage optimisers.
  - ✓ These increase energy yield and automatically reduce the voltage within faulty panels to safe levels, reducing the potential for fire events.
- Ensure solar installations do not obstruct drainage paths or maintenance access to the blue roof system.
- For blue roof systems utilising a hard surface, rather than living roof system, small gravel/pebbles should not be used as ballast.
  - ✓ Such material can become wind-blown and damage panels. Birds also have been known to drop stones and gravel on to panels, which can block inlets and drainage systems.

The following Aviva Loss Prevention Standards provide useful guidance in managing Solar PV systems:

- **Roof Mounted Photovoltaic Solar Panel Systems - General Considerations**
- **Roof Mounted Photovoltaic Solar Panel Systems - Planning for Installation**
- **Roof Mounted Photovoltaic Solar Panel Systems - Installation and Construction**
- **Roof Mounted Photovoltaic Solar Panel Systems - Installed and Ongoing Care**
- **15 Top Tips for Roof Mounted Photovoltaic Solar Panel Systems**

Aviva Loss Prevention Standards **Living Roofs - Design and Installation** and **Living Roofs - Ongoing Care** also provide guidance on installing and maintaining Solar PV systems on living roofs.

Specialist Partner Solutions

Aviva Risk Management Solutions can offer access to a wide range of risk management products and services at preferential rates via our network of Specialist Partners.

For more information please visit:Aviva Risk Management Solutions – Specialist Partners

Sources and Useful Links

- BS EN 12056-3: Gravity drainage systems inside buildings - Roof drainage, layout and calculation
- BS EN 1991-1-1 Eurocode 1. Actions on structures - General actions - Densities, self-weight, imposed loads for buildings
- BS EN 1991-1-3: Eurocode 1. Actions on structures - General actions. Snow loads
- BS EN 1991-1-4: Eurocode 1. Actions on structures - General actions - Wind actions
- BS EN 13501-1: Fire classification of construction products and building elements - Classification using data from reaction to fire tests

- BS EN 13501-2 - Fire classification of construction products and building elements - Classification using data from fire resistance and/or smoke control tests, excluding ventilation services
- BS 6229: Flat roofs with continuously supported flexible waterproof coverings
- Structure: Approved Document A of the Building Regulations
- EN 13956 – Flexible sheets for waterproofing – Plastic and rubber sheets for roof waterproofing – Definitions and characteristics.
- EN 13707 – Reinforced Bitumen sheets for roof waterproofing – Definitions and characteristics
- BS EN 1928 – Waterproofing – Determination of watertightness

Note: Whilst UK standards and legislation are referenced in this document, other international standards and legislation should be referenced where applicable.

Additional Information

Relevant Aviva Loss Prevention Standards include:

- **Blue Roofs - Ongoing Care**
- **Blue Roofs - 10 Top tips**
- **Hot Work Operations**
- **Lightning Protections**
- **Living Roofs - Design and Installation**
- **Living Roofs - Ongoing Care**
- **Living Walls and Roofs - 12 Top tips**
- **Roof Mounted Photovoltaic Solar Panel Systems - General Considerations**
- **Roof Mounted Photovoltaic Solar Panel Systems - Planning for Installation**
- **Roof Mounted Photovoltaic Solar Panel Systems - Installation and Construction**
- **15 Top Tips for Roof Mounted Photovoltaic Solar Panel Systems**
- **Managing Change**
- **Weight of Snow**
- **Self-Inspection**
- **Housekeeping**
- **Use of Thermographic Cameras - General Considerations**
- **Use of Thermographic Cameras - Checklist**

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