Green and Living Walls as External Cladding
A Joint Guide to Managing Risk

Version 1 Published 2024

Fire Protection Association

RISCAuthority

Vertical Meadow

Viritopia

ABI

Biotecture

GrowingRevolution

Scotscape

Scoring matrix for completion ONLY by the authority having jurisdiction (AHJ)

The table below is for completion by the AHJ and NOT by those proposing or designing the building's cladding system that incorporates a Living Wall. The table is made visible to ensure those completing the questionnaire understand in advance some key elements that are considered fundamental to the management of insured risks on buildings with Living Wall systems.

Question For the risks described:	**Answer**
1. Are all stakeholders adequately identified and described? Comment:	Yes / No / NA
2. Is the Living Wall system considered 'simple', whose presence requires no additional consideration to the risk profile of the building or structure to which it is attached? Comment:	Yes / No / NA
3. Have measures been taken to adequately remove, reduce, or prevent the participation of combustible components within the Living Wall system? Comment:	Yes / No / NA
4. Are separation distances to other sources of fire, or items that might be threatened by a Living Wall fire, adequate? Comment:	Yes / No / NA
5. Have measures been taken to ensure a fire on the Living Wall is unlikely to spread to other building components? Comment:	Yes / No / NA
6. Does the design incorporate features to protect against the ingress of fire from the Living Wall to wall cavities and rooms within the building, and egress of fire from the building to the Living Wall, via penetrations? Comment:	Yes / No / NA

Question For the risks described:	Answer
7. Have the potential risks posed by energised systems that might be embedded within, or in close proximity to, the Living Wall system been adequately managed? Comment:	Yes / No / NA
8. Have the threats associated with arson and accidental fire raising been considered and addressed within the proposed design? Comment:	Yes / No / NA
9. Is the irrigation system and associated management/repair regime sufficiently robust to ensure reinstatement within the time period the Living Wall becomes dry enough to be considered unsafe? Comment:	Yes / No / NA
10. Are measures in place to curtail the likelihood of building damage from escape of water, moisture damage, and wind damage? Comment:	Yes / No / NA
11. Do you understand whether the building would be safe for use were the Living Wall system allowed to dry out for a period longer than which it has been tested, and has a sufficient plan been made to manage this event? Comment:	Yes / No / NA

Executive summary

This guide has been produced collaboratively between key Living Wall (LW) providers and UK insurers via the RISCAuthority research scheme[a] to address the potential risks from fire, escape of water (EoW), and weather events that these systems may present if incorrectly designed or managed.

The document is in two key parts:

- **Part 1: Living Walls questionnaire**
- **Part 2: Background information and guidance**

The questionnaire provides an opportunity for the specifier, façade designer, or architect to describe the proposed Living Wall system to any authority having jurisdiction (AHJ) – be that local building control, insurer, fire authority, or other. The responses given to the questions will allow the AHJ to quickly determine if the system presents any potential challenges or not, and to communicate these back to the specifier, façade designer, or architect.

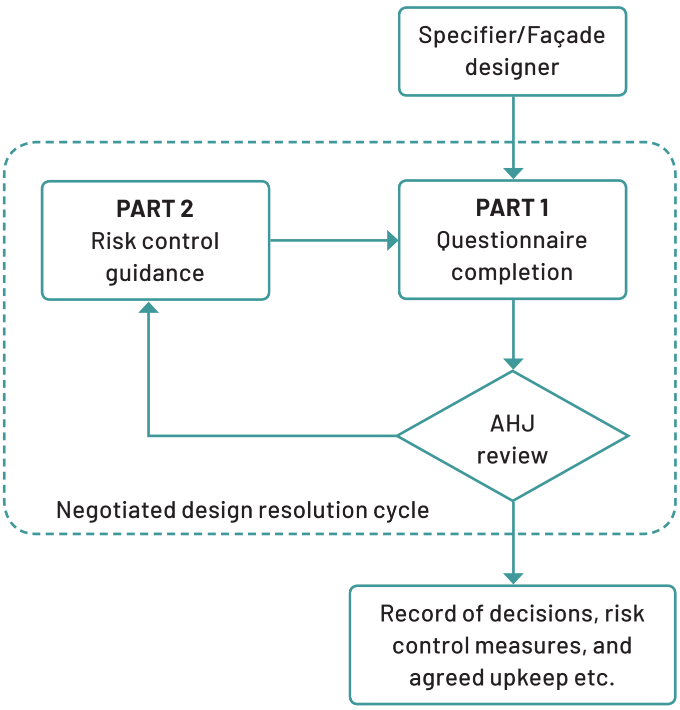
Each question, or suite of questions, asked is supported by explanatory text that will describe why it is being asked, and how the answer might influence the AHJ's viewpoint.

This format is appropriate for supporting an iterative and negotiated design resolution to the challenges. It recognises and adapts to the strengths and weakness of the myriad Living Wall design implementations available and the scale to which they are applied to buildings.

For complex scenarios, where the scale of Living Wall and building coverage warrants detailed consideration, the guide proposes 19 core principles of risk reduction that may be adopted in part, in totality, or met by alternative means, to achieve a satisfactory outcome.

The finalised questionnaire may also serve as a valuable repository of information – a golden thread.

[a] RISCAuthority is a scheme funded by UK insurers with a remit to reduce insured property and business losses from fire, water, and security perils through research, lobbying, and the dissemination of best-practice guidance. Its membership accounts for more than 95% of UK commercial insurance.



Contents

Core principles of risk control for Living Walls

Engagement, Testing, and Documentation	Principle 1	Engage with all stakeholders at the earliest opportunity and maintain dialogue for the entire lifecycle of the building.
	Principle 2	Fire testing must be appropriate to the end use situation and provide an opportunity to test the limit of tolerable irrigation downtime.
	Principle 3	A photographic record of all key fire prevention and performance design detailing shall be made during installation of the system and provided to the owner.
	Principle 4	The building's fire risk assessment shall be updated to include consideration of the Living Wall.
	Principle 5	The system shall be supplied with a handbook detailing system design, monitoring, inspection, maintenance, corrective actions, and training requirements, and include system end-of-life instruction.
	Principle 6	An emergency plan for residents and all other stakeholders shall be provided for at-risk or neglected Living Wall systems.
	Principle 7	The system must always be covered by a maintenance contract, ideally with the OEM or an OEM trained or approved service provider.
Materials	Principle 8	Use non-combustible system component materials wherever possible.
	Principle 9	Where combustible construction materials must be used, minimise their ability to participate in or spread fire.
	Principle 10	Plants and potting medium shall be selected to reduce the likelihood of ignition and reduce the rate and extent of fire spread.
Design	Principle 11	When used as part of a rainscreen-type cladding system, there shall be physical demarcation between the cladding system and Living Wall (fire separation).
	Principle 12	The design shall protect against the spread of fire through both ingress and egress at all penetrations.
	Principle 13	The use of Living Walls must not act to amplify the risks attributable to other building features, such as those presented by combustible cladding, combustible structural building components, façade lighting, and the use of photovoltaic panels.
	Principle 14	Living Walls shall be designed to reduce the likelihood of ignition and limit the rate and extent of vertical and horizontal fire spread over the planted media.
	Principle 15	The system shall be designed to facilitate simple effective repair.
Upkeep and Monitoring	Principle 16	Irrigating water systems shall be resilient in their ability to function, and their management and repair regime will be sufficiently robust to ensure reinstatement in a time period before the Living Wall deteriorates to an unsafe dry condition.
	Principle 17	All parameters that might contribute to raising the fire risk presented by the Living Wall must be constantly monitored.
	Principle 18	All parameters that might contribute to raising water damage potential presented by the Living Wall must be constantly monitored.
	Principle 19	Control construction and hot works risks.

Foreword

Green or Living Walls are becoming a familiar feature of the built environment. Often incorporated as components of newer and more sustainable construction projects, they provide a visible statement of green intent and benefit city biodiversity, air purity, thermal environment, and noise abatement, and are of proven benefit to wellbeing and mental health. Credible as these facets are, there remains a need to consider the implications that the provision of Living Walls may have for the resilience of the building, and the continuity of business or provision of services that are provided from it. Many Living Walls are of a scale and location that presents no additional risk to the scenario that would warrant further consideration, but others, applied at larger scale to a building, might have the potential to exert great influence on the safety and insurability of that building – and others around it – if not properly designed and maintained.

This document and the associated questionnaire seek to:

- elicit key information about the proposed Living Wall system
- quickly gauge whether the systems needs special consideration from a risk and insurance point of view, and if it does:
    - highlight the challenges presented by Living Walls in relation to the perils of fire and water
    - explain why these challenges may act to undermine some core risk control principles that are taken into consideration by insurers
    - suggest practical potential solutions to reduce business and property risks and assist with insurance provision
    - promote the need for through-life monitoring and management of the system
    - highlight that Living Walls are just one feature of many that insurers take into account when assessing building safety and property/business resilience
    - produce a focal point for negotiated risk control conversations.

This document is relevant to building designers, façade engineers, architects, product suppliers, owners, insurers, fire services, and those directly responsible for the day-to-day upkeep, maintenance, and safety of the building.

1 Scope

This document is relevant to the application of Green and Living Walls located on the exterior of buildings and structures. It is aimed at situations where the interaction of the living wall has the potential to significantly alter the risk profile of the building, which will not always be the case. An initial assessment of impact is made within the questionnaire but where doubt exists the user is directed to engage an industry expert or/and, where appropriate, consult directly with the insurer's risk control team.

With a focus on property protection, in the use of this guide it is imperative that national requirements for life safety are not impacted adversely by the adoption of any recommendations made within this guidance.

Adherence to this guide does not guarantee the satisfaction of the AHJ's requirements which must be established as part of this undertaking.

2 Background

[b] Many types of Living Wall system exist, and these challenges will only relate to some of them.

[c] UK legislation seeks to assure life-safety only.

Once included as small decorative areas on buildings, Living Walls are now proposed for much greater expanses, covering an entire side, or even every side, of some buildings. The challenges addressed within this document stem from[b]:

- combustibility of the planted biomass and its dependency on irrigation and maintenance to keep ignition and fire spread potential to a minimum
- the extensive use of plastics in some Living Wall designs in the potting, irrigation, and drainage systems
- the potential complexity of creating a fire-safe design when incorporated into a rainscreen type cladding system
- a lack of guidance on the management of penetrations (windows and vents) to prevent fire ingress or egress between the building's internal compartments, wall voids, and the Living Wall
- a lack of relevance of some certification tests to address the fire challenges
- the potential for the aforementioned factors to allow mass fire spread over the building, both via the planted surface, and within wall cavities behind the potting system
- an overall inadequacy in Building Regulations to address property protection[c]
- a need to additionally consider water and wind damage potential.

Addressing these issues is not straightforward. The management of fire within the built environment is normally controlled by material selection, or the creation of built-up systems where lower performing materials might be encapsulated and kept remote from participating in fire, and it is on this basis that systems and methods are tested and certificated. The idea that a material (such as the plant material and planting medium) should be tested 'wet' or have a specific moisture content – on the premise that it shall (and must) always be in this condition to be safe and actually provide protection – is quite alien. As such, it would be negligent not to consider the consequences if, through neglect, adverse weather, or system failure, the Living Wall were allowed to dry out:

- Should the building be occupied?
- Are other nearby buildings put at risk?
- Will the building be insured when in this condition?
- Will the building be legally in breach of legislation when in this condition?
- What parameters should be used for describing unsafe conditions, what are the limits, and how should they be measured?
- What is the management plan for this situation?

The guidance given does focus greatly on the limitation of combustible materials that the application of a Living Wall can introduce on to a building. This may stem from plastic, which can be a highly problematic material with significant calorific content, persistent burning behaviour, and an ability to spread fire in all directions, including downwards by dripping, burning, and pooling. Its control, in association with measures to properly demarcate the Living Wall from, or incorporate the Living Wall into, the remainder of the cladding system and building fabric, could have a very significant impact on the fire safety of the building and the control of 'in-cavity' cladding fires.

The plant material will always have the potential to burn and in this respect, it should be no surprise that the control measures provided in this guidance stem from wild-fire management and address plant selection, plant placement, and the use of fire breaks, irrigation, building design features, and management controls.

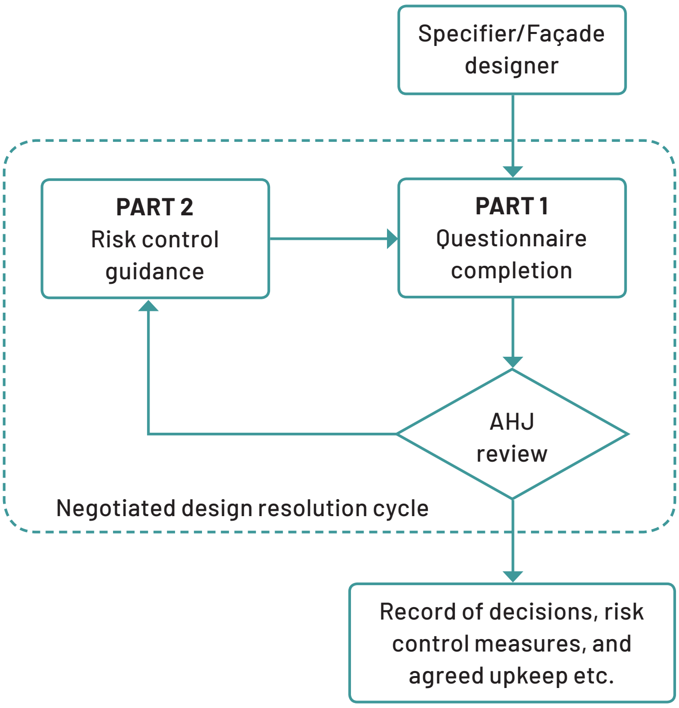
Given that there will always be a residual risk from the plant matter and its associated high dependency on irrigation, maintenance, design detailing, and accuracy of installation, adherence to this document can only achieve so much and it will be down to the authority having jurisdiction (AHJ) to consider if the measures taken are enough in relation to their own risk appetite thresholds.

3 Methodology

The proposed methodology demands the elicitation of information from key stakeholders with a view to assessing:

- the scale of the installed system
- the function and relevance of the building or structure to which it is applied
- the properties of the vertical structure (wall) to which it is applied
- the building's proximity to other structures that it may put at risk or be put at risk by
- the material makeup of the Living Wall system
- how the system is integrated into the façade
- the fire properties of the materials around the Living Wall
- presence of other risk factors
- how the provision of water for irrigation is assured
- inbuilt design features to prevent involvement in fire
- inbuilt design features to prevent escape of water and weather-related damage.

Where the proposed design raises challenges for the AHJ, the questionnaire and associated guidance provide a common framework around which issues may be identified and resolved with the façade designer.


Specifier/Façade designer
PART 2
Risk control guidance
PART 1
Questionnaire completion
AHJ review
Negotiated design resolution cycle
Record of decisions, risk control measures, and agreed upkeep etc.

Part 1: Living Wall questionnaire

4 Living Wall questionnaire

Contents

1. Living Wall Questionnaire – Submission Type[1]	
1.1 Single or part of multiple submission	
Does the building have one type, or multiple different types, of Living Wall on it (or similar types, but in different locations that would impact the risk profile and necessary level of control)?	One / Multiple
Note: *If multiple, please complete section 1.2 below and ensure that a copy of this questionnaire is completed for each Living Wall type/location. Otherwise please proceed to section 2.*	

1.2 Multiple Living Wall types/locations					
If more than one type of Living Wall is used on the building, or the same type is used in different scenarios, then please attach a drawing showing the location of each type and provide the following details. Where more than one questionnaire is completed for a given building, please ensure that each one is provided with an identifying reference number, which should be detailed in the matrix below.					
	Living Wall 1	Living Wall 2	Living Wall 3	Living Wall 4	Living Wall 5
Living wall type					
Living wall name					
Approximate area of coverage (m^2)					
Questionnaire form reference					
Confirm that separate questionnaire completed	This questionnaire	Yes / No	Yes / No	Yes / No	Yes / No
Has a drawing been provided that details the location of each Living Wall type?					Yes / No

2. Contact and Location Information

2.1 Respondent Information[2]	
Name	
Job Title	
Company Name	
Company Address	
Email Address	
Telephone Number	
I confirm that the information provided is correct to the best of my knowledge.	
Signature	

2.2 Proposed Building/Structure Name and Location	
Building/Structure Name	
Address	

2.3 Key Stakeholder Details	
Specifier/Architect's Details	
Contact Name	
Company Name	
Façade Engineer's Details	
Contact Name	
Company Name	
Living Wall Supplier's Details	
Contact Name	
Company Name	
Local Fire Authority Details	
Contact Name	
LAFB Name	
Local Authority Building Control Details	
Contact Name	
LABC Name	
Insurer Details	
Contact Name	
Insurer Name	
Property Owner Details	
Contact Name	
Company Name	
M&E Consultant Details	
Contact Name	
Company Name	

3. Initial Complexity Assessment[3]

3.1 Building or Structure

Note: *A positive (checked box) response to all or a majority of the following questions might indicate the Living Wall scenario to be 'simple' from a risk perspective, and therefore not demanding of description with the same rigour as for a more complex system.*

Is the Living Wall outside (not enclosed or partially enclosed in another structure)?	☐
Is the Living Wall on a structure that is not a building?	☐
Is the Living Wall on a surface that has no windows or penetrations through it?	☐
Is the surface to which the Living Wall is attached non-combustible (e.g. concrete)?	☐
Are all sources of combustible material more than 5 metres away from the perimeter of the Living Wall in all directions?	☐

3.2 Living Wall

Is the Living Wall less than 3 metres in height?	☐
Is the Living Wall predominantly of non-combustible form (aside from biomass and plastic used in irrigation pipes)?	☐
Are robust measures in place to ensure the Living Wall is properly irrigated?	☐

3.3 Complexity Assessment

With reference to the answers provided in this section, the supporting section text, and Part 2 guidance, I am of the view that this implementation of the Living Wall presents few fire, escape of water, or weather related risks of the type that this guide seeks to address. I consider the installation to be 'simple' and my initial submission shall be limited to the description I give below :	YES[5] NO

Simple system description – please refer to the accompanying drawing (only required if Box 3.3 is checked):

4. Building/Structure Details

4.1 Building/Structure Purpose and Use

Please describe briefly below the use to which the building/structure is put:

4.2 Modification Type

Refurbishment ☐ New Build ☐ Extension ☐ Other ☐ Don't know ☐

If Other, please specify:

4.3 Building Structure[6]					
Concrete ☐	Steel ☐	Mass Timber ☐	Light Timber ☐	Hybrid ☐	Other ☐
If Other, please specify:					

4.4 Cladding System Used[7]			
Rainscreen ☐	ETICS ☐	None ☐	Other ☐
If Other, please specify:			

4.5 Cladding System Materials				
Support	Metal ☐	Brick or Concrete ☐	Timber ☐	Other ☐
Insulation	Stone or mineral wool ☐	PUR/PIR ☐	EPS ☐	Other ☐
Cladding	Metal only ☐ Don't know ☐	Brick/Concrete/Stone ☐ Composite ☐	Timber ☐ HPL ☐	GRP ☐ Other ☐
If Other, please specify:				

4.6 Building Size[8]					
Number of floors		Floor area, m^2		Overall dimensions (H×W×D) m	

4.7 Configuration[9]		
Stand-alone ☐	Semi-detached ☐	Terrace ☐

4.8 Proximity	
Separation distances to neighbouring buildings	
North	m
South	m
East	m
West	m

4.9 Penetrations[10]

Which of the following features penetrate the building's envelope, what materials are used, and are they fire stopped?

Penetration		Material	Number	Fire stopped
Windows	☐			☐
Vents	☐			☐
Pipes	☐			☐
Air-conditioning units	☐			☐
Air-bricks	☐			☐
	☐			☐
	☐			☐
	☐			☐

4.10 Occupancy

Residential <11m ☐ Residential >11m ☐ Commercial ☐ Mixed ☐

4.11 Other Features[11]

Does the building have any of the following features?

Green roof ☐ Solar panels ☐ Façade illumination ☐ Heritage status ☐
EV charging ☐ Close proximity car parking ☐ Balconies ☐ Close bin stores ☐
Battery energy storage ☐ Other ☐

If Other, please specify:

5. Living Wall System Details

5.1 System Type

Hydroponic ☐ Soil-based ☐ Other ☐

If Other, please specify:

5.2 Component Materials and Fire Properties[12]		
	Material	EN 13823 Classification
Support rails		
Back board		
Membranes		
Modules		
Receptacles or mats		
Growing medium		
Irrigation pipes		
Others, please specify:		

5.3 Biomass		
	Plant species name	% by coverage
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

5.4 System Certifications[13]		
	Standard	Classification/Result
Fire		
Wind Loading		

5.5 System Component Certifications[14]		
	Standard	Classification/Result
Pumps		
Pipes		
Membranes		

6. Living Wall Installation Details

6.1 Brief Description

Please describe briefly below the location and extent of the Living Wall system:

6.2 Living Wall Scale

What is the overall area of Living Wall installed?	m^2
What proportion of the building's external wall area (or the elevation(s) it is on) does this represent?	%
How high above ground level does the Living Wall start?	m
What are the dimensions of the largest continuous block of Living Wall?	m × m

6.3 Cavities[15]

Does installation of the Living Wall create a void between its rear and the surface to which it is attached?	☐
Are cavity barriers required to seal against the rear of the Living Wall system?	☐

6.4 Penetrations

Which of the following features penetrate the Living Wall system?

Windows ☐	Vents ☐	Pipes ☐	Air-conditioning units ☐
Air-bricks ☐	Other ☐		

If Other, please specify:

6.5 Embedded Systems

Which of the following systems are embedded in the Living Wall system?

Lighting ☐	Bird boxes ☐	Solar panels ☐	Electrical cabling ☐
TV and sound systems ☐	Other ☐		

If Other, please specify:

6.6 Access

Are there locations where the Living Wall can be reached by the public?[16]	☐

7. Risk Control Measures – Fire[17]

7.1 What measures have been taken to reduce the amount of combustible material in the Living Wall system components, and/or reduce the likelihood of remaining combustible materials being involved in fire?

7.2 What design features prevent this system from increasing the likelihood and severity of cavity fires when installed in rainscreen-type cladding systems, or where they create a new cavity with the backing wall onto which they are mounted? (if applicable)

7.3 What design features have been employed to prevent the ingress and egress of fire between the Living Wall and wall/building internals, through penetrations?

7.4 How have risks associated with external ignition sources (from people, cars, EV charge points, bin stores, etc.) been ameliorated?

7.5 How does the design seek to limit the extent and likelihood of fire spread over the planted material?

7.6 What measures assure the resilience of the irrigation system to keep the Living Wall in optimum health?

7.7 What impact will a dried out Living Wall system have on the use and occupancy of the building?

7.8 What is the maximum period the irrigation system may be off-line before the health and fire performance of the Living Wall is compromised, and what measures are in place to assure its reinstatement within this period?

7.9 How will the health of the Living Wall be monitored and maintained?

8. Risk Control Measures – Escape of Water, Water Ingress, and Wind Damage[17]

8.1 What measures have been taken to reduce the likelihood of irrigation water adversely affecting other parts of the building or structure?

8.2 What measures have been taken to protect the irrigation system from pipe bursts associated with freezing weather?

8.3 What design features assist the timely repair of the irrigation system?

8.4 What design features prevent wetting of the fabric of the building that might give rise to moisture and damp issues?

8.5 How has the robustness of the system to adverse weather been assured?

[1] Multiple systems should be declared where a Living Wall on a single building is deployed in areas that might present a different level of risk challenge. This enables separation of lower risk parts from higher risk areas which might assist with focusing discussions on the key areas of concern and speed up the negotiation process. An example might be splitting consideration of Living Wall areas on building surfaces with no windows, and areas that are windowed. Areas of Living Wall that have been formed of distinctly different system types should also be addressed in separate questionnaires.

[2] The ideal 'owner' of this document would be the façade engineer who has responsibility for the entire wall make up.

[3] In association with the other information given in this guidance as to the sources of raised risk for Living Wall systems, this section seeks to ascertain whether the proposed installation demands the level of scrutiny requested in the rest of the questionnaire.

[4] Where a system is considered 'simple,' the user should consult immediately with the AHJ to confirm that no further level of detail is required for their purposes.

[5] If answering YES, this should be confirmed as agreed with the AHJ as soon as possible.

[6] Depending upon the materials of construction, the presence of a Living Wall may be viewed as compounding existing risks – particularly where the structure is of a combustible material.

[7] Due to their close proximity, the cladding system used and the fire performance of its component materials may be viewed as acting to compound Living Wall risks.

[8] The scale of the building exerts a great influence on insurers' perception of risk because, in general, costs of insured perils rise geometrically with size (material damage, business interruption, loss of rent, etc.).

[9] The configuration of the building and separation from other buildings are important as they all represent potential sources of and targets for fire spread.

[10] Penetrations in any cladding or Living Wall system represent potential sources of and targets for fire exchange between the internals of the building and the cladding/ Living Wall system. Penetrations in the external envelope are not subject to the same strict controls as when placed in walls between fire compartments, so the higher level of protection appropriate for Living Walls is a voluntary undertaking in support of property protection.

[11] Other inbuilt and embedded design features in the building may act to compound the risks introduced by the Living Wall.

[12] The materials of construction and their associated fire performance credentials are a primary source of concern for insurers as these can be easily ignitable, difficult to extinguish, and spread fire in all directions.

[13] System certifications of the Living Wall system are meaningful to the insurer if they judge them to be relevant to the proposed installation.

[14] The certification of systems designed to ensure the safety of the Living Wall will be meaningful to the insurer.

[15] Cavities in walling systems can promote fire spread due to their geometry and the presence of combustible materials such as insulation and membranes. It is normal practice to control fire spread in this area by the use of open state cavity barriers, designed to close the cavity under the action of fire. These devices require flat non-combustible surfaces, to form a seal with.

[16] Arson and construction activities still account for many fires. While it is difficult to protect against a committed arsonist, simple measures can be taken to account for opportunistic and accidental fire raising.

[17] The answers to these questions, in association with the properties and management of the Living Wall systems, will inform the AHJ on how well fire risks have been mitigated, or otherwise. Many other factors come in to play during the consideration of buildings as an insured prospect, and other factors, outside the jurisdiction of the façade engineer, may be more relevant.

[18] The answers to these questions, in association with the properties and management of the Living Wall systems, will inform the AHJ on how well water-related risks have been mitigated, or otherwise. Many other factors come in to play during the consideration of buildings as an insured prospect, and other factors, outside the jurisdiction of the façade engineer, may be more relevant.

Part 2: Background information and guidance

5 Types of Living Wall

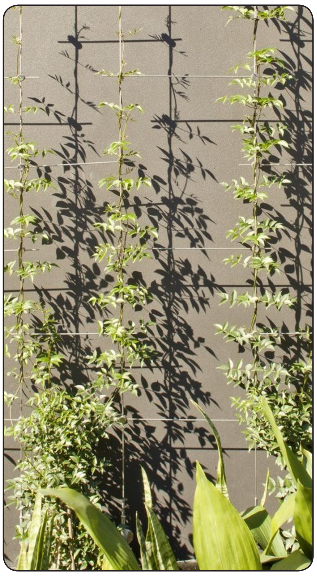
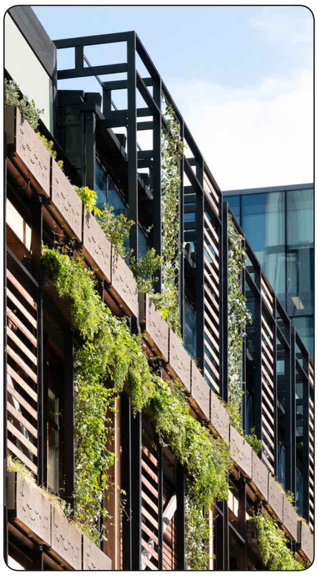
Living Walls are designed systems that present plants in the vertical or steeply inclined plane. Living Walls, also known as Green Walls, bio-walls or vertical gardens, are usually incorporated into or set in the front of structures including buildings. From climbing or trough systems to sophisticated modular rainscreen cladding panels and full façade elements, Living Walls can take many forms that cater for a wide variety of applications, greening methods, and local conditions.

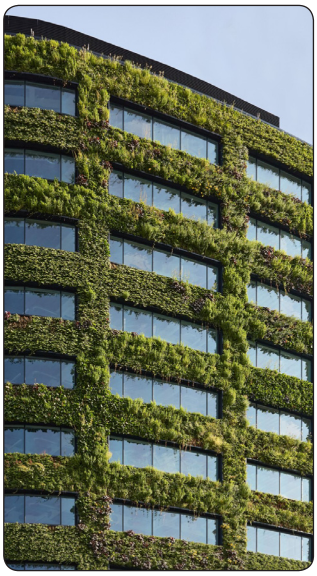
Living Walls are becoming an increasingly important part of Green Infrastructure to boost biodiversity in our cities, reduce air pollution, promote wellbeing, and help to lay the foundations for a more sustainable future. Within our cities, Living Walls can be targeted to the very locations where they can have maximum impact and added value.

While all Living Wall systems share a potential risk presented by the plant material itself, each system's specific detailing and materials of construction may exhibit strengths and weaknesses relevant to the considered scenario that need to be considered, particularly in respect of available combustible materials and the creation/management of voids.

There are many different ways to categorise Living Walls. For the purposes of this document, four main types are considered:

1. Wire trellis or net systems for climbers
2. Troughs (with or without wire trellis or net systems)
3. Fabric-based Living Wall systems
4. Modular panel-based Living Wall systems

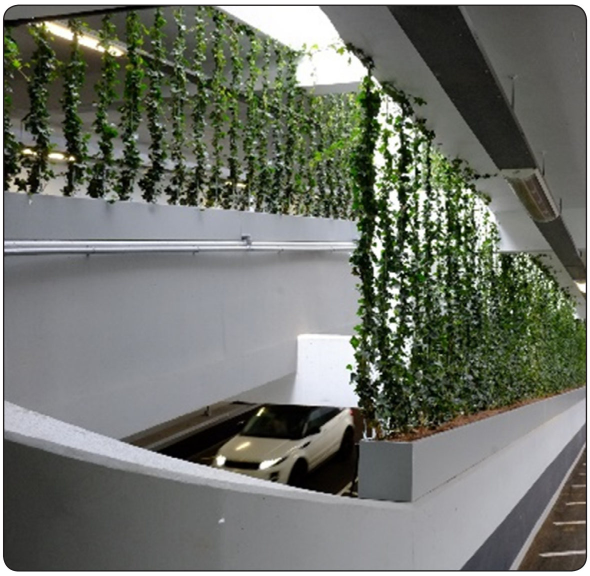


Note: Designed Living Walls include elements of control over the planting and therefore plants that grow directly up and either link to or are connected back to structures in an uncontrolled or ad hoc fashion are not considered in this guidance document. Greenery that falls into this definition poses potential additional risks which are considered to be outside the scope of this document.

5.1 Living Wall Type 1: Wire trellis or net systems for climbers

Vertical, inclined wires, or web-nets of usually stainless steel are fixed back to and set off structures at regular intervals as supports for climbing or trailing plants. The plants are generally planted and set against their supports on site.

The plants grow around the supports with a rotating motion of their shoots. Plants are either planted into the ground or into troughs (see Living Wall Type 2). Generally, plants in this type of Living Wall are grown into horizontally aligned growing media.

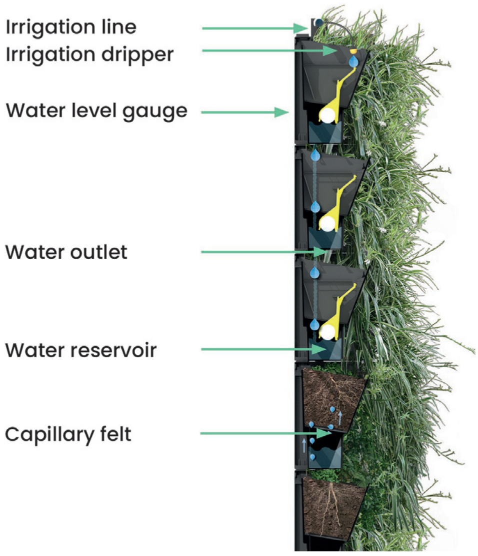


5.2 Living Wall Type 2: Troughs

Trough type Living Walls can be either fixed to or restrained back to structures. The troughs may be modular and stack independently of the structure or they may be supported by the structure. The troughs can be set at varying heights above each other with the planting either giving an appearance of a continual wall of plants or being in discrete, sometimes repeating, elements.

Typically, Living Wall troughs are manufactured from wood, plastics, metals, or other materials. Trough type Living Walls can include supports (usually metal) for climbing or trailing plants.

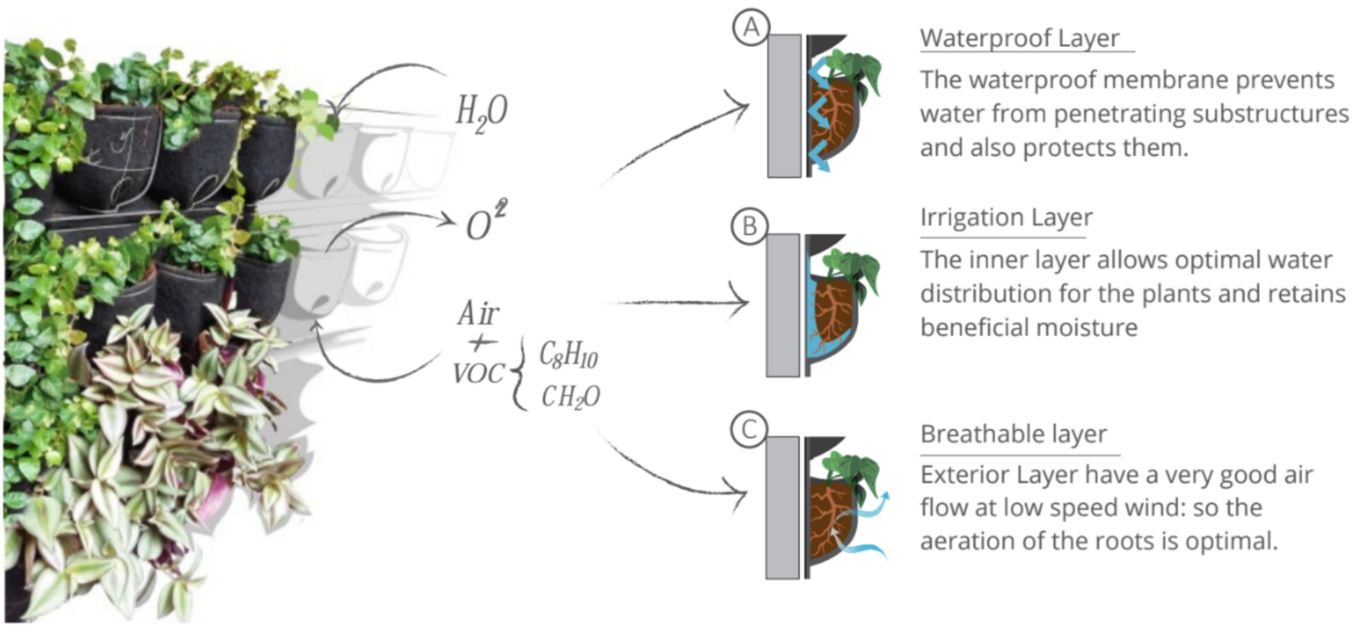
Plants in trough type Living Walls can be climbing, trailing, or of upright form. Plants in this type of Living Wall can be 'pre-grown' off site, usually in commercial greenhouses, or on site. Generally, the growing media for this type of Living Wall is horizontally aligned.

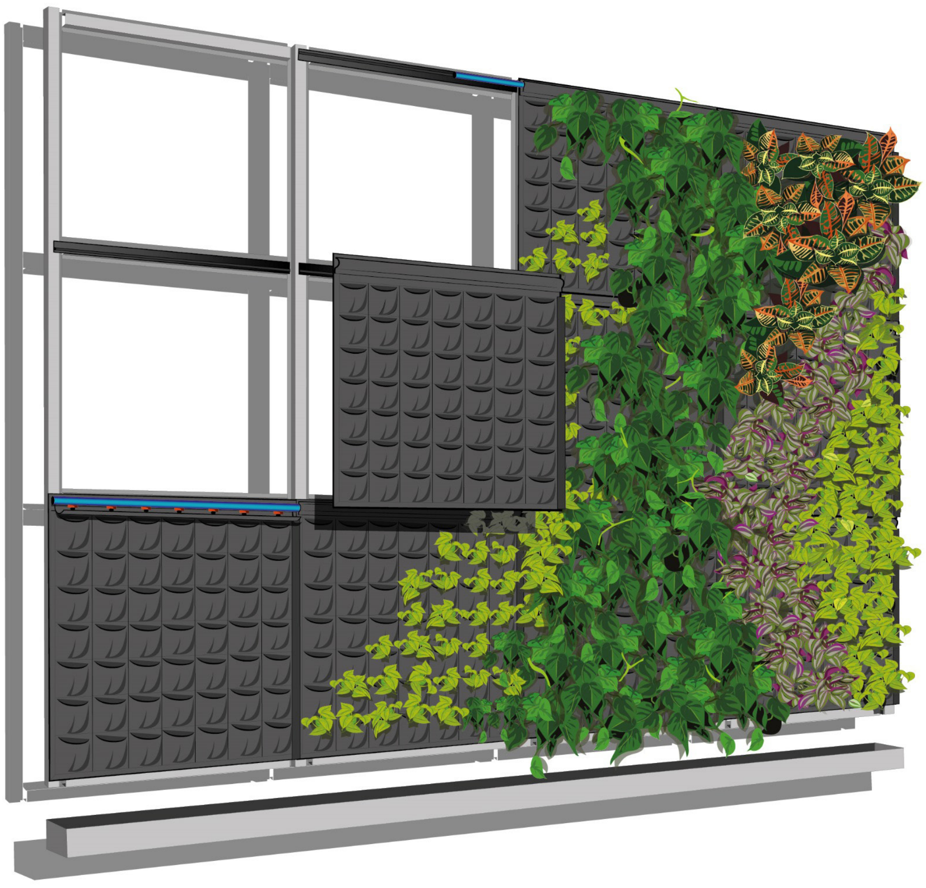


5.3 Living Wall Type 3: Fabric-based Living Wall systems

Fabric-based Living Wall systems are fixed back to structures. This may be a simple fix, for example, to a construction site hoarding or, in a more complex situation, the fabric-based living element of a structure may form the external skin of a rainscreen façade. Typically, fabric-based Living Wall systems are manufactured from textiles with either pockets or slits to house the initial plant roots. Plant root systems then extend into the textile material. Textiles substrates are typically 3mm to 20mm thick.

Planting into fabric-based Living Wall systems generally takes place on site with initial planting being with seeds, cuttings, or small plants generally up to 1 litre in size. The textile substrate combined with the initial growing media in the pockets or slits acts as the growing media overall for this type of Living Wall and is aligned vertically.





5.4 Living Wall Type 4: Modular panel-based Living Wall systems

Modular panel-based systems are fixed back to structures. Again, this may be as a simple fix, but this type of Living Wall also typically becomes the rainscreen element of a façade system. System elements can also include the support structure and cavity zones.

The structure of the panels is usually rigid in form, and they are typically manufactured from plastics or metals. Modular panel-based Living Wall systems are typically between 50mm and 100mm thick.

The panels contain the growing media, which can be loose or of more rigid form. Typically, looser growing mediums are held in the modular panels with an inclined structure whereas the more rigid forms of growing media are held horizontally.

Planting into modular panel-based Living Wall systems usually takes place at controlled off-site horticultural facilities. The 'pre-grown' panels are then delivered and installed on site. Planting can also take place in situ.

Two general implementations for rainscreen cladding exist:

1. Built-up systems
2. Rainscreen cassettes.

In built-up Living Wall systems, the building's cladding is formed from the Living Wall components in association with other wall make-up materials. The overall resulting rainscreen design includes open state cavity barriers and other forms of fire stopping where, and if, the internal compartmentation of the building is extended out to cover any additionally introduced voids.

Typical system build up

Rainscreen cassette systems are designed to replace the front face layer of rainscreen cladding system only (i.e. the ACM, or stone tiling), without introducing additional voids or exerting influence (aside from weight-bearing requirements) over anything behind it.

Full rainscreen cassette option

5.5 Living Wall growing media

Growing media provides plants with the physical support, aeration, and access to water and nutrients that they need. It is therefore a vital component of all Living Walls.

The predominant growing media or substrate material of choice for all the types of Living Walls is either soil-based or hydroponic. Mixes of growing media are also common to suit the desired growing conditions.

Elevated Living Wall systems can be considered to be thin substrate growing environments. This is because they have no connection to any subsoil and being vertical makes the growing environment doubly challenging.

In these instances, regardless of growing media choice, the ability to add nutrients to the growing media is of particular importance for plant health and durability. Nutrients can be added by a number of methods but typically for Living Walls this is carried out via fertigation (the practice of supplying dissolved fertilisers through the irrigation system).

5.6 Living Wall irrigation

On the Living Wall

Living Wall Types 3 and 4 are invariably installed complete with high specification integrated irrigation systems. Typically, this consists of multiple pressure-compensated emitters with regulated flow rates set into irrigation driplines which in turn are set at vertical intervals to suit requirements. Irrigation water from the emitters is directed straight to the root zone area, to reduce evaporation losses and wasted water. The irrigation for these Living Wall Types is typically set to run 12 months of the year.

The pressure-compensated emitters, coupled with the fact that the irrigation dripline is typically manufactured from LDPE, provide significant protection from frost damage. In freezing temperatures pressure is continually relieved as air is able to exit from the emitters.

Living Wall Types 1 and 2 can also include these types of integrated irrigation system but can also be installed with lower specification irrigation options. In some instances, for Living Wall Types 1 or 2 it may be appropriate to shut down the irrigation during the winter months.

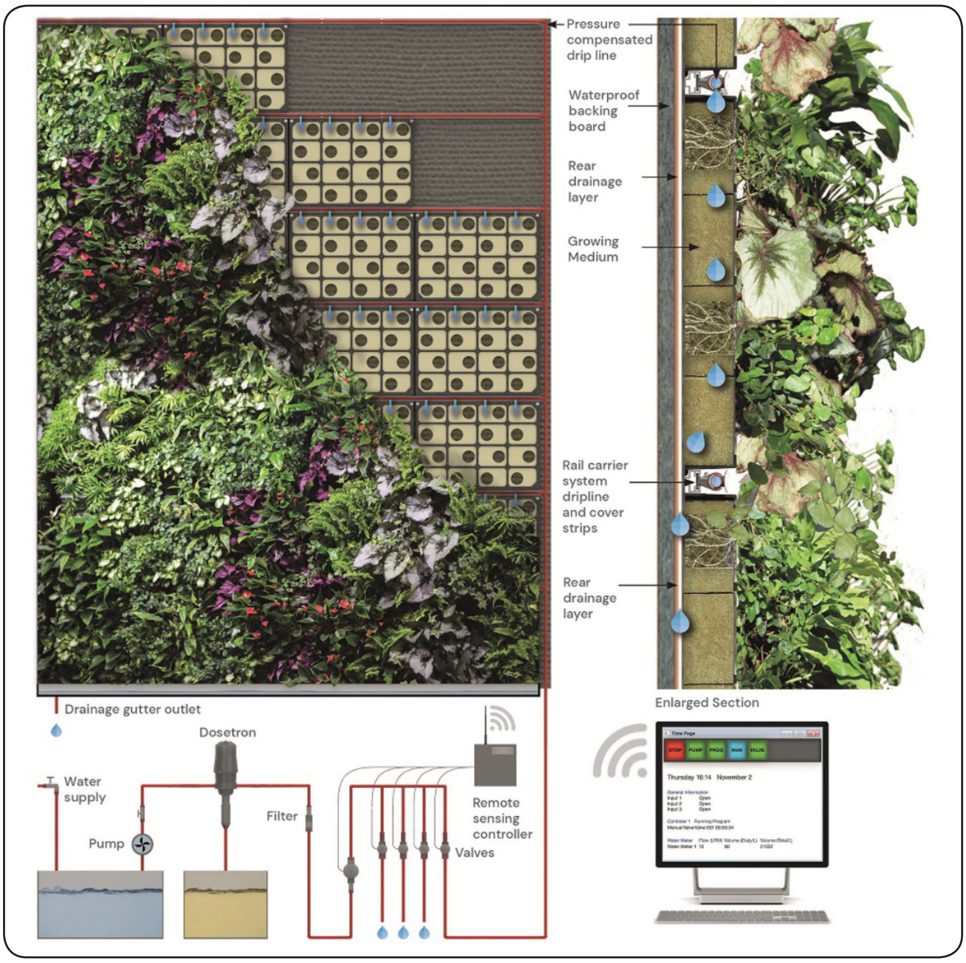
Control and monitoring

Irrigation control for Living Walls that include high specification integrated irrigation systems on the wall tends to be managed by a controller that sets run times and durations for the irrigation. To satisfy water regulations, the source of the irrigation water for the Living Wall comes either from a CAT 5 supply or via a WRAS approved pump set. The irrigation for larger Living Walls is compartmentalised or zoned with the use of solenoid valves that direct the irrigation water to different areas of the Living Walls.

Current best practice irrigation controllers for Living Walls are connected via networks including, for example, wi-fi. This allows them to be remotely sensed and remotely controlled in real time by the Living Wall maintenance company. These best practice irrigation controllers 'report' on performance and will provide exception alerts when conditions fall outside of set parameters (typically flow rate or water content per zone).

Irrigation controllers can also be linked to on-site Building Management Systems. This can allow for additional independent monitoring of the performance of the irrigation system.

Simpler on-site irrigation control can also be appropriate for low risk Living Walls and may include battery operated or manual control. These simpler systems are particularly suited to some Living Wall Type 1 or 2 installations.



Typical high specification Living Wall irrigation schematic

6 Living Walls, stakeholders, and building/business resilience

6.1 Stakeholders

The increasing desire for, and benefit of, Living Walls is accepted and understood, and it is not the intention of this document to reiterate them here. While it is plausible that in certain circumstances the challenges they might present may be relevant to the safety of occupants (life-safety), the more likely risk is to the property they are on, and the impact that this will have on the businesses and services conducted from it. In the UK, Building Regulations are focused exclusively on 'life-safety' and ensuring that a building remains structurally sound for a period to support successful evacuation only. Given this, there needs to be an appreciation that any measures over and above meeting the life-safety requirement are entirely voluntary and will most likely incur additional cost, but may be necessary to appease the building owner, insurer, fire service, or Local Authority Building Control. It is also important to appreciate that Living Walls are just one feature of many that may influence the resilience of a building to fire, water, and weather events so should never be considered in isolation when assessing overall risk (see later).

The principal stakeholders in setting and defining the design and performance requirements of a new building for designers and architects to work towards are:

- the government
- the client
- the insurers (a subset of the client's requirements).

It is these AHJ's that the façade designer must appease with their proposed designs.

On 1 June 2022, the government introduced a new framework to further strengthen and clarify Building Regulations and fire risk guidance, as part of wider reforms to building safety. National legislation now clearly determines the building types where external cladding can be used, which includes Living Wall installations. This means that residential dwellings above 11m high where people sleep are no longer compliant, but all other building types are. Under the Environment Act 2021, all planning permissions granted (with a few exceptions) will have to deliver at least 10% biodiversity net gain. In London, for example, as part of the Urban Greening Factor, London Plan Policy G5 requires all major developments to include urban greening as a fundamental element of site and building design. More detailed information on the legal framework for Living Walls is given in Appendix A, which is extracted from 'External Cladding: Living walls and fire safety – Best Practice Guide December 2022' produced by the Living Wall industry.

Every business and service provider will be cognisant of their legal obligations for safety and their business objectives. It is in the remit of every CEO to ensure their business is profitable, that their workforce is not harmed, and to act in the long-term interest of the shareholders. Inherent in the latter is being resilient against adverse conditions. Other customer facing factors might also be considered as indicated in the diagram below:

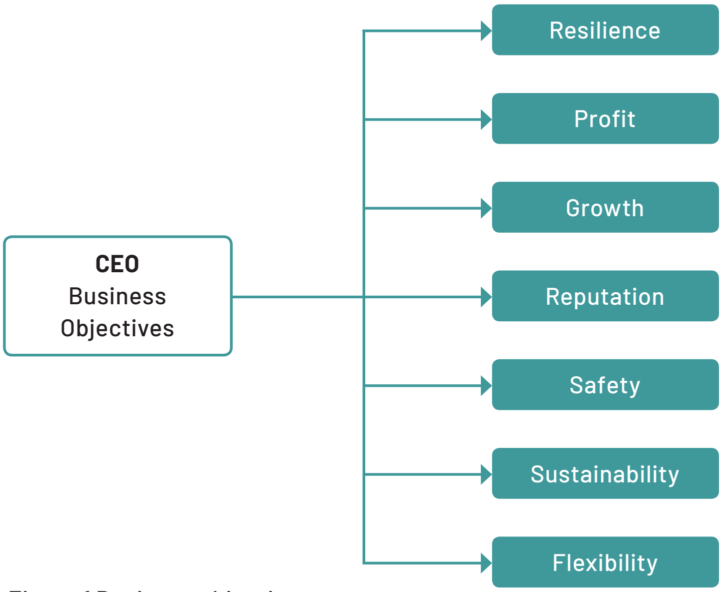


Figure 1 Business objectives

Clearly, Living Walls can support higher-level Environment, Social, and Governance ambitions including:

- sustainability
- reputation (green credentials).

However, if done without due consideration of introduced risks, they can erode:

- resilience
- flexibility
- safety.

Any disproportionate loss caused can lead to:

- reduced profit
- impaired growth
- lost/missed opportunities
- fines
- reputational damage.

Insurers' and business owners' resilience objectives will generally be aligned and, as often as not, the insurers act as a key consultation resource in assisting their clients to establish appropriate risk management controls to reach acceptable insurance risk transfer terms. Damage to a building from fire, flood, moisture, escape of water, and other perils can result in insured loss by:

- Material Damage (MD)
  - building
  - contents
  - machinery and plant
  - stock
- Business Interruption (BI)
  - loss of gross profit
  - loss of rent
  - alternative accommodation.

Provision of insurance requires the insurers to understand the building's risk profile to make an estimation of the potential for loss. In respect of fire, design features that may allow the spread of fire within or over a building will contribute greatly to this estimation. The generic term for this assessment is 'Estimated Maximum Loss' (EML), a vitally important facet which is discussed in more detail below.

6.2 What is Estimated Maximum Loss (EML)?

Insurers use a range of methodologies to estimate potential loss to combined property and business interruption damage. Their meanings and interpretations may vary between insurers and differ through the inclusion or exclusion of mitigations, such as fire sprinklers, and the ability of passive features to perform. Regardless of these variations, the key requirement for all insurers is to establish the Estimated Maximum Loss (EML) or equivalent.

Scale is a vital feature of insurability and can exert great influence during the consideration of provision of building insurance, especially where novel methods and materials are used and, as a result, little claims experience may exist. EML is the most commonly used number for the analysis of insurability and where insurance provision is troublesome, all measures taken to improve the situation must demonstrably act to reduce EML.

Two key areas of interest for insurers in respect of Living Walls are:

- fire spread over and within a building (EML)
- fire spread between buildings (EML/Accumulation).

Fire spread over and within a building

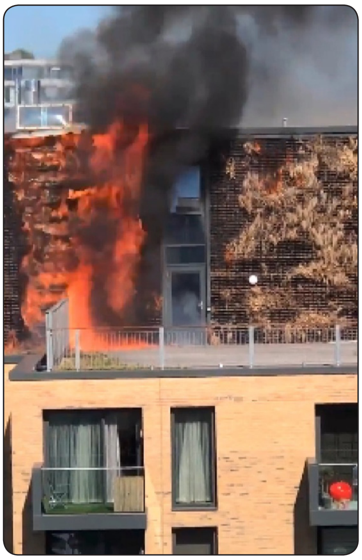
An insurer's appetite and capacity may be provided on the worst-case assumption that the whole building or business would be lost in the event of a fire – an EML of 100%. With appropriate design and mitigation measures in place, an insurer's assessment may consider damage to a lesser amount, aiding the provision of insurance more readily.

As a simple example, for a high-rise building of 20 storeys, an assumption might be made that during a significant fire event, the fire floor would be lost, two floors above might incur damage from smoke, and a floor below might experience water damage from firefighting activities. The assumption is therefore the loss of 4 floors out of 20, or an EML of 20%. It is important to understand however what features give the insurers confidence that such a model is appropriate. In this case:

- There is an assumption that the compartmentation is good enough to ensure the fire cannot spread internally from the floor of origin to other floors above or below.
- There is an assumption that fire cannot spread within internal cavities to other floors or the roof.

- **There is an assumption that fire cannot spread externally to other floors via the cladding system and insulation materials or Living Wall.**
- There is an assumption that the building remains suitably stable during fire to support effective Fire Service intervention.
- **There is an assumption that fire will not spread to other buildings or be spread from other buildings.**

Now consider this in the context of Living Walls where:



- the Living Wall becomes involved in fire ignited externally or by egress of flame from a window of an internal compartment
- external fire spread over the Living Wall allows the fire to ingress into the building at many levels.

You will appreciate how quickly these traditional insurance assumptions can break down.

The importance of EML cannot be overstated: **if the insurers cannot be convinced of the limits of a fire event, there may be no other option but to assign an EML of 100%**. This of course may limit the markets for procuring insurance coverage.

Fire spread between buildings

Just as the insurers will assess the likelihood and extent of internal fire spread, they will also assess the likelihood of fire spread between buildings. Materials of construction used externally play a key role for both the emitter and receiver buildings, as does separation distance. Fire may be spread via a continuous path of combustible material between two points, by flame impingement across gaps, by thermal radiation, or by transport of burning brands. A poorly managed Living Wall on the external envelope of a building can create a large radiation source that, even without direct flame impingement or wind-borne burning brands, may ignite façades of adjacent buildings or be more readily ignited by other fire sources local to it. If the insurer establishes that other buildings they insure may become involved in fire due to their close proximity, then the assumed loss will be an accumulation of all of those buildings – the EML will be an aggregate of all buildings with insufficient separation.

6.3 Other building insurability factors

The incorporation of Living Walls into a building's design is just one of many features that will contribute to its overall insurability. It is important that users of this guide have an awareness of these factors to ensure that the overall design is suitably resilient to maximise access to insurance. There are many factors that have the potential to contribute to large-scale fire spread, either internally (through voids and occupied spaces) or externally (over the envelope of the building). The sensitivity of some materials to water exposure also demands attention, together with the means for mitigating fire and water damage.

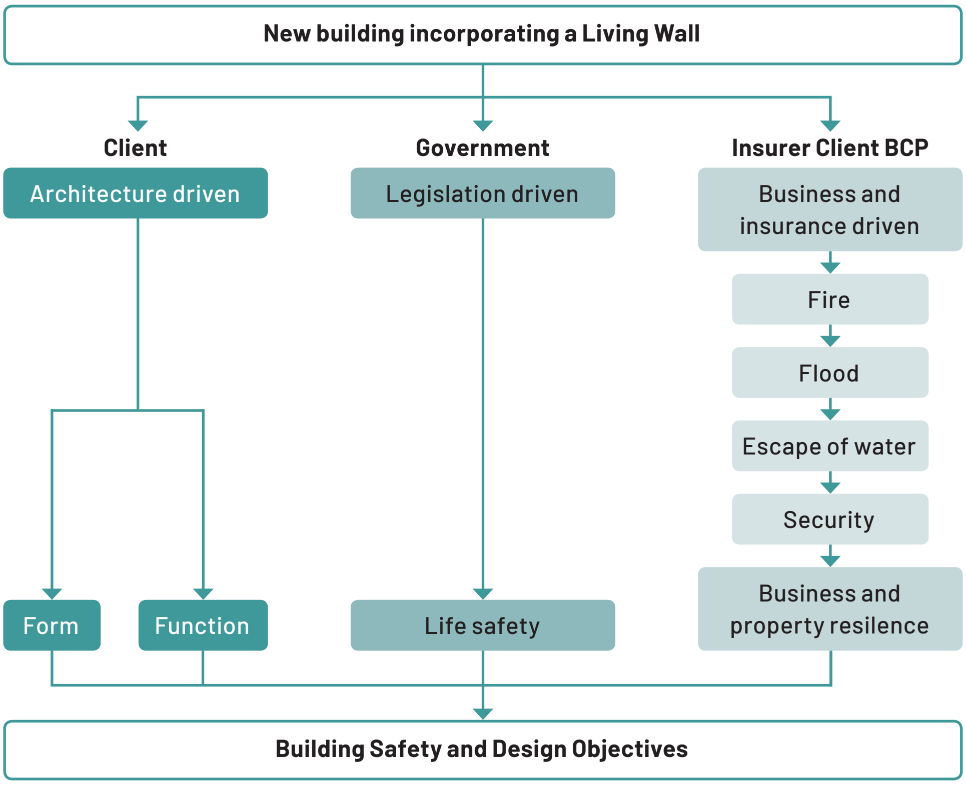
By way of example, the use of Living Walls is often accompanied by allied carbon reduction initiatives, such as the increased use of timber in buildings to replace concrete and steel (in the form of Cross-Laminated Timber (CLT), Light Timber Framing (LTF), Glulam, and Laminated Veneered Lumber (LVL)) and the inclusion of solar energy generation and electrical storage systems, to name but a few. Such measures will act to collectively alter the risk profile of the project

Just as Living Walls might require additional consideration by insurers, so too will the potential for fire spread in combustible structures, the fire safety of solar generation systems, the impairment to firefighting activities these systems may cause, and the challenges of high-current/low voltage DC energy storage systems. It is important to establish that, in combination with the use of Living Walls, these features do not act to amplify disproportionately the scale of risk.

The aforementioned insurance relevant features can be split into the following high-level categories:

- Occupancy
- Structure and Fabric
- Other Risk Factors
- Fire Mitigations
- Water Damage Mitigations

The relevance of each feature in establishing overall building insurability may be heavily influenced positively and negatively by other features included in the design. Insurers will have their own view of the importance of each feature and the trust they place in the correct function of all active, passive, and management controls when required. Each of the categories is described briefly in turn in Appendix B.



7 Core principles of risk control for Living Walls

In meetings held involving insurers, the Living Wall industry, and designers, the following set of principles has been developed for the mitigation of risk presented by Green and Living Walls.

Engagement, Testing, and Documentation	Principle 1	Engage with all stakeholders at the earliest opportunity and maintain dialogue for the entire lifecycle of the building.
	Principle 2	Fire testing must be appropriate to the end use situation and provide an opportunity to test the limit of tolerable irrigation downtime.
	Principle 3	A photographic record of all key fire prevention and performance design detailing shall be made during installation of the system and provided to the owner.
	Principle 4	The building's fire risk assessment shall be updated to include consideration of the Living Wall.
	Principle 5	The system shall be supplied with a handbook detailing system design, monitoring, inspection, maintenance, corrective actions, and training requirements, and include system end-of-life instruction.
	Principle 6	An emergency plan for residents and all other stakeholders shall be provided for at-risk or neglected Living Wall systems.
	Principle 7	The system must always be covered by a maintenance contract, ideally with the OEM or an OEM trained or approved service provider.
Materials	Principle 8	Use non-combustible system component materials wherever possible.
	Principle 9	Where combustible construction materials must be used, minimise their ability to participate in or spread fire.
	Principle 10	Plants and potting medium shall be selected to reduce the likelihood of ignition and reduce the rate and extent of fire spread.
Design	Principle 11	When used as part of a rainscreen-type cladding system, there shall be physical demarcation between the cladding system and Living Wall (fire separation).
	Principle 12	The design shall protect against the spread of fire through both ingress and egress at all penetrations.
	Principle 13	The use of Living Walls must not act to amplify the risks attributable to other building features, such as those presented by combustible cladding, combustible structural building components, façade lighting, and the use of photovoltaic panels.
	Principle 14	Living Walls shall be designed to reduce the likelihood of ignition and limit the rate and extent of vertical and horizontal fire spread over the planted media.
	Principle 15	The system shall be designed to facilitate simple effective repair.

Upkeep and Monitoring	Principle 16	Irrigating water systems shall be resilient in their ability to function, and their management and repair regime will be sufficiently robust to ensure reinstatement in a time period before the Living Wall deteriorates to an unsafe dry condition.
	Principle 17	All parameters that might contribute to raising the fire risk presented by the Living Wall must be constantly monitored.
	Principle 18	All parameters that might contribute to raising water damage potential presented by the Living Wall must be constantly monitored.
	Principle 19	Control construction and hot works risks.

These principles cover the challenges identified in Section 2 as follows:

Challenge	Relevant principles
Combustibility of the planted biomass and its dependency on irrigation and maintenance to keep ignition and fire spread potential to a minimum	1, 2, 4, 8, 9, 10, 13, 14, 16, 17, 19
The extensive use of plastics in some LW designs in the potting, irrigation, and drainage systems	1, 2, 4, 8, 9, 13
The potential complexity of creating a fire-safe design when incorporated into a rainscreen-type cladding system	1, 3, 4, 8, 9, 11, 13, 15
A lack of guidance on the management of penetrations (windows and vents) to prevent fire ingress or egress between the building's internal compartments, wall voids, and the Living Wall	1, 3, 4, 11, 12, 14
A lack of relevance of some certification tests to address the fire challenges	1, 2, 8, 9, 10, 11, 12, 14
The potential for the aforementioned factors to allow mass fire spread over the building, both via the planted surface, and within wall cavities behind the potting system	1, 4, 8, 9, 10, 11, 12, 14, 16, 19
An overall inadequacy in Building Regulations to address property protection	1, 3, 4, 5, 6, 8, 9, 12, 17
A need to additionally consider water and wind damage potential	1, 5, 6, 15, 16, 18

The detail behind each of these principles is discussed in the following section. While potential solutions might be suggested, this guidance should in no way restrict the façade engineer from meeting the principles by other methods. In all cases, the suitability of the approach in ameliorating the identified concerns should be confirmed with the AHJ and not conflict with any national legal requirements.

7.1 Principle 1 – Engage with all stakeholders at the earliest opportunity and maintain dialogue for the entire lifecycle of the building.

Explanation

In Section 6.1, the key stakeholders were identified and their sometimes-conflicting requirements for the building design were discussed. From an insurance perspective, it is important for all stakeholders to understand that the provision of insurance is not a right; against the backdrop of increasing use of more sustainable yet also more combustible construction materials in buildings, it is now necessary for designers (and the façade engineer) to 'court' insurance through meaningful design that incorporates risk control measures that can allow the insurer to assign an EML other than 100%. In respect of Living Walls, this guide seeks to give such guidance. However, as identified in Section 6.3, many other design features will also be taken into consideration which may act to enhance or erode the risk profile presented by the Living Wall component.

The necessary dialogue will need to continue through the life of the building from inception to construction, occupation, re-use, alteration, and disposal, where each phase can present specific challenges and involve different stakeholders.

Requirement

Every person and commercial entity has a role to play with regard to the successful use of Living Walls in our built environment.

Noting the key design stakeholders and the fact that the provision of construction or property insurance is a commercial decision, the ultimate responsibility rests with the client to ensure that appropriate risk mitigation is employed at all stages of the design, construction, and operation of the building.

Both client and insurers should be open to early engagement, ongoing review, and feedback.

Frequent dialogue will be central to assisting with both risk management and communication between parties, and will ensure that all parties have their expectations and needs aligned at any stage during the design, construction, and operation of the Living Wall system.

7.2 Principle 2 – Fire testing must be appropriate to the end use situation and provide an opportunity to test the limit of tolerable irrigation downtime

Explanation

It is recognised that for certain wall make-ups (e.g. rainscreen systems), the method of test by BS EN 13501-1 is not severe enough to replicate a challenge that might lead to involvement of the wall cavity and insulating materials contained therein. Adherence to Principle 11 should ensure the relevance of BS EN 13501-1 to confirming external fire spread performance over the plant matter (subject to realistic worst-case selection of humidity and plant/soil moisture content). Where Principle 11 is not followed, then large-scale testing of the entire wall/Living Wall make-up should be considered to the BS 8414 test methodology.

Testing may also be conducted to establish the 'un-irrigated' period from the normally irrigated condition, after which the Living Wall fails to meet the test requirement. This knowledge can be used to determine the tolerable downtime of the irrigation system (see Principle 16) to support maintenance and repair service level agreements (SLAs), holding of spares, and 'design for repair' (see Principle 15) requirements.

Requirement

The relevance of the BS EN 13501-1 test method to the specific Living Wall system under consideration should be carefully evaluated. Where there is confirmed demarcation of the Living Wall from the supporting structure in terms of fire involvement – either as outlined in Principle 11, or because the wall is of totally non-combustible form (i.e. brick, block, or concrete) – then the test as outlined in BS EN 13501-1 may be deemed appropriate, subject to the test conditions being similarly appropriate (see later). Where this demarcation cannot be assured, then full-scale testing of the type used for combustible cladding systems (BS 8414) should be considered.

For both test types: A credible worst-case condition shall be used for the plants and potting substrate in respect of their moisture content. The level set could be dependent upon the resilience of controls in place to assure correct and continuous function of the irrigation system, as outlined in Principle 16.

For BS EN 13501-1 tests: Where it has been established that a sufficiently robust fire barrier will be in place between the Living Wall and the supporting wall components[d], without forming an additional cavity, and the potting system is extensively non-combustible (Principle 8), then the BS EN 13501-1 test need not replicate the entire building wall make-up – it is a test of the Living Wall components only.

This test may be rerun to determine the limits of safety in respect of days left un-irrigated from a condition of normal operating water provision.

For BS 8414 testing: Where there is insufficient fire separation between the Living Wall and the supporting wall components which may be combustible, or the Living Wall system has significant quantities of combustible material in its make-up, the BS 8414 test

[d] This barrier could be the wall itself if solid and of concrete, brick, or block construction.

should be considered in a form that faithfully recreate the entire wall make-up and Living Wall geometry.

Note: It should not be taken for granted that the AHJ will recognise any test result without prior consultation of the issues they perceive to be most relevant.

7.3 Principle 3 – A photographic record of all key fire prevention and performance design detailing shall be made during installation of the system and provided to the owner.

Explanation

Regulation 38 of the Building Regulations requires that: 'The person carrying out the work shall give fire safety information to the responsible person not later than the date of completion of the work, or the date of occupation ... whichever is earlier'. This regulation aims to ensure that information critical to the fire safety of people in and around the building is communicated to the owner, occupier, and/or end user, so that the building can be operated and managed correctly. Against a backdrop of often poor installation quality of building systems, there is a need to not just 'assure' that things have been done properly, but to extend this to actually 'evidence' that the as-drawn design has been faithfully and accurately recreated in practice. This evidence might be vital to avoiding the need for destructive investigation or surveying if doubt on quality exists at any time in the building's life.

Requirement

To accurately document with photographic evidence:

- the construction detailing is as drawn
- the components used are as specified
- the measures taken to meet the principles outlined in this document have been effectively and accurately actioned, including but not limited to:
  - non-combustible component use
  - control of combustible material in voids
  - position of limited combustible component material and orientation
  - limiting ignition likelihood and fire spread
  - physical fire demarcation between wall construction and Living Wall
  - penetration design and protection
  - control of other hazards that might impact the Living Wall
  - water damage control measures.

7.4 Principle 4 – The building's fire risk assessment shall be updated to include consideration of the Living Wall.

Explanation

A fire risk assessment is required by the Fire Safety Order to assess fire safety risks relevant to both workplaces and buildings with two or more sets of domestic premises. The responsible person must take account of structure, **external walls**, and flat entrance doors in a fire risk assessment.

Requirement

The building owner must be made aware of the need for a new fire risk assessment to be made for the building once the Living Wall is fitted. To mitigate any unforeseen risks, a pre-emptive fire risk assessment could be made prior to installation of the Living Wall, and the output used to inform the design.

7.5 Principle 5 – The system shall be supplied with a handbook detailing system design, monitoring, inspection, maintenance, corrective actions, and training requirements, and include system end-of-life instruction.

Explanation

The most likely cause of issues will stem from neglect of the Living Wall and the systems designed to keep it healthy and safe. The Living Wall must be introduced into the normal building management upkeep regimes with identified ownership.

Requirement

All information necessary for the proper management of the system must be centralised and accessible so that future changes in the occupation and ownership of the building, trading status of suppliers, etc. may be managed without compromising the systems necessary to control risks within the Living Wall system.

7.6 Principle 6 – An emergency plan for residents and all other stakeholders shall be provided for at-risk or neglected Living Wall systems.

Explanation

The ramifications of a neglected system might be far reaching and may even have legal implications. A plan must be in place that considers:

- Should the building be occupied?
- Are other nearby buildings put at risk?
- Will the building be insured when in this condition?
- Will the building be legally in breach of legislation when in this condition?
- What is the management plan for this situation?

Requirement

In association with input from the fire risk assessment (Principle 4), an emergency plan shall be developed that describes the actions necessary were the Living Wall to enter into a state of reduced potential safety. The plan must describe measured thresholds that will initiate each response and the associated timescales.

7.7 Principle 7 – The system must always be covered by a maintenance contract, ideally with the OEM or an OEM trained or approved service provider.

Explanation

No one will be better at maintaining the system in a healthy and safe condition than the original provider, who will have a great interest in showcasing that Living Walls can provide their environmental and societal benefits without presenting a raised level of risk to property and people. If not the OEM, whoever is engaged to maintain the Living Wall must have the necessary horticultural competency as it is a specialised undertaking and will ideally be trained by the OEM on the specific system.

Requirement

The maintenance of the system must be part of a Quality Scheme that assures the scheduling and process of the maintenance activities, and the competencies of the people undertaking them.

7.8 Principle 8 – Use non-combustible system component materials wherever possible.

Explanation

The major components of a Living Wall system that may be combustible include:

- planting pots/felt substrates
- irrigation pipework
- water collection guttering
- ties, brackets, hose clamps, and waterproofing/breather membranes.

The threat from plastic components stems from:

- ease of ignition, high calorific value, and ability to sustain burning in all directions (including downwards by flaming, melting, burning, and dripping)
- the quantities present
- their contiguous (omnipresent) use on the building, meaning they will act as a single fuel source
- their vertical orientation, which will promote fire spread
- the combustible pot back which, when used as part of a rainscreen system, is an inappropriate surface for cavity barriers to close against (see Principle 9).

Requirement

In early conversations with the LW industry, it is clear that there is a good appreciation of the need to reduce the amount of combustible material in the system make-up wherever possible, and many stakeholders have already embarked on making this change. Where possible, it is advised that:

- planting modules should be constructed of metal, ceramic, or other non-combustible material
- all major[e] pipework should be of metal or encapsulated in fire-protected cavities (see Principle 9)
- all guttering should be of metal
- all significant membranes, felts, and other barrier layers used should be of A2 or better.

7.9 Principle 9 – Where combustible construction materials must be used, minimise their ability to participate in or spread fire.

Explanation

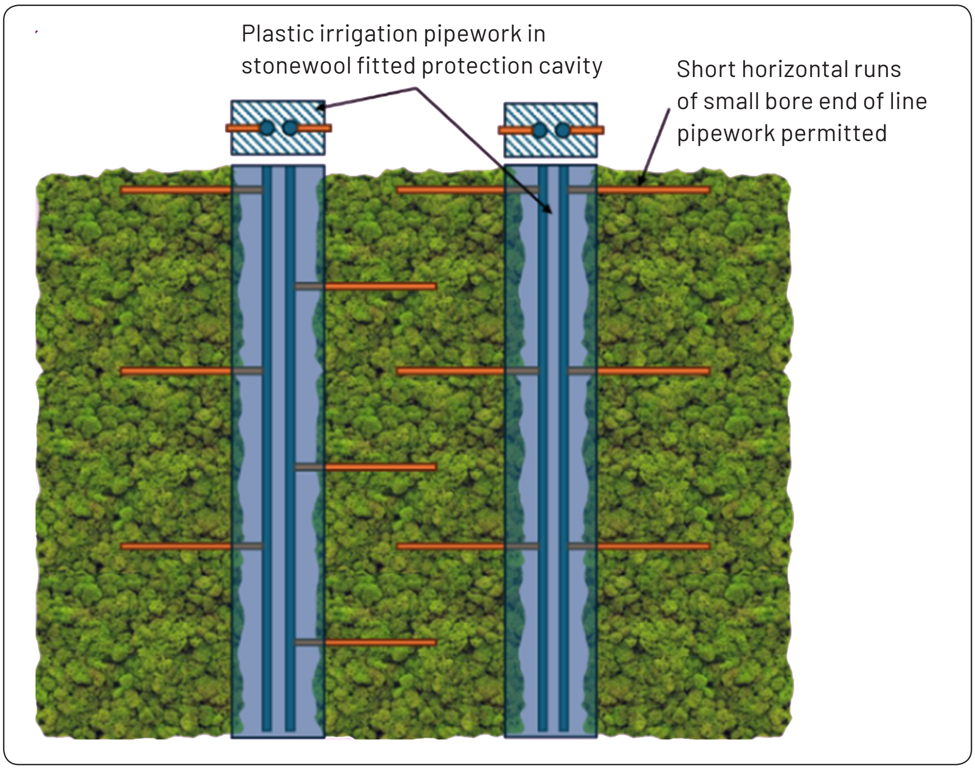
Having reduced the quantity of combustible material through Principle 8, the risk posed by the remaining essential plastic components can be reduced by:

- further reducing the quantity present
- restricting the length of continuous runs
- reducing vertical runs, curtailing the ability of the fire to spread over the material by orienting horizontally
- encapsulating in an inert filled fire resisting cavity
- encapsulating or sandwiching the combustible material between non-combustible components, restricting access for fire participation.

Requirement

Where possible, it is advised that the designer should:

- restrict the use of combustible materials in the vertical orientation
- only permit exposed plastic irrigation pipe if run horizontally
- only permit vertical runs of combustible material if run in protected shafts, filled with a non-combustible material such as stone-wool, and appropriately fire rated
- encapsulate remaining material between non-combustible material.



7.10 Principle 10 – Plants and potting medium shall be selected to reduce the likelihood of ignition and reduce the rate and extent of fire spread.

Explanation

Current guidance looks to increase the non-combustible content of the growing medium and prevent all medium from drying out. Plants having high calorific value (containing high levels of volatile oils or resins, and with woody stems) should be avoided in favour of plants with low calorific value and a lifecycle that avoids a living-but-dry cycle.

Requirement

Plant selection should follow the guidance issued in *External Cladding: Living Walls and Fire Safety Best Practice Guide December 2022*, and have their suitability proven by testing to established standards subject to the considerations of Principle 2.

7.11 Principle 11 – When used as part of a rainscreen-type cladding system, there shall be physical demarcation between the cladding system and Living Wall (fire separation).

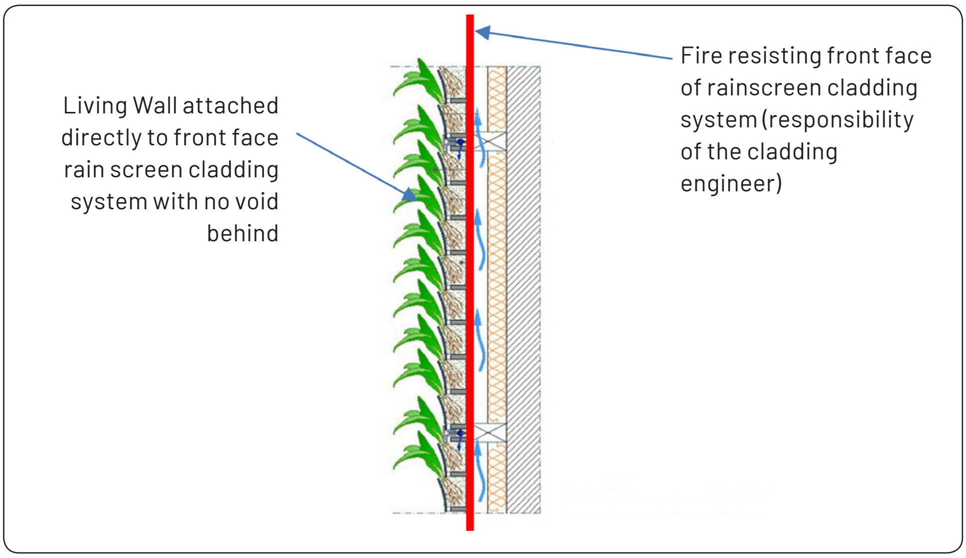
Explanation

Designs that use Living Walls as the front face component of a rainscreen-type cladding system (or any system that might include a cavity with combustible components) can present specific challenges. If the rear face of a plastic potting system is installed to form one side of the rainscreen void, with insulation on the other side, the combination can promote very rapid fire spread out of reach of all protection measures. Cavity barriers designed to close under the action of heat to prevent fire spread in voids should not close against a combustible surface that might spread fire faster than the device's closure speed, or a surface that is irregular or likely to flex. Façade engineering is a specific discipline and this principle, in association with the other measures (see Principle 8), seeks to ensure that the Living Wall can only present an external surface threat from fire and not threaten the internal wall make-up materials. Some existing cassette-type Living Wall systems, specifically designed to form the external cladding of a rainscreen system, address this issue directly.

Requirement

Option 1: Employ a rainscreen cassette-type Living Wall system specifically designed for use on rainscreen cladding, that meets all requirements for non-combustibility (aside from the plant material).

Option 2: Incorporate a significant fire resisting barrier as the rear face of the Living Wall system without forming a new void to restrict the likelihood of fire spread between the Living Wall and the cladding system.



7.12 Principle 12 – The design shall protect against the spread of fire through both ingress and egress at all penetrations.

Explanation

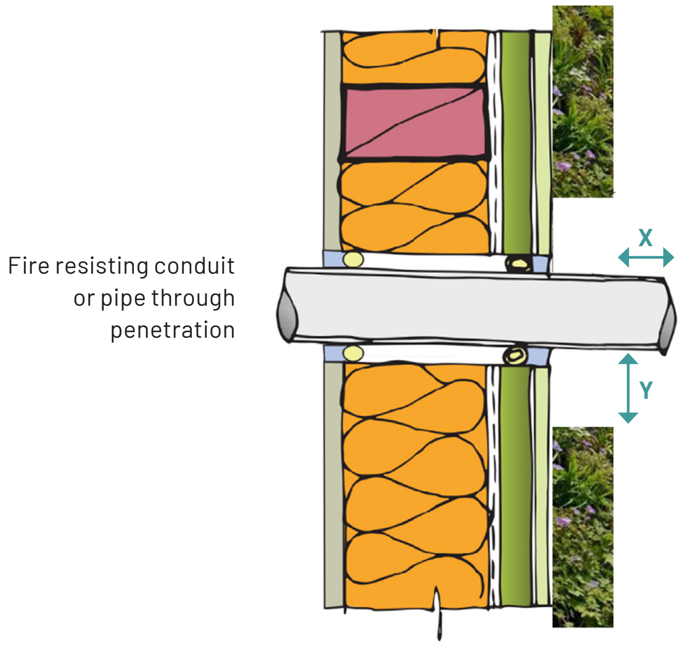
Penetration of the external envelope of the building is not subject to the same rigorous fire stopping requirements as those expected between fire compartments within a building. Fires may start within a room and expose the wall make-up and external surface features through egress of flame and hot gases via windows which may break, or be open, or through extract ducts, air bricks, and grills which have no requirement to be fire rated. Conversely, fire may break into rooms via these routes from an externally ignited Living Wall. This principle seeks to reduce the likelihood of fire spread through the use of Living Wall separation distances from openings, and enhanced fire stopping requirements using methods already adopted in other countries.

Requirement

Vents, ducts, and air bricks: The requirement demands that any fire starting within a room of the building whose external wall is 'greened' and contains an extract duct or similar penetration, cannot spread fire to the internal wall component or the green surface.

Methods for achieving this might include:

- use of a continuous fire resisting (and insulated) sleeve that extends from the internal surface to a point X cm[f] in front of the maximum anticipated growth face of the Living Wall
- clearance of the Living Wall to a tangential distance of Y m[g] around the perimeter of the duct
- prohibition of duct discharge to the rainscreen void (not permitted, but sometimes done).



Windows: The measures to protect against façade involvement from room fires, and vice versa, via window apertures are common to methods employed to the mitigation of external fire spread (see Principle 14).

[f] A distance of 20cm has been proposed in other guidance without evidence of suitability. The distance chosen should be agreed with the AHJ.

[g] Distance to be agreed with the AHJ.

7.13 Principle 13 – The use of Living Walls must not act to amplify the risks attributable to other building features, such as those presented by combustible cladding, combustible structural building components, façade lighting, and the use of photovoltaic panels.

Explanation

Insurers and other bodies will evaluate building risk as a whole, and the inclusion of a Living Wall into the design will need to be considered in association with many other features that might reduce or enhance the perceived risk. The guide cites 26 'insurability features' in Appendix B that contribute to making this assessment to assist the user to understand the insurer's viewpoint. It might be that the deployment of Living Walls is considered acceptable on some forms of construction but not on others, or there might be a preferred location for energy generation systems, etc.

Requirement

Just as this guide asks for assessment of how the Living Wall might threaten the safety of the building, an analysis must be made of all factors that might jeopardise the safety of the Living Wall, especially where the identified threat may overwhelm the protection measures put in place.

Factors for consideration might include, but not be limited to:

- penetration of the Living Wall by services and ducts that might include electrical installations, HVAC, and kitchen/bathroom extracts, stove flues, etc.
- embedment of photovoltaic cells
- embedment of façade, ground, or signage illuminating lighting
- combustible canopies
- combustible balconies
- human access and proximity for accidental fire raising (BBQ areas, arson etc.)
- openable windows / cigarette disposal.

Some risk might be specific to the venue and how it is occupied and used (external fire/firework risks).

7.14 Principle 14 – Living Walls shall be designed to reduce the likelihood of ignition and limit the rate and extent of vertical and horizontal fire spread over the planted media.

Explanation

In addition to measures to prevent fire ingress and egress into and from the building (Principle 12), attention shall be given to the proximity of the Living Wall to deliberate and accidental sources of ignition. Sections of Living Wall may be segregated to provide fire breaks that will limit the extent of spread vertically and horizontally from any section ignited.

A possible solution[h], proposed by the German Fire Brigade Association (GFBA) in their publication Fire Protection of Extensive Green Facades considers the following scenarios[i]. **Until more research is done to support exact parameters, these should be determined and agreed with the AHJ with advice from an appropriate expert ensuring that nothing conflicts with national Building Regulation fire safety (and other) requirements.**

a. Thermal radiation from and to a neighbouring property

The distance between buildings shall conform to the requirements of Approved Document B Section B4. Additional consideration may be given to emissive potential of the Living Wall in all possible states, and the potential for ember transport.

[h] Subject to agreement with the AHJ.

[i] Wording altered to account for translation clarity and local regulations.

[j] The GFBA guidance recommends a value of 3 m but the origin of this value is unknown. Distance to be agreed with the AHJ

b. Fire at the base of the building

Planting is only permitted from a height of at least X m[j] above the surface of the ground in order to protect the planting from flames from a burning rubbish bin, rubbish, or car.

Planting from the base could be possible if all sources of ignition are controlled by other means (motor vehicles cannot be parked directly at the building, EV charging points are not present, rubbish bins are fenced in and set up away from the façade, etc.).

c. Fire inside the building with flames spreading to the outside

To prevent the spread of fire, fire-free areas or fire breaks can be provided around openings in the façade. This prevents the flames from spreading out of the building or delays fire spread until the fire brigade can extinguish the fire. See the variants below.

Requirement

[K] It is important to check that none of the German recommendations conflict with UK Building Regulations and that any values adopted are agreed with the AHJ and have been proven through research.

[l] The GFBA guidance recommends a value of 1.0 m. Distance to be confirmed with the AHJ.

[m] The GFBA guidance recommends a value of 20 cm. Distance to be agreed with the AHJ.

[n] The GFBA guidance recommends a value of 1 mm. Thickness to be agreed with the AHJ.

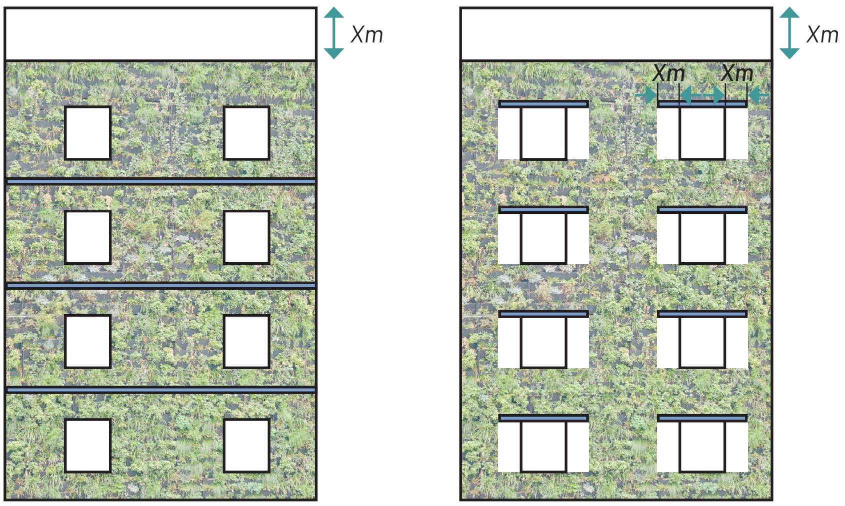
The requirements proposed by the German Fire Brigade Association in their publication Fire Protection of Extensive Green Facades are given as follows[k]:

Appropriate protective measures are required to prevent the flames from spreading vertically. Particular attention must be paid to protecting the wall/roof connection area, as this is always a dry and usually unprotected connection point. For this purpose, in each variant below, the planting must maintain a minimum distance of X m[l] from the wall/roof connection area.

A suitable protective measure against the vertical spread of fire might be horizontal fire breaks installed without openings in front of the façade. These must not be overgrown over the lifetime of the building (regular maintenance). If no lower dimensioning can be proven, the metal sheets should protrude by at least X cm[m]. A version of the fire break made of sheet steel (minimum thickness X mm[n]) seems suitable to prevent the direct flame impingement of plant material lying above the fire break, in order to effectively slow down the vertical spread of the fire until the fire brigade can extinguish the fire.

For Living Wall systems: continuous fire breaks are to be installed between the floors (see variant a in the figure below).

For Climbing Plant systems: the attachment of fire bars can be limited to the window lintels (see variant b in the figure below).



a) Fire bars between storeys

b) Fire bars on window lintels

[o] Fire bars is the German translation for fire breaks.

[p] The GFBA guidance recommends a value of 3 m. Distance to be agreed with the AHJ.

[q] The GFBA guidance recommends a value of 0.5 m. Distance to be agreed with the AHJ.

[r] The GFBA guidance recommends a value of 1.0 m. Distance to be agreed with the AHJ.

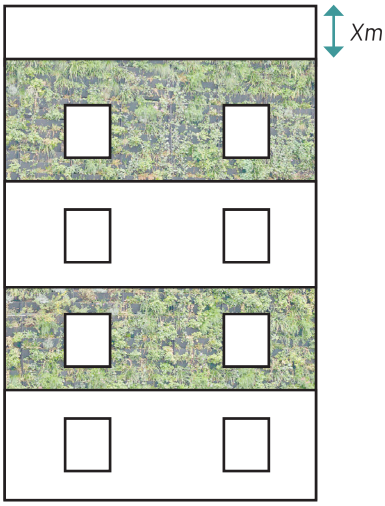
Alternatives to fire bars[o]: Different variants can be accepted:

- Fire breaks (unplanted façade sections) with a height of at least X m[p] or the height of a full storey (see variant c in the figure below).
- Fire breaks (unplanted areas) around openings in the façade of at least X m[q] on each side and X m[r] above the opening, with openings projecting storey by storey (see variant **d** in the figure below).

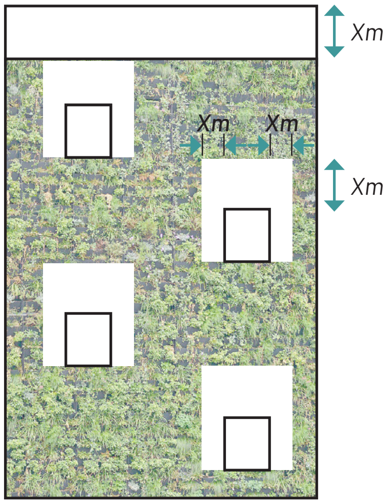
[s] The GFBA guidance recommends a value of 0.5 m. Distance to be agreed with the AHJ.

[t] The GFBA guidance recommends values of 3.0 m × 3.0 m. Size to be agreed with AHJ.

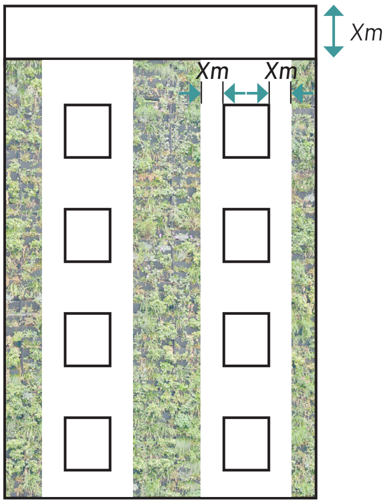
- Strip-like planting of the façade with a lateral distance of at least X m[s] to each opening in the façade (see variant e in the figure below).
- cassette-like design of the planting with a size of up to X m × X m[t] (see variant **f** in the figure below).



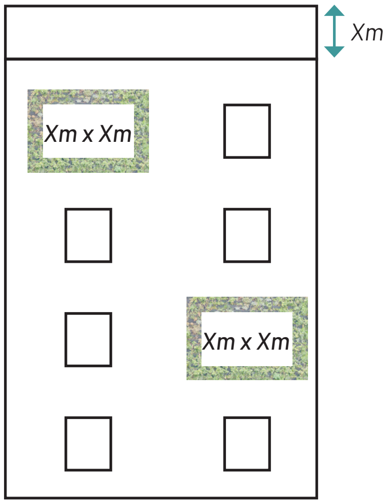
c) Unplanted storeys



d) Unplanted areas around openings



e) Strip planting



f) Cassette-like planting

7.15 Principle 15 – The system shall be designed to facilitate simple effective repair.

Explanation

Damage to all components of the Living Wall system resulting from material degradation, blockage, malfunction, freezing, impact, etc. shall be repairable without significant disturbance to unaffected areas. This will reduce both costs and the time period for which affected safety critical systems are impaired, which might have ramifications for the inhabitability of the building.

Requirement

Repairability is a fundamental system design consideration. Features typical of a repairable system include:

- modular design
- use of standardised parts
- ease of access by non-destructive means
- documentation and labelling

Aside from the system design, its location on a building in respect of access must also be considered.

7.16 Principle 16 – Irrigating water systems shall be resilient in their ability to function, and their management and repair regime will be sufficiently robust to ensure reinstatement in a time period before the Living Wall deteriorates to an unsafe dry condition.

Explanation

The health of the Living Wall exerts such a great impact on building fire safety that, in some cases, the means of irrigation, monitoring, and alerting must be considered the same as for any other life-safety system, such as fire sprinkler systems. This may require the inbuilding of redundancy which can take the form of duplicate pumps, alternative water sources, and filter monitoring; protection against factors that may impair function such as freezing and blockage from dirty water supplies; and the option for remote monitoring. Monitoring systems (see Principle 18) shall ideally be integrated with the Building Management System (BMS). Alternatively, if through testing, the time period is known for a water-starved system to become dry to the point of being 'unsafe', and robust management and repair procedures are in place to ensure this time is never exceeded, this may be used as an alternative approach.

Requirement

A hazard and operability study of the irrigation system should be undertaken in respect of:

- the equipment, system, and resource dependencies required for correct function
- determination of a suite of credible worst-case scenarios that might challenge the correct function of the Living Wall pertinent to:
  - weather regimes and extremes (dry, freezing, etc.)
  - water supply stability
  - maintenance provision
  - equipment function
  - etc.
- identification of the consequences of potential failure when considered against the credible worst-case scenarios
- resolution of all potential points of failure through (typically) duplication, anticipatory maintenance, etc.
- ability to respond to loss of water events on a timescale shorter than that which makes the system unsafe.

At all stages, study of past incidences and new experience should be used to inform and update the methods used to ensure the resilience of the irrigation system against failure.

7.17 Principle 17 – All parameters that might contribute to raising the fire risk presented by the Living Wall must be constantly monitored.

Explanation

Technical solutions are required for the monitoring of growth medium and plant health (moisture content) which is fundamental to the fire safety of the Living Wall system, along with assessment of plant growth, plant death, and the introduction of invasive species that might not meet the plant selection requirements. Developments in photographic autorecognition systems are likely to support this.

Requirement

The capability of the monitoring systems, level of automation, level of integration with Building Management Systems, and overall effectiveness at:

- ensuring the health of the system
- timely determination of imminent problems
- automatic rectification of problems
- ability to alarm and inform

should all be viewed as prime drivers for buyer selection of the Living Wall system. As previously discussed, the systems in place must robustly identify and control situations that impact the irrigation system (such as freezing pipes and loss of water supply), and measures designed to control fire (such as overgrowth and species invasion). Specific sensor suites might be required to inform of loss of water through blockage of filters or freezing.

7.18 Principle 18 – All parameters that might contribute to raising water damage potential presented by the Living Wall must be constantly monitored.

Explanation

Some building types are especially sensitive to water ingress and can result in high insurance losses from short- and long-term exposure which might manifest as stains and loss of surface finish, damage to contents and equipment, rot, and loss of structural capability. Living Walls present an additional water bearing system for consideration that might include tanks, irrigation pipes, and guttering, all of which have the potential to fail and leak water to where it is not intended. The inclusion of leak detection and monitoring systems to either identify abnormal water use or detect water in unexpected locations can ameliorate the potential for damage from water exposure.

Requirement

Measures to reduce the likelihood of escape of water (EoW) events from piped systems are described in *Insurer Requirements for Enhanced Escape of Water Protection and Safety in Building Plumbing and Water-Based Fire Suppression Systems – based on The Building Regulations 2010: Sanitation, hot water safety, water efficiency*, and should be implemented wherever possible.

The use of leak detection systems, in association with sensors pertinent to the Building Management System's control of water services (pressure and flow), can be used to inform of issues long before they manifest visibly within the building, or on the Living Wall.

7.19 Principle 19 – Control construction and hot works risks.

Explanation

Fire raising during construction from hot works and other building activities remains a prevalent cause of loss and was identified as the ignition source in one very high-profile loss in London involving a Living Wall. Periods of building construction, maintenance, and modification represent a time of significantly heightened risk. It is vital that risk assessments (Principle 4) and emergency plans (Principle 6) are reviewed and updated specific to the works being done to account for the presence of the workforce, smoking controls, temporary removal/deactivation of some protection systems, introduction of electrical and hot works equipment including welders, grinders, roofing torches etc.

Requirement

Hot work should not take place above or on the façade when combustible elements are exposed during construction. Once installed, precautions must still be taken to ensure sparks or other molten materials from hot works are not allowed to come into contact with the green wall.

8 Conclusion

The role of this document is to highlight the potential challenges from Living Walls to building safety and business interruption from an insurance perspective. The environmental and societal benefits of Living Walls are not disputed. While this document may suggest empirical ways of mitigating identified risks, it is not intended to be a design guide and it remains up to the façade engineer to address the principles in their own way. The principles form a sound basis for engaging with insurers and determining whether the measures taken to address them are meaningful to them or other AHJs. It should not be assumed that adherence to these principles is enough to court the insurance sought universally; each insurer and AHJ will have their own view on risk, risk appetite, and acceptability of the methods used to curtail risk.

Appendix A – The legal framework: Approved Document B, June 2022 Update and its relevance to Living Walls[u]

[u] Reference 'External Cladding: Living walls and fire safety – Best Practice Guide December 2022' produced by the Living Wall industry.

On 1 June 2022 the Government introduced a package of measures to further strengthen and clarify building regulations and fire safety guidance as part of wider reforms to building safety.

The update to Approved Document B sets clearer, stronger standards which in turn sets limits on the combustibility of materials used in the external walls of buildings. This June 2022 Update was the culmination to a series of events with regards to fire safety compliance requirements for external cladding:

December 2018 – in response to the Grenfell tragedy the Government introduced a ban on combustible materials in and on the external walls of residential buildings over 18 metres in height. As a result, materials that become part of an external wall or specified attachment of a Relevant Building must be of European Classification A2-s1, d0 or Class A1 (i.e. non-combustible). At that time a Relevant Building was simply defined as a residential building.

January 2020 – the Government issued a technical consultation paper reviewing the 2018 ban on the use of combustible materials in and on the external walls of buildings including attachments. Members of the Green Wall External Cladding Industry responded as part of this consultation.

June 2022 – the Government published their update on the building regulations and fire safety guidance in response to the 2020 technical consultation paper and as part of wider reforms to building safety.

The new statutory guidance determines the maximum protection in terms of a ban on non-combustibles which now applies to hotels, hostels and boarding houses in addition to blocks of flats, hospitals, care homes, student accommodation and dormitories in boarding schools.

The update also reduces the height of the requirement for non-combustibles as part of the external cladding from 18 metres to 11 metres for all building types that conform to building types classified as residential purpose groups.

The full set of requirements per building type is confirmed in the updated Table 10.1 of the Approved Document B: June 2022 update as follows:

Table 10.1 Reaction to fire performance of external surface of walls

Building type	Building height	Less than 1000mm from the relevant boundary	1000mm or more from the relevant boundary
'Relevant buildings' as defined in regulation 7(4) (see paragraph 10.14)		Class A2-s1, d0[1] or better	Class A2-s1, d0[1] or better
All 'residential' purpose groups (purpose groups 1 and 2)	More than 11m	Class A2-s1, d0[2] or better	Class A2-s1, d0[2] or better
	11m or less	Class B-s3, d2[2] or better	No provisions
Assembly and recreation	More than 18m	Class B-s3, d2[2] or better	From ground level to 18m: class C-s3, d2[3] or better From 18m in height and above: class B-s3, d2[2] or better
	18m or less	Class B-s3, d2[2] or better	Up to 10m above ground level: class C-s3, d2[3] or better Up to 10m above a roof or any part of the building to which the public have access: class C-s3, d2[3] or better[4] From 10m in height and above: no minimum performance
Any other building	More than 18m	Class B-s3, d2[2] or better	From ground level to 18m: class C-s3, d2[3] or better From 18m in height and above: class B-s3, d2[2] or better
	18m or less	Class B-s3, d2[2] or better	No provisions

NOTES:

In all cases all the following provisions apply.

- Regulation 7(1A) prohibits the use of relevant metal composite materials in the external walls of all buildings of any height (see paragraphs 10.11 and 10.12).
- The advice in paragraph 10.4 should always be followed.

In addition to the provisions within this table, buildings with a storey 18m or more above ground level should also meet the provisions of paragraph 10.6.

In addition to the provisions within this table, buildings with a storey 11m or more above ground level should also meet the provisions of paragraph 10.7.

1. The restrictions for these buildings apply to all the materials used in the external wall and specified attachments (see paragraphs 10.13 to 10.16 for further guidance).
2. Profiled or flat steel sheet at least 0.5mm thick with an organic coating of no more than 0.2mm thickness is also acceptable.
3. Timber cladding at least 9mm thick is also acceptable.
4. 10m is measured from the top surface of the roof.

Extract from The Building Regulations 2010, Amendments to the Approved Documents, June 2022

Building types (purpose groups) are defined as follows:

1. Residential – dwellings
2. Residential – institutional
3. Offices
4. Shops and commercial spaces
5. Assembly and Recreation
6. Industrial
7. Storage and other non-residential (including car parks)

Table 10.1 of Approved Document B confirms the requirements per building type with regards to the required reaction to fire performance of the surface of the external walls.

The requirements for Living Walls are therefore as follows:

Building Type 1 or 2 buildings over 11 metres in height:

Because of organic matter being a necessary part of the system, Living Walls cannot achieve class A2 or A1 and so Living Walls should not be included as part of external cladding of residential buildings in purpose groups 1 or 2 that are above 11 metres in height.

Building Type 1 or 2 buildings under 11 metres in height & other Purpose Group Buildings (i.e. non-residential) irrespective of height:

Living Walls should be permitted providing the Living Wall is in compliance with Class B-s3,d2 or better.

Note: there are also less stringent requirements for buildings where the external surface of the walls is 1000mm or more from the relevant boundary. In this case, as per Table 10.1, the requirements are clear and vary according to building Purpose Group and height.

Appendix B – Building insurability features: all building construction methods

B.1 Occupation

Residential and commercial buildings are subject to different regulatory requirements and shared usage can result in great complexity for risk profiling given the shared responsibilities and influences present.

- **Residential buildings:** There is great variability in scale in this occupancy category, ranging from single dwellings to large multi-storey apartment blocks. The distinguishing insurance considerations are the lack of regulation around risk control (in comparison to the commercial environment), sleeping risks, multi-storey buildings, use of modern construction methods, cladding, emerging hazards from lithium ion batteries, frequency of water damage events, type of residential tenure, and specific occupant challenges that might include hoarding and illegal manufacturing use. Costs associated with re-homing during repair can be considerable.
- **Commercial buildings:** There is great variability in scale in this occupancy category ranging from small offices to large multi-storey buildings and large production warehouses, with great diversity in hazards of the operations undertaken. Insurers may specialise in specific commercial areas. A distinguishing insurance consideration can be the high value of equipment, and the Business Interruption (BI) component following an insured loss.
- **Residential over commercial buildings (mixed-use residential):** This occupancy type – which includes multi-storey residential apartments over shops, offices, takeaways, cafés, bars, restaurants, and many other types of business – presents specific property and safety challenges related to differing regulatory requirements and the diversity of hazards. Fire services note that poor practices within commercial premises, including external waste storage, can impact the safety of residents and their ability to escape. It is also recognised that the risk-share is bi-directional and commercial activities can be impacted by fire and water escape events from the residential apartments above. Costs associated with re-homing of residents during repair can be considerable, and the commercial insurance considerations can include the high value of equipment, and the BI loss component following an insured loss.
- **Hotels and halls of residence (including build to rent):** This occupancy type presents specific property and safety challenges that can include risks associated with: sleeping occupants, unfamiliar occupants, commercial kitchens, bars and restaurants, underground and incorporated car parks, EV storage and charging, tall buildings, and heritage/building conversion. Having many bathrooms, escape of water challenges can be significant especially in the multi-storey situation. Fire and escape of water events can result in significant material damage and BI losses that include business reputational damage.
- **Storage warehousing (low, medium, and high hazard):** This occupancy type is characterised by warehouse construction methods (very large compartments) with the potential loss determined by the scale of the building, the hazard presented by the stored goods, the value of the stored goods, the sensitivity of the stored goods to fire, smoke, and water, and the BI potential associated with the loss. These environments are typically sparsely populated by people with hazards also stemming from site equipment, such as the use of fork-lift trucks.
- **Manufacturing warehousing (low, medium, and high hazard):** This occupancy type is characterised by great diversity of manufacturing component processes, some of which can be highly hazardous, using dangerous component chemicals, involving specialist, high-cost equipment, with great BI and plant and equipment loss potential following an insured event.

B.2 Structure and fabric

B.2.1 Building structure material

An understanding of the materials that form the structural load-bearing elements of the building is critical to the insurance assessment of the building. In fire law, materials are specified for life safety, and therefore their period of structural integrity need extend no longer than the time required to be assured that all occupants have vacated the building in the event of fire. Obviously, business owners and insurers would like the building to outlast the fire event and so there follows a preference for the structure to be made of non-combustible materials, which are also generally more resilient to water exposure. Some building methods use materials that introduce additional routes for fire spread in combustible voids, which can greatly increase the extent of damage and raise the EML assessment. Repairs to structural damage can be costly and the associated increased repair times can significantly impact BI and costs associated with providing alternative accommodation. An EML of 100% would be allocated to any building deemed vulnerable to collapse in the event of fire or water exposure.

B.2.2 Ground floor structure

The ground floor structure of a building may be different from that of the floors above and be selected as a means of mitigating risks during both construction and occupation. It is not uncommon for timber buildings to have the first floor built in concrete, which can benefit the overall building in terms of:

- reduced likelihood of fire loss during construction by incidental and deliberate fire raising
- increased resilience to flood, escape, and ingress of water damage during construction and through life.

B.2.3 Construction method

The construction method selected normally describes the materials that give the building its load-bearing capability. Damage to these elements can greatly increase the cost of insured loss as repair can be challenging requiring special techniques and equipment. Structural elements that are less sensitive to fire and water damage are more likely to require only cosmetic repair following exposure. For modern products, such as composite timber materials, there may also be a lack of engineering understanding of the consequence of exposure and how assessment of residual capability can be made.

B.2.4 Core structure

It is not uncommon for the core of a building to be constructed of materials that are different to the rest of the structure. The core may accommodate lift shafts, stairwells, and routes for services distribution. If constructed out of materials that can be assured of retaining their structural integrity during fire and water exposure events, this can greatly add to a building's overall resilience, and to the level of confidence and assistance that might be provided by the attending fire service.

B.2.5 Floor/ceiling structure

In EML determination, floor construction plays a major role as the key passive element that prevents vertical internal fire spread. Traditional materials like concrete are resilient to both fire and water. Some newer construction methods use timber floors, while others – such as modular construction – have no continuous floorplate. The floor panelling may be a structural element of the building (i.e. panelised systems), or may only need to support what is on it (as is the case for post and beam build systems). Materials are often used in composite forms to address strength, fire resilience, water resilience, and acoustic issues.

The building's floor composition can also impact structural stability during fire, which can influence fire service effectiveness. There are also implications for EoW, where long-term issues – such as rot and delamination – might contribute to loss of structural integrity, and short-term escapes might result in unacceptable staining and the loss of aesthetic finish which can exacerbate costs.

B.2.6 Cladding system

Knowledge of any building's cladding system is a key component of EML determination since external fire spread has the potential to involve the whole building in a short period of time. Cladding systems may be the same as the building's main construction components (i.e. brick, block, or timber), or may be a specifically applied building component that may be complex in form and involve many individual materials, some of which may be combustible. Cladding system selection can impact the vulnerability of the building to fire spread from fires starting both inside and outside the building, and can feature in considering the risk associated with the building's proximity to others nearby.

B.2.7 Interior surfaces

The fire properties of the interior surfaces of the building (walls and ceilings) can impact greatly the rate of fire development within a compartment, and the likelihood of spread to other areas. Combustible surfaces not only contribute to fire loading, but can also accelerate the rate of spread through re-radiation of heat to other surfaces. In building designs of combustible structure, the internal wall finishes are the principal form of structural protection and prevention of spread to wall voids and adjacent compartments. The ability of lining systems to protect timber structure may require specific testing in order to be fully certified. Plasterboard is only effective for a certain period of time: once the embodied water has been driven off, its insulating capabilities are critically reduced.

B.3 Other risk factors

B.3.1 Atria

An atrium is a large, open, skylighted covered space within a building that might traverse all floors from ground to the roof. Providing internal light, it often also serves as the location for lifts, stairways, and escalators. In terms of risk, it presents challenges pertinent to fire and smoke spread between floors and can pose a difficult scenario for methods of smoke venting, fire suppression, and detection in these 'compartments' with very high ceiling heights.

B.3.2 Internal car parks (including connecting basements)

Car parks within buildings present a range of insurance challenges including their high value, the high fuel loading associated with the cars themselves and the fuel they contain, and their close proximity to each other. Electric vehicles and electric vehicle charging stations can result in fires that are very persistent and difficult to extinguish. Factors that feature in determining the level of risk also include whether the car parks are below ground (unable to vent hot smoke and gas freely), and whether they are sprinkler protected.

B.3.3 Balconies and terraces

Balconies can allow human access to the exterior features and materials of the building, can be combustible in their own right, and as such can increase the overall risk profile of the building.

B.3.4 Swimming pools and spa baths

As major sources of water, failure of containment and poor maintenance of systems can result in significant escape of water loss.

B.3.5 Hazardous materials

Storage, use, or production of hazardous materials (flammable materials, gases, dusts, etc.) will have an obviously raised risk profile in terms of fire and explosion risks.

B.3.6 Green surfaces

Green surfaces can introduce significant quantities of combustible materials onto the external surfaces of the building in the form of plastic membranes, irrigation systems, plastic planting modules, and plant material. The fire risk may be influenced by weather changes such as drought, and maintenance standards. Failure of membranes may lead to water damage risk for some construction material types. Certification methods for the approval of these cladding systems are considered inappropriate.

Blue roofs seek to capture and hold up the dispersal of rainwater. As an additional wet system, they may raise challenges for water damage potential of some construction materials if they fail or are poorly maintained.

B.3.7 Green energy systems

Green energy systems, including solar panels, wind turbines, and their associated electrical storage and distribution systems, can present challenges when they fail. Fires can be persistent, high energy, and in remote locations, and can impair fire service response (the application of water to high energy systems that cannot be isolated presents risks to those fighting fires, and solar panels can shield water application to burning roofs).

B.4 Fire mitigations

B.4.1 Combustible void protection

The threat of internal fire spread posed by combustible voids can be protected against by lining with non-combustible board, provision of sprinklers, or filling with non-combustible fibre insulation (a requirement under US International Building Codes, but not currently in the UK).

B.4.2 Automatic suppression systems

Suppression systems can greatly increase the resilience of buildings to fire and prevent internal fire spread. Their provisioning is made against specific rulesets which can be problematic for some construction forms. Only property protection focused sprinkler installation rulesets are considered appropriate for the mass timber environment (such as BS EN 12845/LPC Rules for Automatic Sprinkler Installations). Domestic and residential-type sprinkler and watermist installations for occupant life-safety (i.e. BS 9251) are not appropriate. The water sensitivity of local materials must also be considered along with the potential for leakage.

B.4.3 Building separation

The proximity of the building to others is important in understanding all initiating risks, and the potential scale of loss.

B.4.4 Firefighter provisions

While firefighters are under no obligation to take risk in the preservation of property or business, inbuilt features that assure the structural integrity of the building – such as non-combustible material choices, good access (external and stairwells), and the provisioning of reliable resources (water supplies, dry and wet risers etc.) – can increase their effectiveness if the situation permits.

B.4.5 Stairwells

Improved access into and out of the building supports improved safety and fire service response.

B.5 Water damage mitigations

B.5.1 Designing for flood

In flood zones, the building should ideally be positioned above the highest predicted flood level (HPFL). Where this is not possible, the floors up to the HPFL can be built out of water-resistant materials, and all critical services and infrastructure will be located on upper floors. It is not uncommon for car parks to be located in the potential flood areas. Where no such measures are possible, property level protection systems (PLPS) and flood management schemes can be used to keep water out of the building. All measures to reduce the risks to people and property should act to reduce flood damage, speed up recovery, and facilitate reoccupation of flooded buildings. Temporary protection measures should also be considered during the construction phase.

B.5.2 Designing for escape of water – during both construction and operation

Escape of water (EoW) losses are particularly damaging in the multi-storey situation with potentially high associated individual incident costs. As immensely prevalent events, on aggregate they result in great financial loss. Building designs should consider the consequence of long-term and short-term EoW events on the building and design in fluid systems that fail-to-safe discharge, and room designs that can drain-to-safe place. Rapid means of system isolation and the use of water-stop type detection devices can also greatly reduce the loss. Where buildings might have a core built of water resisting materials, such as concrete, this can present a resilient location in which to position water bearing rooms (such as kitchens, toilets, and bathrooms). Maintenance of systems following good design is key to the prevention of EoW issues over the life of the building.

Materials management regarding exposure to water is also of key importance. Temporary protection, just-in-time delivery systems, and effective scheduling are all of key importance.

B.5.3 Designing to minimise impact of water ingress

Ingress of water through failed roofing and cladding systems is most destructive when it goes unnoticed. Systems deliberately designed to reveal issues are preferred., Where such systems are not possible, water detection devices – akin to those used for the detection of EoW events – can be deployed.

Fire Protection Association
London Road
Moreton in Marsh
Gloucestershire GL56 0RH
T: +44 (0)1608 812500
E: info@riscauthority.co.uk
W: www.thefpa.co.uk

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