Rethinking the Building Envelope

Incorporating Rigid Air Barriers as the Foundation of Modern Façade Design

JamesHardie™

Introduction

Good facade design plays a critical role in high-performing Australian buildings – from managing condensation and preventing water penetration, to resisting the spread of fire on the exterior of buildings. In today's market, a variety of cladding materials are available, including fibre cement, terracotta and zinc to name a few, giving architects and builders significant design flexibility. However, despite the range of solutions on the market, traditional facade design and installation methods have been falling short in some key areas.

According to a 2019 study by Deakin University in conjunction with Griffith University and other research partners, building defects relating to components of external wall systems, specifically the building fabric and exterior cladding, are common across the country.[1] The study analysed 2012 building defect reports across multiple states, finding that 33% of issues were related to water penetration and moisture caused by non-compliant or poorly-fitted cladding, or ineffective waterproofing.[2] According to recent industry reports, cladding defects related to fire performance are also rampant.[3]

In Australia, new buildings are emerging that push the limits of architectural complexity, heights and beauty. Presenting a unique design challenge due to more extreme weather conditions at greater heights, exteriors with more joints and junctions and elevated requirements for airtightness, efficiency and durability, these new structures have made compliance more difficult using traditional methods. New, holistic approaches to building facade design and construction are needed to meet strict demands for weather and airtightness, energy efficiency, resilience and fire protection.

Rigid air barriers have emerged as the foundational component for external wall systems of the future. A new approach to facade design in Australia, rigid air barrier panels are high-performance weather barriers that are specially designed to meet changing industry requirements and withstand Australia's unpredictable climate.

"For tall, complex structures, rigid air barriers can outperform many of the current solutions on the market when installed correctly as part of a full façade solution."

What is a functional facade?

Facades form the outermost layers of external wall systems, as distinct from the inner insulated wall and framing. A functional facade effectively manages the site conditions and forces that are applied to it to deliver performance that meets or exceeds regulatory requirements across a number of key categories. These key categories are:

- fire resistance;
- acoustic insulation;
- energy efficiency (airtightness); and
- weather protection (waterproofing and wind resistance).

These criteria reflect the overall trend of sustainable design in Australia and the importance of the building envelope to sustainability. In 2019, changes were made to strengthen the energy efficiency provisions in Section J of the *National Construction Code* (NCC), emphasising the importance of weather and airtightness. At the same time, fire protection continues to be a major regulatory focus in Australia.

However, as buildings increase in size and scale, it has become harder to control these factors through conventional facade design. High-rise apartment blocks and commercial buildings are subject to higher wind pressures and pose a greater fire safety risk. As the climate warms, the increased frequency and intensity of rain events[4] expedites moisture ingress in poorly-constructed buildings. Complex building exteriors are especially vulnerable as there are more openings and points for water ingress.

In the residential sector, homeowners are looking for effective ways to improve weather resistance and energy efficiency. This is partly due to the rise of government schemes, such as the Building Sustainability Index (BASIX) in New South Wales, regulating the sustainability and performance of new residential buildings. Homes built on the coast and in cyclonic regions must contend with harsh weather conditions and require external wall systems that are up to the task.

Buildings across all sectors generally are under increasing pressure to reduce operating costs and deliver long term durability. Specific institutions, such as healthcare and aged-care facilities, have elevated requirements for airtightness due to their operational needs and for the health and wellbeing of their users.

Delivering enhanced strength, durability and performance, rigid air barriers have emerged as an effective, all-weather solution to meet these challenges across a wide range of facade applications.

Rigid air barriers: battling against the elements

What are rigid air barriers?

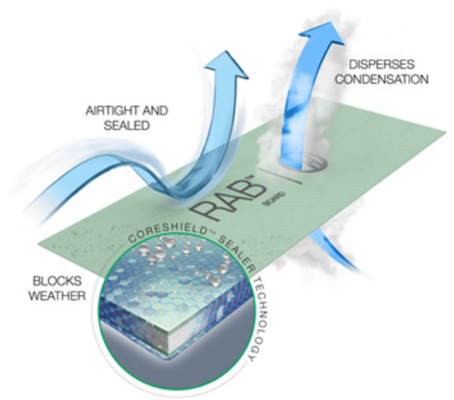
Rigid air barriers are incorporated within open facade and rainscreen systems (also known as "cavity" or "ventilated facade systems") behind the rain screen/cladding and ventilation cavity, as a protective skin over the internal lining and insulation. In particular, rigid air barriers are a proven alternative to flexible building membranes, with levels of performance suitable for mid to high-rise building structures that are subject to challenging site conditions.

There are three main ways that rigid air barriers are a superior weather barrier to alternatives on the market: improved condensation control is due to the breathability of the material; water penetration is minimised as the barrier is impermeable and taped at the joints; and the strong and rigid nature of the material helps defend facades against wind forces.

Rigid air barrier solutions protect the vulnerable wall framing and moisture-sensitive materials within the structure from water penetrating through the cladding. Cladding is the first line of defence against inclement weather, with the weather barrier (also referred to as "underlay") acting as back-up beneath the building cladding or rainscreen. Flexible underlays, such as building wraps, may be used, but cannot defend against water penetration, resist wind forces and manage condensation as effectively as a rigid air barrier. In higher wind pressure conditions, flexible underlays can deteriorate as a result of positive/negative pumping actions created by gusting winds within the cavity and on the building facade. Due to these pressures, a flexible underlay may not perform as desired in the long term.

The importance of moisture control

A key function of a weather barrier (such as a rigid air barrier or sarking) is effective management of water penetration and condensation that would otherwise prove costly to address during the building's lifecycle. Note that high-performance rigid air barrier solutions are vapour permeable to manage condensation from within the structure, but not all weather barriers within the rigid air barrier category offer this feature. The risks of poor moisture control are discussed as follows.



1: Structural integrity

The cumulative effects of excess moisture can affect the building envelope. Excess moisture in external wall systems can lead to failure around fastener points (nail popping and screw corrosion) and joint movement, potentially leading to further water ingress. In mid to high-rise steel and concrete buildings, poor moisture control can lead to building decay and rust, and deterioration of moisture-sensitive elements within the wall system,[5] all of which can compromise the strength and integrity of the structure.[6] In extreme cases, rust can cause serious structural damage and building failure.[7]

2: Energy efficiency

Poor moisture control is typically indicative of facades that do not deliver weather and airtightness, both of which are critical to the performance of building envelopes. Uncontrolled air leakage to the outside through the building envelope can reduce the efficiency of thermal insulation and heat resistance. This results in greater reliance on mechanical heating and cooling systems, and increased emissions and operational costs.

3: Health and wellbeing

Excess moisture within a structure can also cause a reduction in indoor air quality. Excess moisture can encourage bacteria, mould and fungi growth, which produces irritants and toxins that negatively impact human respiratory health.[8] Other risks to health effects associated with excess moisture include increased chemical emissions, internal conditions that attracts pests and, in some climates, an increased amount of dust mite allergens.[9]

4: Pressure equalisation

RAB™ Board provides a sealed rigid backing fixed to the buildings structure that helps in equalising the pressure within the cavity to that on the exterior of facade. This pressure equalisation stops any moisture being sucked behind the façade through its joints or any penetrations etc. This improves the weathertightness of the facade as compared to facades that have been fixed in conjunction with a flexible sarking which leaks air all the time and thus allows the moisture to be sucked in.

Incorporating rigid air barriers in modern façade design

The challenges of modern façade design

Finding a balance between water and condensation management, air-tightness and non-combustibility can be challenging, especially for buildings that must contend with Australia's more frequent extreme weather events. There is no single product solution, rather the facade and external wall system as a whole, how it is installed and the way each component performs together will determine the building's overall performance. In other words, the facade is more than the sum of its parts – it is a *system*.

When designing a facade system, current practice involves combining different solutions to varying levels of performance. Many lightweight external wall systems are constructed without a cavity behind the exterior cladding. Over time the cladding is subject to wear, resulting in leaks and water infiltrating the wall system. As the cladding is directly in contact with the wall frame, the drying potential of the wall is reduced leading to condensation within the wall and insulation. Building wraps installed behind the cladding have been historically relied on to address this problem but there are other effective design solutions now available.[10]

Open facade and rainscreen systems with ventilated cavities are growing in use due to their improved waterproofing and moisture control capabilities. In such systems, the cladding is separated from the wall system by a ventilated cavity, providing drainage and airflow to ventilate water, isolating cladding from framing movement, and blocking direct sunlight from the wall.

The cavity acts as the first layer of weather protection, preventing water from infiltrating the building structure. A weather barrier is incorporated behind the cavity as further protection against water ingress. As open facades and rainscreen systems are designed to allow water to enter the cavity, the weather barrier is subject to the forces of rain and wind and must perform accordingly. The weather barrier must also be capable of allowing vapour to escape the main wall assembly into the ventilation channel where it evaporates into the environment.

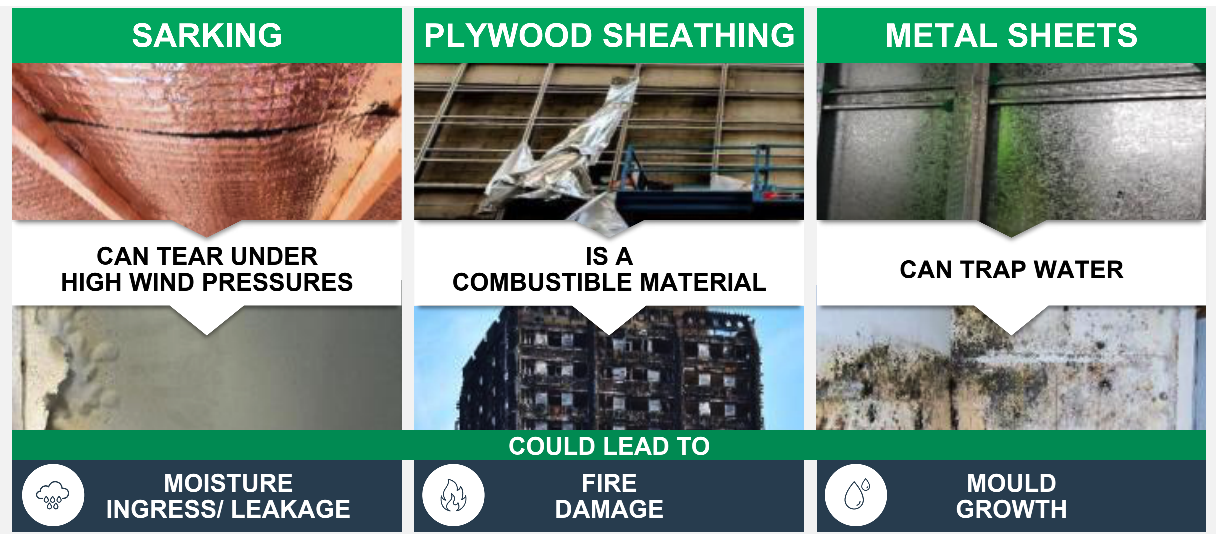
Pressure-equalised rainscreens offer even greater waterproofing capabilities. These systems are characterised by open joints and a compartmentalised cavity, relying on equal air pressure between the cavity and exterior of the rainscreen to prevent water from being driven or sucked through the joints.[11] Due to this pressure equalisation, the weather barrier must be able to withstand high wind loads.

Weather barriers: existing products

Builders are employing a variety of solutions to protect the wall framing and insulation from water ingress and condensation. However, existing sheathing, sarkings and wrap products can struggle to deliver weather and airtightness *and* vapour permeability while also meeting the NCC performance requirements for non-combustibility – three essential requirements of a functional facade.

For example, plywood sheathing is popular in residential applications for its stability, ease-of-use and resilience

ONE OF THE KEY DEFENCES OF THESE ELEMENTS IS THE BUILDING ENVELOPE.
HERE IS HOW BUILDERS ARE ATTEMPTING TO MEET THE CHALLENGES OF BUILDING COMPLIANCE



DIY Solutions with harmful consequences

against water damage but would be deemed combustible and a fire safety risk under the NCC. Metal wall panels are fire resistant and act as a rainscreen but are prone to condensation behind the panel increasing the risk of rust and mould growth.

Sarkings and other aluminium foil-type wraps are non-combustible and airtight, but also vapour-tight, meaning they are prone to issues with condensation. Any attempt to puncture holes in these types of products to allow the wall system to dry can compromise weather and airtightness.

Open facade and rainscreen systems with open joints or requiring pressure equalisation need to have a robust air barrier, which a traditional sarking cannot easily provide. Due to its inherent flexibility, sarkings and other flexible underlays lack tensile strength and are prone to flapping in the frame. Under high wind pressures, sarkings can tear, making them vulnerable to moisture ingress and leakage. Furthermore, buildings that require airtight envelopes (such as hospitals) can have issues using sarkings due to multiple penetrations and overlaps.

Rigid air barriers: a design solution as required by the NCC

For tall and complex structures, rigid air barriers outperform many of the current solutions on the market when installed correctly as part of a full facade solution. Suitability will depend on a variety of factors, but rigid air barriers offer several clear advantages when considered in the context of current Australian regulatory requirements and industry standards. Under Volume 1 of the NCC 2019, the relevant performance requirements are found in the below provisions:

- Weatherproofing: Section F;
- Energy Efficiency: Section J;
- Condensation Management: Part F6 (see also Part 3.8.7 in Volume 2 of the NCC); and
- Fire Safety: Section C.

Below we consider the attributes of rigid air barriers that contribute to code-compliant and functional facades.

Weather and airtightness

Under Performance Requirement JP(1)(e) of the NCC, buildings must meet an airtightness requirement for energy efficiency. Compliance with JP(1)(e) involves verifying whether a building envelope is sealed at an air permeability rate in accordance with Verification Method JV4. The testing regime for air permeability is set out in *AS/NZS ISO 9972:2015 Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method*.

As the NCC trends towards requiring more envelope airtightness testing, it is advantageous to identify solutions that exceed current minimum requirements. Building wraps, which are cut, lapped and sometimes taped on-site, will deliver varying levels of effectiveness depending on quality of craftsmanship. By comparison, rigid air barrier solutions provide a reliable fully-continuous, gapless seal across the façade.

Performance Requirement FP1.4 of the NCC further provides that all external walls must be weatherproof. Rigid air barrier solutions are comprised of an air barrier seal that prevents water driving into the building via joints and junctions, and a water barrier that prevents moisture being absorbed through the sheet itself.

Condensation management

In Volume 1 and 2 of the NCC respectively, Parts F6.2 and 3.8.7.2 make vapour permeability a requirement for any wall wrap with water barrier properties that is installed onto an external wall frame in Climate Zones 6, 7 and 8. The definition of "vapour permeable" is found in *AS/NZ 4200.1:2017 Pliable building membranes and underlays, Part 1: Materials*.

Leading rigid air barrier solutions feature an advanced breathable design that enables water vapour to escape, allowing the wall system to dry without compromising on weather and airtightness. Note that other solutions within the rigid air barrier category, such as metal back pans, do not offer this specific benefit – this should be considered during the specification process.

CASE STUDY

Project: 18 at Chatswood

Architect: Mayoh Architects

Builder: Novati Constructions

Location: Chatswood, NSW

Product: RAB™ Board and ExoTec™ Vero™

"The combination of ExoTec Vero and RAB Board is a great system that is Building Code Australia (BCA) compliant for non-combustible façade elements and provides excellent weather resistance," says Anthony Melia, Project Manager of Novati Constructions. This resistance to harsh weather was reflected with the lack of water leaks during Sydney's major storm period in February 2020.

"RAB Board is lightweight and easy for sub-contractors to work with. The time savings for the RAB Board are not found at the beginning of the job but prior to installing the ExoTec Vero as there is no going back to patch torn sarking. Once the ExoTec board has been installed its job is finished." Continues Melia.

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Wind resistance

Unlike traditional flexible underlays, rigid air barrier underlays offer sufficient rigidity and strength to withstand extremely high wind pressures and equalise pressure inside the wall cavity. In this respect, rigid air barrier underlays are a barrier upgrade from the AS/NZS 4200.1-compliant sarking type materials.

AS/NZ 4200.1:2017 is the relevant Australian Standard for building wraps. Under this Standard, the allowable use of pliable building membranes is determined by its "duty classification", which is based on tensile strength, edge tear resistance and burst strength. The common industry practice for "light" duty membranes is the ability to withstand building wind pressures of up to 2kPa or incorporated with a rigid sheathing for higher wind pressures. Rigid air barriers provide a solid, continuous seal that can withstand up to 7kPa of wind pressure, whilst simultaneously performing the weather barrier function.

Non-combustible

Under the NCC, external walls of buildings of Type A and Type B construction must be constructed wholly of materials that are not deemed combustible either by testing in accordance with *AS 1530.1:1994 Methods for fire tests on building materials, components and structures - Combustibility test for materials* or by a defined Deemed-to-Satisfy solution.[12] C1.9(a)(i) of the NCC requires that all components of an external wall system be non-combustible, including the façade covering.

Leading rigid air barrier are made from fibre cement, which is deemed non-combustible under C1.9 of the NCC. Fibre cement offers other benefits including resistance to rot, decay, cracking and swelling, which contributes to increased longevity and durability in tough weather conditions.

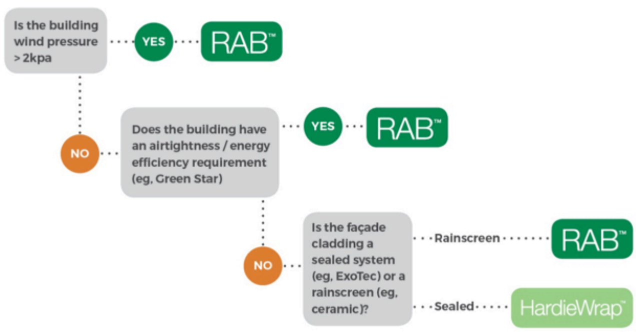
Choosing a weather barrier

Vapour-permeable building wraps vs. rigid air barriers

Specifying external wall systems for code-compliance is a multilayered process that involves determining suitability of a given solution based on project requirements, building type and installation context. Vapour-permeable building wraps and rigid air barriers should be considered as viable options in addition to the range of existing solutions on the market.

When determining whether a rigid air barrier solution is sufficient for your project, three questions should be asked:

- Will the building be subject to wind pressures exceeding 2kPa?
- Does the building have an airtightness/energy efficiency requirement (e.g. NCC, GreenStar or other sustainability scheme)?
- Is the façade cladding a sealed system or an open/ rainscreen system?



If the building features an open facade or rainscreen system, and is subject to wind pressures exceeding 2kPa and elevated energy efficiency requirements, then a rigid air barrier solution will be ideal as the foundation of a code-compliant external wall solution. In sealed facade systems, vapour-permeable building wraps will provide a high-performing alternative to traditional building products.

Rigid air barrier can be installed under a wide range of cladding types providing architects, designers and builders ample design flexibility. However, careful consideration has to be made as to whether the entire wall system as a whole will deliver code-compliant performance.

Performance testing and compliance

The performance of the entire external wall system should be considered. A single component could adversely impact performance in relation to any of the above requirements. Leading manufacturers offer fully-compliant wall systems that have been designed and tested to meet all the performance requirements stipulated by Australian building standards and regulations.

When designing and specifying external wall systems, a critical step is requesting documentation that each component individually and as a system has been tested and proven to perform to the extent claimed by the manufacturer. For guidance, the Australian Building Codes Board provides an Evidence of Suitability framework with a hierarchy of the different forms of evidence arranged with stronger forms of evidence listed first.[13]

The highest form of evidence is a CodeMark Certificate of Conformity. CodeMark is a voluntary third-party building product certification scheme that authorises the use of new products in specified circumstances in order to facilitate compliance with the NCC.[14] Other forms of evidence include a Certificate of Accreditation, a certificate by a certification body, a Report by an Accredited Testing Lab and an Engineer's Report.

Determining the appropriate forms of evidence for an external wall system is dependent on the follow considerations:[15]

- The form of evidence used to demonstrate compliance must be appropriate to the use of the component to which it relates.
- A risk assessment as outlined in the Evidence of Suitability framework[16] – if the likelihood of component failure and the subsequent consequences are assessed to be "high" risk, more rigorous forms of evidence are needed.

Each aspect of an external wall system's performance should be assessed according to the performance categories discussed earlier as well other applicable standards. For rigid air barriers made from fibre cement, a relevant question is whether the product conforms to the standards for fibre cement sheets (i.e. *AS/NZS 2908.2:2000 Cellulose-cement products Flat sheet and ISO 8336:1993 Fibre-cement flat sheets*).

Weatherproof testing requirements are described in further detail in FV1.1 and V2.2.1 of the NCC. This involves a series of tests including water penetration, water management and wetwall tests. Practitioners should note that the cladding is generally not the reason for a failing grade as weatherproof testing mostly focuses on joints, interfaces and penetration details.

"High performing rigid air barriers feature an advanced breathable design that enables water vapour to escape, allowing the wall system to stay dry without compromising on weather and airtightness."

James Hardie

James Hardie is a global leader in the production of interior and exterior building products, generating more than $2.5 billion in net sales and employing people across operations in North America, Australia, New Zealand, the Philippines, and Europe. The company's goal is to remain at the forefront of the building products industry in every market in which they operate.

James Hardie is a global leader in fibre cement building products specialising in their manufacturing and technological development since pioneering the technology in the 1980s. James Hardie® systems are high quality, dependable and designed to meet the needs of design and construction professionals, homeowners, developers and builders alike. The company serves their customers through industry-leading innovation, an empowering company culture, and the scale of their global operations.

RAB™ Board by James Hardie

RAB™ Board is a high-performance rigid weather barrier comprised of fibre-cement sheathing, which can be installed behind external cladding or rainscreens to improve the durability, performance and comfort of the building.

Finding the balance between water and condensation management, strength and non-combustibility, RAB™ Board works by equalising the air pressure within the external wall cavity, providing superior weather resistance while meeting the fire performance requirements under the NCC. RAB™ Board can also contribute to building airtightness when installed as part of an airtight assembly (Contact an Air Tightness Testing & Measurement Association ATTMA member for further guidance). These qualities set RAB™ Board apart from traditional flexible wall underlay, which can struggle to perform in challenging weather conditions.

RAB™ Board not only provides a rigid air barrier, but due to its proprietary CoreShield™ sealer technology, it provides an all-in-one rigid, water-resistant and vapour-permeable membrane, meaning there is no need for additional sarking or treatment.

James Hardie offers an efficient path to compliance with their deemed-to-satisfy wall solutions. All components are deemed non-combustible or exempt in accordance with C1.9 of the NCC. With RAB™ Board alongside Villaboard™ lining, ExoTec™ Top Hat Fixing System and ExoTec™ Façade Panel, James Hardies offers a complete façade solution that has been extensively tested at James Hardie's state-of-the-art R&D facility and other accredited laboratories.

RAB™ Board is quick and easy to install. RAB™ Board is lightweight, easy to cut with a 'score and snap' knife, and screw or nail to the frame, while the joints are simply taped. Leave RAB™ Board exposed for up to 180 days before installing the cladding.

For more information **RABboard.com.au**

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All information provided correct as of May 2020

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