Building with Plasterboard
## 2.1 Material Properties

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## 2.3 Building Requirements and Solutions

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Knauf has manufacturing facilities in Australia and around the world and offers a wide range of solutions for lightweight construction. These include metal framing, insulation, plasterboard linings, adhesive, jointing compounds, fire sealant and cornice.

Knauf wall and ceiling linings are available with a wide range of properties for different applications from substituting the look and feel of masonry to aesthetic ceiling linings that absorb sound.

Along with providing these solutions, Knauf offers a suite of Knowhow services to help bring your project to life from instant online calculators and system selectors to personal technical advice and all backed by a 10 year Knauf warranty.
Benefits of Lightweight Construction

Lightweight construction is the efficient use of component materials, to provide an effective composite performance; the result is a vast range of combinations so that the desired performance can be tailor made.

Lightweight construction is so called because it can achieve heavy weight performance while decreasing the weight and cost of the entire building.

A typical lightweight wall construction consists of metal framing, insulation and plasterboard and or other lining board.

Knauf steel studs are an efficient, non-combustible way of providing framing for plasterboard and other lining materials.

Knauf Earthwool acoustic and thermal insulation enhances the performance of walls and ceilings.

Plasterboard is made from a core of a naturally occurring mineral called gypsum, also known as calcium sulphate dihydrate or CaSO₄·2H₂O. The core is sandwiched between two layers of heavy duty recycled paper. The face paper is suitable for painting or wallpaper. Plasterboard has square profile cut ends and long recessed edges to enable easy jointing.

Knauf manufactures plasterboard to strict internal standards which meet or exceed the requirements of AS/NZS 2588:1998, Gypsum Plasterboard.

The Australian Standard for plasterboard installation is AS/NZS 2589:2017, Gypsum linings – Application and finishing.

Where extreme water resistance is required, Knauf Permarock is a solid, engineered wall and ceiling lining made from inorganic aggregated cement with glass fibre mesh embedded in both the face and back. Available for both indoor and outdoor application, it is the ideal tile substrate and provides a solid and dry foundation for external rendered and painted facades.

Environmental Benefits

Plasterboard is an ideal product for sustainable construction. As a lightweight building material, plasterboard reduces transport costs and emissions as well as the total weight of buildings. Plasterboard is 100% recyclable, with low embodied energy, and made largely from a naturally occurring mineral – gypsum. The liner paper used to make plasterboard is biodegradable and made from recycled paper such as waste newspaper and cardboard.

The plasterboard manufacturing process operates under strict environmental guidelines:

- Efficient use of energy and water including heat recovery and storm water collection
- Effective collection and monitoring of dust.
- Ongoing waste and raw material usage reduction.
- Minimisation of plant impact on surroundings.

Since 2009 Knauf Australia has introduced a number of initiatives to reduce carbon emissions which has also resulted in the first certified carbon neutral opt in program for plasterboard.

Combining plasterboard with lightweight framing such as timber or steel provides a vast array of system performances, which can be efficiently gauged to the precise needs of any project. Lightweight steel framing is both strong and durable, and like plasterboard has the potential to be fully recycled at end of life.

For more information refer to: knaufplasterboard.com.au/sustainability

Dimensional Stability

Plasterboard is dimensionally stable when compared to other building materials. Two measures of dimensional stability are listed below:

- Thermal coefficient of linear expansion \((\alpha) = 16.7 \times 10^{-6}^\circ\text{C}^{-1}\), measured unrestrained over the temperature range of \(3\degree\text{C} – 32\degree\text{C}\)

- Hygrometric coefficient of expansion = \(6.5 \times 10^{-6}^\%\text{RH}\), measured unrestrained over the Relative Humidity (RH) range of 10% – 90%.
Fire Resistance

All plasterboard is naturally fire resistant and is classified as non-combustible according to the National Construction Code (NCC) Volume One, Section C1.12. The core slows down the spread of fire by releasing chemically bound water when heated. This is a similar process to evaporation and aids cooling. Steel is non-combustible and like plasterboard may be used in Type A construction according to the NCC.

FIRE HAZARD PROPERTIES

The NCC regulates the fire hazard properties of coverings and lining materials in buildings according to NCC Volume One, Specification C1.10. Floor linings and coverings must have a high enough critical radiant flux to comply with NCC Volume One, Specification C1.10, while wall and ceiling linings must have a low enough group number. The group number indicates how quickly wall and ceiling linings spread fire, with Group 1 products ranked the slowest and Group 4 the fastest.

The following products are classified as:

<table>
<thead>
<tr>
<th>Group 1</th>
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<tbody>
<tr>
<td>MastaShield</td>
<td>SpanShield</td>
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<tr>
<td>WaterShield</td>
<td>SoundShield</td>
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<tr>
<td>FireShield</td>
<td>OPAL</td>
</tr>
<tr>
<td>TruRock</td>
<td>CurveShield</td>
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<tr>
<td>PermaRock</td>
<td>GIB X-Block</td>
</tr>
<tr>
<td>SpanGrid Ceiling Panel - Paper Faced</td>
<td></td>
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<tr>
<td>Designpanel</td>
<td>Stratopanel</td>
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<td>SpanGrid Protech Ceiling Panel</td>
<td></td>
</tr>
<tr>
<td>SpanGrid Cleancare Ceiling Panel</td>
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</table>

All Knauf products shown in the tables have an Average Specific Extinction Area of <250 m²/kg as required by Specification C1.10a, Clause 3(c) of the NCC.

Thermal Properties

THERMAL 'R' VALUE

The R-Value of plasterboard is a measure of its thermal insulation ability. Higher numbers indicate a better insulator. The values for plasterboard are:

- 10mm plasterboard = 0.059 m².K/W
- 13mm plasterboard = 0.076 m².K/W
- 16mm plasterboard = 0.094 m².K/W

Steel conducts heat very well so a thermal break is needed when steel studs are used to construct external walls. Refer to the NCC for more details.

SPECIFIC HEAT CAPACITY

Specific heat capacity is the amount of heat energy required to raise the temperature of 1 kg of material by 1°C.

Plasterboard is 1090 J/kg/K.

Steel is 490 J/kg/K.

Safety

Steel and plasterboard are not classified as hazardous according to the criteria of Safe Work Australia. They are non-toxic and non-flammable.
### Care and Use

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Storage, Delivery and Handling

Wall and ceiling linings must be kept dry and should be stacked clear of the floor using supports not more than 600mm apart as shown in Figure 1. If outdoor storage is unavoidable, linings and accessories should be fully protected from the weather. Plasterboard that has been exposed to direct sunlight, or has been fixed and left standing unpainted for long periods, may become discoloured. If this happens, it must be sealed with a solvent borne stain sealer undercoat as recommended by the paint manufacturer.

Plasterboard finishing compound must not be left unpainted as it becomes susceptible to moisture absorption and can develop shrinkage defects or become powdery and flake off if painting is attempted.

Reduce the possibility of damage to plasterboard, arrange delivery to site immediately before installation. During delivery, care should be taken not to damage recessed edges.

Exposure to excessive humidity during storage can result in plasterboard becoming damp and soft, and may appear defective. In this case allow the plasterboard to dry out and handle with care during installation.

To help protect plasterboard from absorbing humidity:

- Avoid open sources of water such as wet floors
- Wrap the plasterboard with plastic overnight when storing outside
- Provide ventilation
- Install soon after delivery
- Install during dry weather for best results.

Store Knauf steel products where they are not in constant contact with water or in wet environments for extended periods. Avoid exposure to airborne contaminants such as sea spray.

FIGURE 1 Correct pallet storage
Condensation and Ventilation

Plasterboard must not be installed until the building is weatherproof, particularly in coastal areas subject to sea spray. Complete all exterior doors, walls, windows and the roof before installing plasterboard. Prevent rain from entering buildings, avoid water on floors or other sources of open water and allow wet concrete or masonry to dry. These precautions will reduce excessive humidity that may be absorbed by timber or unpainted plasterboard and minimise defects caused by timber shrinkage or moist plasterboard.

Condensation of water onto either the face or back of the plasterboard must be avoided. Insufficient protection from condensation can result in joint distortion, plasterboard sagging, mould growth and fastener popping.

Many inter-related factors must be taken into account to control condensation. Good practice is to make use of wall and ceiling insulation, vapour barriers, and especially ventilation. Ventilation must be considered for the spaces in walls, under floors and in particular under roofs.

To minimise the effects of condensation:

- Use WaterShield or TruRock to increase protection against moisture.
- Use moisture barriers, sarking, and insulation. However, it is important that the right type is selected for the construction type and that it is installed correctly. [Refer to the manufacturer’s specifications]
- Use foil backed insulation under metal roofs which are susceptible to forming condensation.
- Install eave vents, gable vents and roof ventilators in the roof cavity. [Refer to Figure 2]
- Remove humidity from bathrooms via an exhaust fan to the outside.
- Use a quality paint system to provide protection against paint peeling and condensation soaking into plasterboard and compounds.
- Ensure the building design controls condensation on the steel components so they are not constantly wet.

In hot and humid climates where the building is air-conditioned below the dew point of the outside air, the wall and ceiling framing members and internal linings should be fully protected by moisture barriers to separate them from the humid external air. The moisture barriers should be thermally insulated to maintain them at a temperature above the dew point.
2.2 CARE AND USE
Plasterboard

External Ceilings

External ceilings include alfresco areas, carports, balconies and breezeways with plasterboard installed horizontally or sloping away from the main dwelling.

External ceilings are subjected to harsher conditions than internal ceilings, and therefore they need additional protection from the weather. This extra protection is designed to control the major causes of external ceiling faults which are:

- Condensation on the plasterboard
- Condensation on framing or roof lining and dripping down onto the plasterboard
- Water penetrating the paint system
- Distortion of joints
- Plasterboard sagging
- Mould growth
- Fastener popping.

MINIMUM CONDITIONS TO USE PLASTERBOARD IN EXTERNAL CEILINGS

- The plasterboard substrate must be designed for the appropriate loading conditions including wind loading.
- The cavity above the plasterboard ceiling must have cross ventilation. [Refer to Condensation and Ventilation]
- Condensation on the back and front of the plasterboard lining must be controlled. Use condensation prevention measures such as, adequate roof cavity ventilation and thermal insulation. In particular, foil-backed insulation must be used under a metal roof.
- The plasterboard and compounds must not be subjected to any direct water, long periods of high humidity, sea spray or damp conditions.
- The plasterboard and compounds must be installed after the roof covering has been completely installed and sealed.
- Minimum 100mm clearance from external ceiling lining to lower edge of verandah beam or masonry lintel, otherwise provide protection against wind blown rain.

INSTALLATION REQUIREMENTS FOR EXTERNAL CEILINGS

- Use either 10mm SpanShield, 13mm MastaShield, 10mm OPAL, 13mm SoundShield, 13mm or 16mm FireShield or TruRock.
- Ceiling framing at maximum 450mm framing centres.
- Provide additional framing around the perimeter by inserting trimmers between ceiling frames or installing steel angle, or installing additional ceiling battens.
- Fix the ceiling sheets using the ‘Screw Only Method’. Nails are not permitted in this application. [Refer to Section 3.4.1 for ceiling installation] Additional screws may be required for high wind areas.
- Fix the perimeter of the plasterboard sheets using screws at 300mm maximum spacing.
- Install control joints in at 6m maximum intervals.
- Back-block all plasterboard joints. [Refer to Section 4.2]
- Plaster set joints using two coats of MastaBase or MastaLongset and any Knauf finish coat.
- Roll or brush on a high quality sealer undercoat designed for exterior use.
- Use a premium exterior paint system that includes a mould inhibitor.

Please note that plasterboard must not be installed in eaves or as exterior cladding.
Exposure to High Humidity

Ceilings in rooms such as indoor swimming pools and communal showers are subject to long periods of high relative humidity (above 90%). The use of plasterboard on these ceilings is not guaranteed by Knauf. PermaRock Cement Board Indoor is recommended for these areas.

WaterShield or TruRock completely covered with a waterproof membrane complying with AS/NZS 4858:2004 may be used for walls in rooms subject to long periods of high relative humidity. Vertical junctions and wall to floor junctions must also be waterproof. [Refer to Section 3.1.4 for installation of wet areas]

For rooms with intermittent periods of high relative humidity such as bathrooms, WaterShield or TruRock may be used. In these rooms a source of ventilation is required to enable removal of excess moisture, such as an open window or exhaust fan.

Exposure to Excessive Heat

Plasterboard is an ideal building material for normal ambient temperatures. It is not suitable for long periods at elevated temperatures such as installed near fireplace flues or chimneys. FireShield is no exception. It is designed to slow down a fire, not to resist constant elevated temperatures.

The effect of high temperatures on plasterboard is to chemically dehydrate the core. This process generally begins at around 80°C but can occur at lower temperatures under certain conditions.

AS/NZS 2589:2017, Gypsum linings – Application and finishing, states that plasterboard must not be exposed to temperatures above 52°C for prolonged periods.

Heat generating appliances have installation instructions for the correct distances between plasterboard linings and heat sources. The National Construction Code (NCC) also has requirements for installation of heating appliances.

GLASS OR STAINLESS STEEL SPLASHBACK

AS 5601.1-2013 Gas Installations allows plasterboard to be used behind splashbacks near domestic gas burners as follows:

- Behind ceramic tiles any plasterboard may be used if the ceramic tiles are minimum 5mm thick
- If clearance to glass or stainless steel splashback is 200mm* or more then any plasterboard may be used
- If clearance to glass splashback is less than 200mm* then 10mm plasterboard may be used if the glass is marked as 'toughened safety glass'
- Clearance to stainless steel splashback is less than 200mm* then 6mm fibre cement over 10mm plasterboard may be used if the steel is at least 0.4mm thick.

*Clearance is measured from the edge of the nearest burner to the splashback.
Building Requirements and Solutions

Wall and ceiling systems are typically composed of framing, linings and jointing compounds, along with other specified materials such as adhesives, sealants, fixings and insulation.

While individual products alone do not meet the National Construction Code (NCC) performance requirements, using them correctly in the complete assembled system will.

Always check that the building solution you have selected complies with the requirements of the National Construction Code (NCC).
Using Products in Systems to Meet Building Requirements

Knauf offers wall and ceilings systems for a large variety of building requirements.

- Fire protection
- Sound insulation
- Sound absorption
- Thermal insulation
- Wet areas
- Impact resistance
- X-ray shielding
- Aesthetics

System performance relies not only on selecting the correct nominated material components such as plasterboard, compounds, studs and insulation, but also on following the correct installation details such as stud spacing and fixing centres. Even small details like sealing gaps can have a large effect on system performance.

Variations in construction or materials may reduce a system’s fire and sound insulation rating, structural capacity or other aspects of performance. Where performance is compromised it can result in non-compliance. Non-compliance is costly to rectify and if not done the ultimate cost can be human life.

Both systems in Figure 3 use exactly the same products but have a significant difference in sound insulation performance. The system on the left has Rw of 37, while the system to the right has an Rw of 47. There is a large difference in the performance between these two wall systems as a result of the type of construction.

STEEL COMPONENTS

Systems in this manual were designed using steel components manufactured by Knauf in Australia using:

1. Grade 300 MPa steel with corrosion protection of Zincalume ‘next generation’ AM150. Zincalume AM150 is a corrosion protection coating of Aluminium, Magnesium and Zinc alloy which coats the steel 150 g/m² in total for both sides.

2. Grade 270 MPa (G2) steel with corrosion protection of Galvanized Z275. Galvanized Z275 is a corrosion protection coating of Zinc over the steel at 275 g/m² in total for both sides.

In Volume Two of the NCC, Section 3.4.2.2, corrosion resistant steels including AM150 and Z275 protected steels are allowed within the building envelope (behind cladding) provided it is more than 300m from breaking surf.


![Figure 3](image-url) Sound insulation performance comparison
2.3 BUILDING REQUIREMENTS AND SOLUTIONS
Using products in systems to meet building requirements

TIMBER COMPONENTS
Unless otherwise stated, timber components used in the systems in this manual were designed using grade MGP10 timber.

Timber is a natural product and its dimensions vary with changes in surrounding moisture. Timber should be allowed to reach equilibrium with its surroundings before lining it with plasterboard. The equilibrium moisture content of timber is usually 10 - 14%.

This manual does not cover timber framed systems for low rise buildings - please refer online for timber framed systems.

INSULATION
Minimum densities for insulation nominated in Knauf systems are listed in the following table.

<table>
<thead>
<tr>
<th>Insulation Description</th>
<th>Minimum Density (kg/m³)</th>
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<tbody>
<tr>
<td>25mm EarthWool</td>
<td>24</td>
</tr>
<tr>
<td>50mm EarthWool</td>
<td>11</td>
</tr>
<tr>
<td>75mm EarthWool</td>
<td>11</td>
</tr>
<tr>
<td>110mm EarthWool</td>
<td>11</td>
</tr>
<tr>
<td>50mm Glasswool Semi-Rigid</td>
<td>32</td>
</tr>
<tr>
<td>30mm Polyester</td>
<td>14</td>
</tr>
<tr>
<td>50mm Polyester</td>
<td>7</td>
</tr>
<tr>
<td>60mm Polyester</td>
<td>7</td>
</tr>
<tr>
<td>75mm Polyester</td>
<td>8</td>
</tr>
<tr>
<td>100mm Polyester</td>
<td>10</td>
</tr>
</tbody>
</table>

Insulations with a nominated R-Value have no restrictions on density or thickness.

FIBRE CEMENT
Systems in this manual that include fibre cement were tested and evaluated using James Hardie fibre cement products.

FASTENERS
Green timber and certain treated timbers such as Copper Chromium Arsenate (CCA) treated timbers are corrosive to steel components, especially in combination with moisture.

Select appropriate fasteners for the conditions by consulting the manufacturer.

Seek corrosion advice prior to using stainless steel fasteners for fixing into galvanised or Zincalume protected steel.

<table>
<thead>
<tr>
<th>Minimum Fastener Corrosion Resistance Class</th>
<th>Atmosphere of Intended Use</th>
<th>Examples</th>
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<tbody>
<tr>
<td>1</td>
<td>General use in internal applications</td>
<td>Offices</td>
</tr>
<tr>
<td>2</td>
<td>General use in other than external applications but where significant levels of condensation occur</td>
<td>Warehouses or sport halls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outdoor areas &gt;50km from the coast*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When covered with coating system</td>
</tr>
<tr>
<td>3</td>
<td>External use in mild, moderate industrial or marine environments</td>
<td>Dairies or food processing plants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coastal areas with low salinity</td>
</tr>
<tr>
<td>4</td>
<td>External use in severe marine environment</td>
<td>Indoor swimming pools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outdoor areas &lt;50m from bay shorelines or 400m to 1000m from surf*</td>
</tr>
<tr>
<td>5</td>
<td>Beachfront</td>
<td>Outdoor areas &lt;400m from surf</td>
</tr>
</tbody>
</table>

* Distances are approximate. Refer to AS4312 for more detail.

Note: This table is a general guide to minimum requirements only. Obtain specific advice if in doubt.
Structural Frame Design for Lightweight Systems

LOAD DETERMINATION

To design the frame for a wall or ceiling system, first the loads acting on the system must be determined. The Australian and New Zealand 1170 series of standards must be referenced to define the loads that a structure is subjected to.

- AS/NZS 1170.0 Structural Design Actions – General Principles
- AS/NZS 1170.1 Structural Design Actions – Permanent, imposed and other actions
- AS/NZS 1170.2 Structural Design Actions – Wind actions
- AS/NZS 1170.3 Structural Design Actions – Snow and ice actions
- AS 1170.4 Structural Design Actions – Earthquake actions in Australia

An abridged version of the wind actions standard, specific to wind loads for certain Australian low-rise residential dwellings may also be used, and it is called AS 4055 Wind loads for housing.

There is also a joint Australian and New Zealand standard specific to suspended ceilings, AS/NZS 2785 Suspended ceilings – design and installation, which does cover additional loads and load cases.

COMMON LOADS ON WALL AND CEILING SYSTEMS

The most common loads which may act on a wall or ceiling system include:

1. Dead loads (G): Weight of the wall or ceiling itself.
2. Live loads (Q): Shelf loads, Hand-rail loads, Impact loads, and any other variable loads.
3. Wind loads (W): External wind loads, and internal wind loads.
4. Services loads (U): A nominal service load specific to ceiling systems.
5. Earthquake loads (E): Forces acting on wall and ceiling systems due to an earthquake event.

Other load types do exist for particular situations, and the AS/NZS 1170 series should be referred to.

WIND PRESSURES

External and internal wind pressures for a building or dwelling on a specific site are determined using the relevant standards, either AS/NZS 1170.2 for larger buildings or AS 4055 for low-rise residential dwellings. Reference to these standards should be made as both contain limitations to the type and size of structures covered.

The calculation of wind pressures using the method prescribed in AS/NZS 1170.2 when used for a specific project is summarised below. As this is a guide only, it is recommended to refer to the appropriate standard or seek professional engineering advice when determining wind pressures for a specific building/dwelling.

To determine the wind pressures for a particular structure, the following items need to be determined:

1. Building Importance Level from the National Construction Code (NCC), Volume One, Section B1.2. This section of the NCC sets out the appropriate annual probability of exceedance limits for wind, snow and earthquake loads for the relevant importance level of the building. The building importance levels range from 1 (least important) to 4 (most important).

2. Determine the site wind speed,

\[ V_{sit,\beta} = V_R \cdot M_d \cdot M_{z,cat} \cdot M_b \cdot M_t \]

where:

- \( V_{sit,\beta} \) is the site wind speed (metres per second) based upon the 8 cardinal directions.
- \( V_R \) is the regional gust wind speed (metres per second) based upon the wind region [Refer to Figure 4. Australian Wind Regions] and the annual probability of exceedance.
- \( M_d \) is the wind directional multipliers for the 8 cardinal directions. For simplicity the wind direction multiplier is usually taken is 1.
- \( M_{z,cat} \) is the terrain/height multiplier, and is a function of the Terrain Category surrounding the location, and the height of the building or particular building element above the ground. The terrain/height multiplier ranges from 0.75 to 1.32.
2.3 BUILDING REQUIREMENTS AND SOLUTIONS
Structural Frame Design for Lightweight Systems

3. Determine the specific design pressure for the location of a building element.

\[ p = (0.5 \rho_{\text{air}}) \left( V_{\text{des,θ}} \right)^2 C_{\text{fig}} C_{\text{dyn}} \]

where:

- \( p \) is the wind pressure, in pascals (Pa). As this is usually a large number it is simplified to kilo-pascals (kPa).
- \( \rho_{\text{air}} \) is the density of air, taken as 1.2 kg/m³
- \( V_{\text{des,θ}} \) is the maximum value of \( V_{\text{sit,β}} \) in the range of \( ± 45° \) from the building's 4 orthogonal directions.
- \( C_{\text{fig}} \) is an aerodynamic shape factor for the building element in question. \( C_{\text{fig}} \) can be relevant for external (\( C_{\text{fig,e}} \)), internal (\( C_{\text{fig,i}} \)), and a combination of external and internal wind pressures (\( C_{\text{fig,net}} \)). For a detailed explanation of the aerodynamic shape factor, see the relevant wind sections below.
- \( C_{\text{dyn}} \) is a dynamic response factor and is related to the effects of fluctuating forces and resonant response of wind-sensitive buildings. It analyses the along wind and cross wind response of a building during wind events. Generally taken as 1, but it may go higher than 1. Specialist wind engineering expertise may be required for certain buildings.

\[ M_s \] is the shielding multiplier, and is usually taken as 1.

\[ M_t \] is the topography multiplier, and should be checked as it also depends on the terrain surrounding the location. The topography multiplier is usually taken as 1 but it may also go higher than 1.

**FIGURE 4** Australian wind regions

This wind region map is a simplified representation and is to be used as a guide only. AS/NZS 1170.2 must be referred to for an accurate site determination.
EXTERNAL WIND PRESSURES FOR ENCLOSED RECTANGULAR BUILDINGS

External wind pressures apply to cladding elements and structural elements directly supporting cladding like top hat framing. For a specific building element the external aerodynamic shape factor can be calculated by:

\[ C_{\text{fig,e}} = C_{p,e} K_a K_L K_p \]

where:

- \( C_{\text{fig,e}} \) is the aerodynamic shape factor for external wind pressures.
- \( C_{p,e} \) is the external pressure coefficients for the outer surface of a building. There are different external pressure coefficients for windward walls, leeward walls, side walls and roofs.
- \( K_a \) is an area reduction factor based upon the tributary area (m²) that a building element structurally supports. Generally taken as 1 for light-weight systems as the tributary area is rather small compared to larger structural members supporting the main structure.
- \( K_L \) is a local pressure factor for wind pressures applied to cladding and members that support the cladding including all relevant fasteners. This factor is dependent on the geometric properties of the building including height (h), breadth (b) and depth (d) and (a) minimum of 0.2b, 0.2d or h. [Refer to Figure 5. Typical wind zones on a building], where depending on the location of the building the local pressure factor may be in the range of 1 up to 3.

INTERNAL WIND PRESSURES FOR ENCLOSED RECTANGULAR BUILDINGS

Internal wind pressures apply to internal wall and ceiling systems, and they are a function of the external wind pressures (site wind speed) and the size of any potential openings in the external surfaces. Potential openings include doors, windows and vents, which may be left open or may fail during a wind high event.
In regions C and D [Refer to Figure 4. Australian Wind Regions] the internal wind pressure must also contend with the potential effects of airborne debris during high wind events. An assessment should be made for each case; therefore professional advice will be required.

For a specific building element inside a building, the internal aerodynamic shape factor can be calculated by:

\[ C_{\text{fig,i}} = C_{p,i} \]

where:

- \( C_{\text{fig,i}} \) is the aerodynamic shape factor for internal wind pressures.
- \( C_{p,i} \) is the internal pressure coefficient for the spaces inside a building. When there are no potential openings in any external surface greater than 0.5% of the total surface area, then the internal pressure coefficients are generally taken as \(-0.3\) (suction) when the external walls are equally permeable around a building, or \(-0.2\) (suction) when a building is effectively sealed having non-openable windows.

For cases where the potential openings in any external surface can be greater than 0.5%, then the internal wind pressures gradually increase right up to the external pressures if the opening is large enough. Advice should be sought from Knauf or a professional engineer should this case occur for your project.

Implementing a sufficient building management plan for high wind events when a building is operational, is a possible way to reduce the potential size of external openings, and thus keeping the internal wind pressures to more economical levels.

For some applications it is also common in the drywall industry to use nominal internal wind pressures of \( W_{\text{ult}} = 0.375 \) kPa, and \( W_{\text{ser}} = 0.25 \) kPa with either a maximum deflection of height/240 for flexible linings (i.e.: plasterboard) or height/360 for brittle linings (i.e.: fibre cement, masonry) for walls, and span/200 for suspended ceilings or span/360 for horizontal stud or top hat ceilings. If a project determines that this design criteria is acceptable, then the nominated wall height and ceiling span tables may be used to select the appropriate frame.

It must be noted though, these nominal pressures should not be confused with NCC Volume One, Specification C1.8 which is a robustness criteria for lightweight fire rated walls, such as fire rated plasterboard walls, and should not be confused with site specific internal wind pressures.
FIGURE 6  Typical internal wind pressure coefficients for internal wall frame design

When there are no potential openings in any external surface greater than 0.5% of the total surface area

Section view

For more information, refer to Clause 5.3.4 Internal Walls and Ceilings from AS/NZS 1170.2 Wind Actions

Technical Advice 1300 724 505 knaufplasterboard.com.au
2.3 BUILDING REQUIREMENTS AND SOLUTIONS
Structural Frame Design for Lightweight Systems

2.3.1 Internal Wind Pressure Coefficients

Case 1: Internal Ceiling $C_{p,i} = -0.3$ (suction)
1. Building with all external walls equally permeable
2. Internal ceiling
3. Effectively sealed ceiling with an impermeable roof.

Case 2: Internal Ceiling $C_{p,i} = -0.2$ (suction)
1. Effective sealed building with non-opening windows
2. Internal ceiling
3. Effectively sealed ceiling with an impermeable roof.

Case 3: Internal Ceiling $C_{p,i} = -0.3$ (suction) and $C_{p,i} = 0.2$ (uplift)
1. Building with all external walls permeable and impermeable
2. Internal ceiling
3. Effectively sealed ceiling with an impermeable roof.

For more information, refer to Clause 5.3.4 Internal Walls and Ceilings from AS/NZS 1170.2 Wind Actions.

Internal wind pressure coefficients may go above what is shown in these cases. It occurs when openings in any external surface is greater than 0.5% of the total surface area.

FIGURE 7 Typical internal wind pressure coefficients for internal ceiling frame design
When there are no potential openings in any external surface greater than 0.5% of the total surface area
Section view
### Building Importance Level 2

| Region | A | B | 
| --- | --- | --- | --- | 
| Ultimate Wind Speed $V_{500}$ (m/s) | 46 | 57 | 68 | 
| Serviceability Wind Speed $V_{25}$ (m/s) | 37 | 39 | 41 | 
| Height above ground (z) | 1.5 | 2.5 | 3 | 
| Terrain Category | 1 | 2 | 3 |
| $M_z,\text{cat}$ (kN.m) | 0.28 | 0.30 | 0.31 | 
| Ultimate Wind Pressure (kPa) | 0.34 | 0.34 | 0.34 | 
| Serviceability Wind Pressure (kPa) | 0.28 | 0.28 | 0.28 | 

### Building Importance Level 3

| Region | A | B | 
| --- | --- | --- | --- | 
| Ultimate Wind Speed $V_{1000}$ (m/s) | 46 | 57 | 68 | 
| Serviceability Wind Speed $V_{25}$ (m/s) | 37 | 39 | 41 | 
| Height above ground (z) | 1.5 | 2.5 | 3 | 
| Terrain Category | 1 | 2 | 3 |
| $M_z,\text{cat}$ (kN.m) | 0.28 | 0.30 | 0.31 | 
| Ultimate Wind Pressure (kPa) | 0.34 | 0.34 | 0.34 | 
| Serviceability Wind Pressure (kPa) | 0.28 | 0.28 | 0.28 | 

### Building Importance Level 4

| Region | A | B | 
| --- | --- | --- | --- | 
| Ultimate Wind Speed $V_{2000}$ (m/s) | 46 | 57 | 68 | 
| Serviceability Wind Speed $V_{25}$ (m/s) | 37 | 39 | 41 | 
| Height above ground (z) | 1.5 | 2.5 | 3 | 
| Terrain Category | 1 | 2 | 3 |
| $M_z,\text{cat}$ (kN.m) | 0.28 | 0.30 | 0.31 | 
| Ultimate Wind Pressure (kPa) | 0.34 | 0.34 | 0.34 | 
| Serviceability Wind Pressure (kPa) | 0.28 | 0.28 | 0.28 | 

---

$C_p$ = Internal wind pressure coefficient
### TYPICAL INTERNAL WIND PRESSURES $C_{pi} = 0.4$

$C_{pi} = \text{Internal wind pressure coefficient}$

#### Building Importance Level 2

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<td>39</td>
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<td>1    1.5  2    2.5  3    1    1.5  2    2.5  3</td>
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- $M_{z,\text{cat}} = 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07 \times 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07$

- Ultimate Wind Pressure (kPa) | 0.54 0.59 0.61 0.52 0.56 0.59 0.49 0.53 0.57 0.44 0.51 0.55 0.40 0.47 0.52 | 0.87 0.94 0.97 0.83 0.90 0.95 0.78 0.86 0.92 0.71 0.81 0.88 0.85 0.76 0.83 |
- Serviceability Wind Pressure (kPa) | 0.37 0.40 0.41 0.35 0.38 0.40 0.33 0.36 0.39 0.30 0.34 0.37 0.27 0.32 0.35 | 0.41 0.44 0.46 0.39 0.42 0.45 0.37 0.40 0.43 0.33 0.38 0.41 0.30 0.35 0.39 |

#### Building Importance Level 3

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- $M_{z,\text{cat}} = 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07 \times 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07$

- Ultimate Wind Pressure (kPa) | 0.57 0.61 0.63 0.54 0.58 0.62 0.51 0.56 0.60 0.46 0.53 0.57 0.42 0.49 0.54 | 0.97 1.05 1.08 0.92 0.99 1.05 0.86 0.95 1.02 0.79 0.90 0.98 0.72 0.84 0.92 |
- Serviceability Wind Pressure (kPa) | 0.37 0.40 0.41 0.35 0.38 0.40 0.33 0.36 0.39 0.30 0.34 0.37 0.27 0.32 0.35 | 0.41 0.44 0.46 0.39 0.42 0.45 0.37 0.40 0.43 0.33 0.38 0.41 0.30 0.35 0.39 |

#### Building Importance Level 4

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- $M_{z,\text{cat}} = 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07 \times 1.12 \times 1.21 \times 1.25 \times 1.06 \times 1.15 \times 1.22 \times 1.00 \times 1.10 \times 1.18 \times 0.92 \times 1.04 \times 1.13 \times 0.83 \times 0.97 \times 1.07$

- Ultimate Wind Pressure (kPa) | 0.62 0.67 0.69 0.59 0.64 0.67 0.55 0.61 0.65 0.51 0.58 0.62 0.46 0.54 0.59 | 1.07 1.15 1.19 1.01 1.10 1.16 0.95 1.05 1.12 0.87 0.99 1.08 0.79 0.92 1.02 |
- Serviceability Wind Pressure (kPa) | 0.37 0.40 0.41 0.35 0.38 0.40 0.33 0.36 0.39 0.30 0.34 0.37 0.27 0.32 0.35 | 0.41 0.44 0.46 0.39 0.42 0.45 0.37 0.40 0.43 0.33 0.38 0.41 0.30 0.35 0.39 |
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<td>Height above ground (z)</td>
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<td>0.50</td>
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**COMBINATION EXTERNAL PLUS INTERNAL WIND PRESSURES**

\[ C_{\text{fig,net}} = (C_{\text{fig,i}} + C_{\text{fig,e}}) K_c \]

where:

- \( C_{\text{fig,net}} \) is the combination net pressure coefficient of \( C_{\text{fig,i}} \) acting with \( C_{\text{fig,e}} \) (Refer to Figure 8. Example of internal and external wind pressures acting in the same direction). When calculating the combined internal with external wind pressure actions, \( C_{p,i} \) is taken as 0.2 for side walls and leeward walls, and either −0.3 when the building has all walls equally permeable or −0.2 when the building is effectively sealed having non-openable windows.

- \( K_c \) is a combination factor. It allows for a concession to the overall net wind pressure when considering the combination of external and internal wind pressures acting together in the same direction. When considering the combined effects of internal and external wind pressures, then \( K_c \) can be taken as 0.9, otherwise for all other cases \( K_c \) must be taken as 1.

As an alternative to determining the site specific wind pressures from AS/NZS 1170.2, a project may employ the services of a specialist wind engineering consultancy to determine the wind pressures associated with a specific building on a specific site. They are usually engaged to provide cost savings for large projects.

**STRUCTURAL ANALYSIS**

Once all the loads on the walls and/or ceilings have been derived, then an analysis is conducted using various load cases to determine the strength and stiffness requirements from the frame and lining.

**Walls: Common load cases to satisfy the Ultimate Limit State (Strength):**

- Case 1: 1.35G
- Case 2: 1.2G + \( W_{\text{ult}} \)
- Case 3: 1.2G + 1.5Q_{\text{impact}}
- Case 4: 1.2G + 1.5Q_{\text{handrail}}
- Case 5: 1.2G + 1.5Q_{\text{basin / monitor arm}}
- Case 6: 1.2G + 1.5Q_{\text{shelf}}
- Case 7: 1.2G + 0.6Q_{\text{shelf}} + \( W_{\text{ult}} \)
- Case 8: 1.2G + 0.6Q_{\text{shelf}} + Q_{\text{impact}}
- Case 9: G + 0.6Q_{\text{shelf}} + E_{\text{ult}}

**Walls: Common load cases to satisfy the Serviceability Limit State (Stiffness):**

- Case 1: G + \( W_{\text{ser}} \), deflection limited to height/240 for flexible linings (i.e.: plasterboard)
- Case 2: G + \( W_{\text{ser}} \), deflection limited to height/250 for expressed jointed fibre cement
- Case 3: G + \( W_{\text{ser}} \), deflection limited to height/360 for brittle linings (i.e.: fibre cement, tiled walls, masonry veneer, AAC walls)

---

**FIGURE 8** Example of internal and external wind pressures acting in the same direction

Total wind pressure \( (C_{\text{fig,net}}) \) acting on the external wall stud framing

Section view

Internal positive pressure ➔ External negative (suction) pressure

External Wall \( C_{\text{fig,net}} = C_{\text{fig,i}} \) acting with \( C_{\text{fig,e}} \)

1. Combination factor \( K_c \) can be taken as 0.9
BUILDING REQUIREMENTS AND SOLUTIONS
Structural Frame Design for Lightweight Systems

2.3

Case 4: G + Q_{\text{impact}}, deflection limited to height/200 or 12mm maximum
Case 5: G + Q_{\text{handrail}}, deflection limited to height/480
Case 6: G + Q_{\text{basin / monitor arm}}, deflection limited to height/360
Case 7: G + Q_{\text{shelf}} + W_{\text{ser}}, deflection limited to height/360
Case 8: G + Q_{\text{shelf}}, deflection limited to height/480
Case 9: G + 0.6Q_{\text{shelf}} + E_{\text{ser}}, deflection limited to height/360

Ceilings: Common load cases to satisfy the Ultimate Limit State:
Case 1: 1.4G + 1.7U
Case 2: 1.2G + 1.2U + W_{\text{ult}}
Case 3: 0.9G + W_{\text{ult}} (uplift)
Case 4: 1.2G + 1.2U + E_{\text{ult}}
Case 5: 0.9G + E_{\text{ult}} (uplift)

Ceilings: Common load cases to satisfy the Serviceability Limit State:
Case 1: G + U, deflection limited to span/500 for suspended concealed, horizontal stud, and top-hat frame ceilings.
Case 2: G + U + W_{\text{ser}}, deflection limited to span/200 for suspended ceilings (top cross rail, furring channel, batten)
Case 3: G + U + W_{\text{ser}}, deflection limited to span/360 or 12mm maximum, for stud ceilings and top hat ceilings.

where:
G is the dead load
U is the live load
W_{\text{ult}} is the ultimate limit state wind load
W_{\text{ser}} is the serviceability limit state wind load
U is a nominal service load specific to ceiling systems
E_{\text{ult}} is the ultimate limit state earthquake load
E_{\text{ser}} is the ultimate limit state earthquake load

After the structural analysis is complete, then the frame and lining is selected to satisfy the predicted loads during the service life of the wall or ceiling system.

DESIGN STANDARDS
Wall and ceiling system framing must be designed according to the relevant design standard:
> AS 1684 Residential Timber Framed Construction
> AS 1720 Timber Structures
> AS/NZS 2785 Suspended Ceilings
> AS 3623 Domestic Metal Framing
> AS/NZS 4600 Cold Formed Steel Structures
> NASH Standard for Residential and Low-rise Steel Framing, Part 1

CONTROL JOINTS
Control joints allow for building movement resulting from influences such as moisture migration, structural movement and foundation settlement. Cracks in plasterboard and plasterboard joints should be minimised by using control joints and the correct installation techniques.

According to AS/NZS 2589:2017, Gypsum linings – Application and finishing, control joints must be installed in plasterboard walls and ceilings at:
> Maximum 12 metre intervals
> Control joints in the structure
> Any change in the substrate material

Distance between control joints may need to be reduced to less than 12 metres due to conditions such as large temperature or humidity variations. Control joints used in plasterboard external ceilings must have 6 metre maximum intervals, and for tiled plasterboard walls must have 4.8 metre maximum intervals.

An internal or external corner, bulkhead or full height door or window may perform the function of a control joint.
Fire Resistance

FIRE TERMS AND DEFINITIONS

Fire resistance level

Fire systems are rated to withstand a fire under test conditions for a certain period of time. This time is known as the Fire Resistance Level (FRL) and consists of the three criteria listed below:

- Structural Adequacy
- Integrity
- Insulation

Figure 9 below shows an FRL of 60/60/60. This means that if a building element were exposed to a standard fire test, it would not be expected to fail for 60 minutes in each of the three criteria. The NCC specifies FRLs for building elements such as walls, columns, roofs and floors. These FRLs can be many combinations of the three criteria, e.g. 90/-/-, 90/60/30 or -/60/60. A dash in the FRL means there is no requirement for that criterion.

**STRUCTURAL ADEQUACY**
The ability to maintain stability and adequate load bearing capacity as determined by AS 1530.4

**INTEGRITY**
The ability to resist the passage of flames and hot gases as specified by AS 1530.4

**INSULATION**
The ability to maintain a temperature over the whole of the unexposed surface below that specified by AS 1530.4

Figure 9 Fire resistance level 60/60/60

Fire testing is carried out in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures. All fire rated plasterboard systems in this manual have been the subject of a report by a registered testing authority.
LOAD BEARING OR NON-LOAD BEARING?

If a building element is load bearing then it must have a Structural Adequacy component to the FRL, for example 60/60/60. The definition of load bearing from the NCC states that a structure is ‘intended to resist vertical forces additional to those due to its own weight’. Therefore walls such as those holding up a floor or roof above are load bearing. While (in general) walls that span between concrete slabs and are not holding up the slab, are considered non-load bearing.

The NCC ‘deemed to satisfy’ provisions, specify FRLs based on whether the building element is load bearing or not [Refer to NCC Volume One, Specification C1.1]. For example, walls separating sole occupancy units in a Class 2 building of Type A construction (residential high rise) need an FRL of -/60/60 if they are non-load bearing and 90/90/90 if they are load bearing. Residential high rise buildings are usually slab to slab construction in which case the concrete columns are load bearing but the plasterboard infill walls are not.

If an FRL with Structural Adequacy is specified (e.g. 90/90/90) where there is no additional vertical load, a building element without Structural Adequacy may be used (e.g. -/90/90). [Refer to NCC Vol. 1 Specification A2.3 (6)].

ACCEPTABLE VARIATIONS TO FIRE RATED SYSTEMS

Fire rated systems must be built according to the installation instructions in Section 3. However, there are some variations allowed that will not degrade the performance of the system:

- Increasing cavity width
- Increasing stud size or metal thickness
- Adding noggings to support fixtures or services
- Decreasing stud spacing
- Decreasing fastener spacing
- Substituting 13mm FireShield with 13mm TruRock or 13mm TruRock HD
- Substituting 16mm FireShield with 16mm TruRock
- Adding additional linings to a system up to a weight of 20 kg/m² and no thicker than 25mm per side. This includes fibre cement board up to 9mm thick and plasterboard up to 25mm thick. For load bearing walls, the load per stud must include the extra lining
- Adding tiles up to 32kg/m² per side.

RESISTANCE TO INCIPIENT SPREAD OF FIRE (RISF)

Resistance to the Incipient Spread of Fire (RISF) is the ability of a ceiling to limit the temperature rise in the ceiling cavity [Figure 10]. The RISF is a requirement of the NCC in specific applications. They are appropriate where the ceiling is the primary fire barrier that limits fire spread via the ceiling space. The RISF for Knauf fire rated ceilings are stated in the system tables.

![Figure 10 Resistance to incipient spread of fire](image)

PLASTERBOARD TO RESIST FIRE

Knauf recommends the installation of FireShield, or TruRock wall and ceiling systems to control the spread of fire.

These specially formulated products contain additives that improve the natural fire resisting properties of the plasterboard.
MODIFICATIONS TO FIRE RATED SYSTEMS

Fire rated systems are often modified by the installation of:

- Fire rated inspection hatches
- Fire rated power points
- Fire rated light fittings
- Fire rated doors
- Fire dampers
- Electrical cables
- Metal or plastic pipes
- Other fire rated penetrations.

It is the responsibility of the manufacturer of these components to ensure that the fire and acoustic properties of the plasterboard system are maintained.

Some modifications are detailed in Section 3, many include the use of Knauf Fire and Acoustic Sealant. Any modification not covered in this manual must be according to the relevant manufacturer’s instructions.

SMOKE WALLS

The purpose of a smoke wall is to prevent smoke passing from one side of a wall to the other. A smoke wall must be built from non-combustible materials like steel studs or materials deemed non-combustible such as plasterboard.

Doors and windows used in smoke walls must comply with requirements in the NCC Volume One, Specification C2.5. Ducts through the smoke wall must use a smoke damper, unless the duct is part of the smoke handling system and is required to function during a fire.

Class 9A Healthcare Buildings, Class 2 and 3 Residential Buildings

Smoke walls in Class 9a, 2 and 3 buildings must extend up to:

- The floor above, or
- A non-combustible roof covering, or
- A ceiling having an RISF of 60 minutes.

Class 9C Aged Care Buildings

Plasterboard used for smoke walls in Class 9c buildings must have a thickness of at least 13mm. Smoke walls in Class 9c buildings may also be lined on one side only and must extend up to:

- The floor above, or
- A non-combustible roof covering, or
- A jointed plasterboard ceiling with a minimum thickness of 13mm with all penetrations sealed.
Acoustics

SOUND WAVES

Sound is energy that consists of sound waves or vibrations that create small amounts of pressure. Sound pressure is measured in decibels (dB) using a special logarithmic scale. Decibel is the unit of measurement used when describing the sound level in a room.

Sound waves also known as vibrations are measured in hertz (Hz) which is the number of vibrations per second. The length of a sound wave varies – low pitch sounds have a long wavelength whereas high pitch sounds have a shorter wavelength. Accordingly low pitches (long wavelengths) have a low frequency and high pitches (short wavelength) have a high frequency.

PERCEPTION OF SOUND

People with normal hearing can perceive sounds between 20 Hz and 20,000 Hz, however the ear is at its most sensitive in the frequencies between 250 and 3150 Hz, also known as the consonant frequency range and where the most important information is contained for speech.

Voice communication is essential for humans and understanding what is said involves much more than the meaning of the words. Tone of voice and rhetoric are also important elements in understanding.

The perception of sound is subjective and contextual, what is perceived as good sound by one person can be very different to another person’s view. Physiological factors, taste, culture, habit, mood and environment can all affect our perception of what constitutes positive and negative sound.

SOUND STRATEGIES

It is important that the acoustics of a space match the function of that space; and that everyone that resides or works in that space experiences good acoustic comfort.

In order to modify the sound experienced in a room, there are a number of strategies that can be employed:

- Block the sound from entering the room
- Absorb the sound inside the room
- Spread the sound around the room
- Redirect the sound away from and within the room
- Emphasise the sound in parts of the room
- Mask the sound in the room

The following pages look at the principles and definitions of sound insulation – a strategy for blocking sound, i.e. preventing it from entering a room, and sound absorption and diffusion – strategies for dealing with the sound inside a room.
Sound Insulation

ACOUSTIC TERMS AND DEFINITIONS

Rw (Weighted Sound Reduction Index)
Rw describes the airborne sound insulating power of a building element. It is a laboratory measured value that can apply to walls, ceiling/floors, ceiling/roofs, doors or windows. The higher the number, the greater the sound insulating power of the building element.

For example, an increase in the Rw of a wall by 10 points will reduce the perceived loudness of sound passing through the wall by about half. Table 1 shows how the sound insulating effectiveness of walls depends on their Rw (or Rw + Ctr) values.

Rw+Ctr (Rw Plus Spectrum Adaptation Term)
Rw + Ctr is equal to Rw with the addition of a low frequency sound correction, Ctr. The use of Rw + Ctr has been adopted due to the increase in low frequency sound sources such as surround sound systems, traffic and aircraft noise, drums and bass guitars. Two walls can have the same Rw rating but have different resistance to low frequency sound, thus a different Rw + Ctr.

DnTw and DnTw+Ctr (Measured On-Site)
These values are the equivalent of Rw and Rw + Ctr, but are measured on-site. Rw is the value measured in an acoustic laboratory, while DnTw is the value measured on-site.

An on-site measured value of DnTw + Ctr is permitted to be 5 points lower than the Rw + Ctr value. Where the NCC may call for an Rw + Ctr ≥ 50, the same requirement may be satisfied by measuring DnTw + Ctr ≥ 45 on-site.

Ln,w (Impact Sound Insulation Rating)
Ln,w describes how easily impact sound travels through a floor. Impact sound is generated by sources such as dryers, washing machines and heeled shoes on a wooden floor.

Unlike Rw values, better performing floors have lower values. Therefore when specified, Ln,w values are maximums while Rw values are minimums. For example, the NCC requires some floors to have Ln,w ≤ 62.

Impact sound insulation
Walls that have Impact Sound Insulation are defined in the NCC as walls that do not have any rigid mechanical connection between two separate leaves except at the perimeter.

Systems in this manual that satisfy this NCC requirement are staggered stud plasterboard walls with no noggings, and walls that use resilient mounts.

Impact sound insulation with discontinuous construction
Discontinuous Construction is defined in the NCC as walls that have a gap of at least 20mm between two separate leaves. Double stud plasterboard walls are classed as ‘discontinuous’ [Refer to the NCC for a complete definition].

Ceiling Attenuation Class (CAC)
Ceiling Attenuation Class (CAC) indicates the ceiling’s ability to reduce airborne sound transmission via the ceiling cavity when the dividing wall does not extend past the ceiling to the underside of the floor or roof.

In this manual CAC is expressed as Rw and Rw + Ctr ratings. These represent the sound reduction from one room to the next via the two ceilings and the cavity above the ceiling.

The noise in the source room can pass through the wall and through the ceiling cavity. To compensate for the additional noise level in the receiving room, when sound isolation is important, Knauf recommends using wall and CAC ceiling systems that both have an Rw rating 3 points higher than the requirement.

According to the NCC Volume One, Part F5.5, where a wall required to have sound insulation has a floor or roof above, the wall must continue to the underside of the floor or roof above, or a ceiling that provides the sound insulation required for the wall.

TABLE 1 Effect of Various Walls on Sound Insulation Performance

<table>
<thead>
<tr>
<th>Rw</th>
<th>Effect of Different Values of Rw and Rw + Ctr on Sound Insulation Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Normal speech can be heard easily</td>
</tr>
<tr>
<td>30</td>
<td>Loud speech can be heard easily</td>
</tr>
<tr>
<td>35</td>
<td>Loud speech can be heard but not understood</td>
</tr>
<tr>
<td>42</td>
<td>Loud speech heard as murmur</td>
</tr>
<tr>
<td>45</td>
<td>Must strain to hear loud speech</td>
</tr>
<tr>
<td>48</td>
<td>Loud speech can be barely heard</td>
</tr>
<tr>
<td>53</td>
<td>Loud speech can not be heard</td>
</tr>
<tr>
<td>63</td>
<td>Music heard faintly, bass notes ‘thump’</td>
</tr>
<tr>
<td>70</td>
<td>Loud music still heard very faintly</td>
</tr>
</tbody>
</table>
### TABLE 2 NCC Sound Insulation Requirements For Sole Occupancy Units (SOU)

<table>
<thead>
<tr>
<th>Building Class 1 – NSW, Vic, Qld, Tas, WA, SA and ACT</th>
<th>Airborne Sound Insulation</th>
<th>Impact Sound Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls separating a bathroom, toilet, laundry or kitchen and a habitable room (other than a kitchen) in adjoining SOUs.</td>
<td>Rw + Ctr ≥ 50</td>
<td>Discontinuous</td>
</tr>
<tr>
<td>Walls separating SOUs in all other cases.</td>
<td>Rw + Ctr ≥ 50</td>
<td></td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a habitable room.</td>
<td>Rw + Ctr ≥ 40</td>
<td></td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a kitchen, bathroom or other non-habitable room.</td>
<td>Rw + Ctr ≥ 25</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Class 2 &amp; 3 – NSW, Vic, Qld, Tas, WA, SA and ACT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls separating habitable rooms in adjoining SOUs.</td>
<td>Rw + Ctr ≥ 50</td>
</tr>
<tr>
<td>Walls separating kitchens, toilets, bathrooms and laundries in adjoining SOUs.</td>
<td>Rw + Ctr ≥ 50</td>
</tr>
<tr>
<td>Walls between a bathroom, toilet, laundry or kitchen and a habitable room (other than a kitchen) in adjoining SOUs.</td>
<td>Rw + Ctr ≥ 50</td>
</tr>
<tr>
<td>Walls between a SOU and a public corridor, public lobby, stairway or the like or parts of a different classification.</td>
<td>Rw ≥ 50</td>
</tr>
<tr>
<td>Walls between a SOU and a plant room or lift shaft.</td>
<td>Rw ≥ 50</td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a habitable room.</td>
<td>Rw + Ctr ≥ 40</td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a kitchen or other non-habitable room.</td>
<td>Rw + Ctr ≥ 25</td>
</tr>
<tr>
<td>Floors between SOUs and between a SOU and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.</td>
<td>Rw + Ctr ≥ 50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Class 1, 2 and 3 – Northern Territory</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls separating a bathroom, toilet, laundry or kitchen and a habitable room (other than a kitchen) in adjoining SOUs.</td>
<td>Rw ≥ 50</td>
</tr>
<tr>
<td>Walls separating SOUs in all other cases.</td>
<td>Rw ≥ 45</td>
</tr>
<tr>
<td>Walls or ceilings separating a soil or waste pipe from a habitable room.</td>
<td>Rw ≥ 45</td>
</tr>
<tr>
<td>Walls or ceilings separating a soil or waste pipe from a kitchen, bathroom or other non-habitable room.</td>
<td>Rw ≥ 30</td>
</tr>
<tr>
<td>Floors between SOUs.</td>
<td>Rw ≥ 45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Class 9c – All Australian States and Territories</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls separating SOUs from a kitchen or laundry.</td>
<td>Rw ≥ 45</td>
</tr>
<tr>
<td>Walls and floors separating SOUs and walls separating SOUs from a bathroom, toilet, plant room or utilities room.</td>
<td>Rw ≥ 45</td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a habitable room.</td>
<td>Rw + Ctr ≥ 40</td>
</tr>
<tr>
<td>Walls or ceilings separating a duct, soil, waste or water supply pipe or storm water pipe from a kitchen or other non-habitable room.</td>
<td>Rw + Ctr ≥ 25</td>
</tr>
</tbody>
</table>

Table 2 is not intended as a substitute for the NCC. [Refer to the NCC for the full details of sound insulation requirements]
SOUND INSULATION REQUIREMENTS

Performance requirements of the NCC relating to sound insulation shown in table 2 can be satisfied in a number of ways that include the following:

1. Deemed-to-satisfy construction

Construct a wall or ceiling system that complies with the deemed-to-satisfy provisions of the NCC Volume One, Specification F5.2 (2). This section of the NCC details generic systems that satisfy the NCC sound insulation requirements. However, more efficient solutions can be found in this manual.

2. Laboratory test

Many of the systems in this manual were tested in an acoustic laboratory according to AS 1191:2002. Acoustic testing laboratories are designed to ensure that flanking paths do not occur. Tested systems are constructed with extreme care to achieve optimum performance. For these reasons, on-site performance may be different to laboratory performance.

3. On-site testing

Conduct on-site acoustic testing on a wall or ceiling system. This is a ‘verification method’ accepted by the NCC to confirm the performance requirements are met. Also the effectiveness of the complete installed system can be verified by on-site acoustic testing.

4. Certification by an acoustic consultant

An acoustic consultant can certify that the construction on a particular site meets the NCC requirements. This certification includes the effectiveness of penetrations and flanking paths. It usually involves some level of on-site testing.

5. Acoustic Opinion

Acoustic consultants can provide acoustic opinion on the sound insulation rating of building elements. An acoustic opinion may provide sufficient evidence of compliance depending on the type and size of building. Check with the building certifier prior to construction.

HIGHER ACOUSTIC REQUIREMENTS

Where performance is critical or noise is higher than normal, accredited acoustic engineers should be consulted. Their role is to ensure that design and construction will meet any specific requirements.

All acoustic ratings in this manual are either test results or professional opinions based on test information. Acoustic opinions in this manual were provided by Day Design Pty Ltd consulting acoustical engineers of Sydney NSW.

Acoustic predictions for systems not published in Knauf technical literature can often be generated by acoustic modelling software. Contact Knauf Technical Services for an acoustic prediction based on the Knauf product range.

The Association of Australian Acoustical Consultants (AAAC) offer detailed guidance on acceptable acoustic performance. They have published their own star rating system. Ratings range from 2 to 6 stars and are based on field testing by an AAAC consultant to verify that they have been achieved. More information about AAAC Star Ratings for apartments and townhouses is available at www.aaac.org.au.

ACOUSTIC TESTING AND ACTUAL PERFORMANCE

Attention to detail during construction is important for achieving good sound insulation, as performance may be is determined by the weakest link in the system. Performance of installed acoustic systems may fall short of laboratory measured results. Acoustic measurements in a typical laboratory test represent the maximum performance that can be achieved.

Actual site conditions are usually less than ideal and sound flanking paths normally exist around the perimeter of the system. Flanking paths may be minimised by sealing the perimeter with sealant and by installing services using acoustically rated details.
SOUND INSULATION PERFORMANCE OF WALL AND CEILING SYSTEMS

Sound insulation ratings for single steel stud walls are based on 600mm stud spacing and the thinnest BMT in the system table.

Sound insulation performance listed in systems tables may vary due to decreased stud spacing and increased steel stud thickness (BMT) to the tested systems. Sound insulation performance may also vary due to any additional linings on battens or on separate stud walls.

The sound insulation rating of a basic wall or ceiling system can be upgraded by using a combination of:

- SoundShield or TruRock
- Additional plasterboard layers
- Insulation in the cavity
- Resilient mounts
- Knauf Acoustic Studs
- Larger size studs
- Double stud walls
- Staggered stud walls.

SOUNDSHIELD FOR SUPERIOR NOISE CONTROL

Knauf recommends the installation of SoundShield wall and ceiling systems to minimise noise from aircraft, traffic and neighbours.

SoundShield is a plasterboard with enhanced sound insulation qualities. SoundShield has a super high-density* core which helps to resist the transmission of noise into rooms.

*The denser the plasterboard, the better it will resist sound transfer.
Sound Absorption

Sound absorption is an ability of a material or a construction to reduce the amount of sound energy reflecting back into the same space.

As a general rule heavy objects with smooth surfaces such as concrete, reflect sound and light objects with porous surfaces such as fabric, absorb sound.

Sound absorbers can be light and porous materials like Knauf EarthWool or they can be a ceiling construction made of perforated panels like Knauf DesignPanel with a cavity behind, or a combination of both.

**SOUND ABSORPTION COEFFICIENTS**

If a material is 100% reflective then its sound absorption coefficient $\alpha$ is 0, and if it is 100% non-reflective, then $\alpha$ is 1.

The same material can have different sound absorption coefficients at different frequencies.

The sound absorption coefficient of a material or system is measured in a reverberation chamber in an acoustic test laboratory. The measured sound absorption coefficient at a one-third octave band frequency such as 100 Hz, 125 Hz and 160 Hz is called $\alpha_S$. For each octave band frequencies such as 125 Hz, 250 Hz and 500 Hz, the average of the measured $\alpha_S$ of three consecutive one third octave band frequencies is rounded to the nearest multiple of 0.05, which is then called the practical sound absorption coefficient, $\alpha_p$.

**NOISE REDUCTION COEFFICIENT (NRC)**

A single number sound absorption rating obtained from an arithmetic average of sound absorption coefficients, $\alpha_S$, at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz rounded to the nearest multiple of 0.05.

The higher the NRC, the better the sound absorption of a material or system in the normal frequency range of human speech.

**WEIGHTED SOUND ABSORPTION COEFFICIENT ($\alpha_w$)**

Designing room acoustics based on NRC can be misleading and result in poor acoustic performance in practice. That’s because an average value can mask high and low values at different frequencies.

A more sophisticated way to measure acoustic performance is to calculate a weighted sound absorption coefficient ($\alpha_w$). An $\alpha_w$ value is calculated by comparing the sound absorption coefficients $\alpha_p$ at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz to a standard curve [Refer AS ISO 11654:2002].

The $\alpha_w$ rating is more commonly used in Europe than NRC; it gives a better picture of a material’s performance across all of the frequencies important to human hearing, as the $\alpha_w$ figure is reduced by any low performance frequencies with respect to the reference curve. In other words, any weak points in the material’s acoustic performance are uncovered by an $\alpha_w$ value.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>$\alpha_S$</th>
<th>$\alpha_P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>125</td>
<td>0.58</td>
<td>0.85</td>
</tr>
<tr>
<td>160</td>
<td>0.67</td>
<td>0.90</td>
</tr>
<tr>
<td>200</td>
<td>0.76</td>
<td>0.80</td>
</tr>
<tr>
<td>250</td>
<td>0.82</td>
<td>0.65</td>
</tr>
<tr>
<td>315</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>630</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>1250</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>3150</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td><strong>Average $\alpha$</strong></td>
<td><strong>0.73</strong></td>
<td></td>
</tr>
</tbody>
</table>
Sound Reflection and Diffusion

Sound reflection in multiple scattered directions is called sound diffusion. Sound diffusion is helpful to spread sound evenly inside a closed space and in combination with sound absorption, helps avoid echoes and uneven reverberation time distribution throughout the room creating more uniform and favourable room acoustics environment.

Vertical ceiling baffles made of Knauf Heradesign can act as diffuser and absorber simultaneously. Knauf Designpanel and Knauf Stratopanel assist sound diffusion via irregular sound reflection from the walls of perforations.

Reverberation Time (RT)

In an enclosed space, sound gets reflected from hard, smooth surfaces creating reverberation, the persistence of sound even after its source has stopped. Sounds reflected from multiple surfaces increase the noise level in a room.

The time required for the reverberated noise level to decay by 60dB is called reverberation time, represented by RT (or RT60) measured in seconds.

Spaces without sound absorbing materials such as large, unfurnished rooms have long reverberation times while spaces with lots of sound absorbers such as cinemas have short reverberation times.

REVERBERATION TIME REQUIREMENTS

Reverberation time requirements are dependant on the function of a room. Long reverberation times make a space acoustically 'live', while short reverberation times reduce noise and if too short can deaden the sound. To enhance speech intelligibility it is important to have a suitable reverberation time across the frequency range.

AS/NZS 2107:2000 provides recommended design sound levels and reverberation times for building interiors [Refer to Table 3].
CHOOSING THE RIGHT KNAUF SOUND ABSORPTION SYSTEMS

Knauf sound absorption systems can be selected from the wide range of premium acoustic solutions from Knauf: Designpanel, Stratopanel, Plaza, AMF Thermatex or Heradesign; depending on the aesthetics, design and performance requirements like absorption ratings (\(\alpha_w\) or NRC), sound attenuation ratings (CAC), impact resistance, moisture resistance, health and hygiene, maintenance, curving etc.

Two products or systems with similar NRC or \(\alpha_w\) ratings might perform differently in practice. The sound absorption of a product or system at different frequencies must be considered while also evaluating reverberation time and other acoustics characteristics, such as sound diffusion, reflection, attenuation, etc.

The sound absorption performance of cavity or resonance absorbers such as Knauf Designpanel and Stratopanel can vary depending on the perforation type, perforation ratio, depth of ceiling cavity and the type and thickness of insulation material used in the cavity.

The placement of sound absorbing materials must take into account the occupants and activity to ensure that sound is absorbed, reflected and spread in the required manner. It is often common practice to only use sound absorbing materials on the ceiling, however in narrow or large rooms with high ceilings, placement of sound absorbers on the walls may be necessary to achieve the right acoustic environment.

FOR SOUND ABSORPTION PERFORMANCE

Knauf recommends the installation of Stratopanel and Designpanel perforated acoustic linings to create a comfortable acoustic environment and enhance audibility.

Designpanel and Stratopanel are available in a range of perforation patterns and have the added benefit of CLEANEO air-cleaning technology.

Figure 14 illustrates that wider frequency analysis is important when selecting an acoustic material.

Ceilings 2, 3 and 4 all use a material that has a single number sound absorption rating of 0.7, but with different results in practice.

For instance, Ceiling 2 meets reverberation time requirements at lower frequencies only; and Ceiling 4 meets them at only 1000 Hz and 2000 Hz. Only Ceiling 3 meets reverberation time at all frequencies.

FIGURE 14. Reverberation time comparison
Calculated using Knauf Reverberation Time Calculator for 10m long x 7.5m wide x 4m high reception room in a hospital for hard and smooth surfaced walls, sparsely occupied and lightly furnished.
Thermal Performance

THE IMPORTANCE OF TOTAL R-VALUE FOR ENERGY EFFICIENCY

Energy efficient construction requires a building envelope that resists the transfer of heat. This thermal resistance is measured as an R-Value.

Total R-Value is one of the most important indicators of the thermal performance of a building element. The higher the Total R-Value, the better the thermal insulation, i.e. the longer it takes the heat to get into the building (in summer) or out of the building (in winter).

Total R-Value is defined in the National Construction Code (NCC) as the sum of the R-Values of individual component layers in a composite element. This includes any building material, insulating material, airspace and associated surface resistances.

DEFINITION OF R-VALUE

R-Value is the thermal resistance of a component calculated by dividing its thickness by its thermal conductivity.

Total R-Value, \( R_T = R_{Si} + R_1 + R_2 + \ldots + R_n + R_{Se} \)

Where \( R_{Si} \) is the thermal resistance of the internal surface and \( R_{Se} \) is the thermal resistance of the external surface; both depend on temperature, speed of air flow and the emissivity of the surface. \( R \) is the thermal resistance of \( i^{th} \) layer parallel to the heat flow direction.

WINTER VS SUMMER

The R-Value of an individual component may vary in different temperatures, as its thermal conductivity depends on the mean temperature of the material. The higher the mean temperature (i.e. in summer) the higher the thermal conductivity and hence a lower R-Value.

In a solid material, such as concrete or plasterboard, the effect of temperature on thermal conductivity is marginal, but in a thermal insulating material like EarthWool, the effect can be significant. The surface thermal resistances, \( R_{Si} \) and \( R_{Se} \) in the above formula may also vary in winter and summer.

The effect of temperature and the direction of heat flow on R-Value of an air space, such as the cavity in a wall or roof, are even more significant. Therefore, the Total R-Value of a composite building element may vary in winter (heat flow outwards) and summer (heat flow inwards).

REFLECTIVE AIR SPACE

Heat transfer may happen by conduction (transfer via contact of materials, such as heat transfer in solids), convection (transfer via physical movement of material, like heat transfer in liquids and gases) and radiation (transfer without any material via electromagnetic waves, such as solar radiation). Reflective surfaces such as aluminium foil can effectively block the heat transfer via radiation, and hence increase the total R-Value of a building element.

However it’s important to be cautious while using the reflective surface’s contribution towards the Total R-Value. A very basic principle is that the reflective surface must always face a free air cavity.

CALCULATING THERMAL PERFORMANCE

Knauf offers an easy to use online Wall Thermal Calculator, that allows you to build up your wall, layer by layer and get the estimated Total R-Value.


FOR THERMAL PERFORMANCE

Knauf recommends Earthwool to provide a cost-effective, thermal and acoustic barrier for energy-efficient construction.

Earthwool is made using recycled glass and with ECOSE® Technology, having no added formaldehyde or artificial colours or dyes it is a new generation of super-soft, sustainable glasswool.
2.3 BUILDING REQUIREMENTS AND SOLUTIONS

Wet Areas

The NCC requires wet area construction to protect the occupants from dangerous or unhealthy conditions, and to protect the building from damage. Acceptable construction for wet areas is detailed in the NCC and Australian Standard AS 3740:2010, Waterproofing of Domestic Wet Areas.

WaterShield, TruRock and TruRock HD are all water resistant plasterboards. The installation of these products in accordance with Section 3.1.4 of this manual complies with the requirements for wet areas from AS 3740 and the NCC.

TruRock and TruRock HD are water resistant plasterboards that are also fire resistant and can be substituted for FireShield in all systems.

Use PermaRock for highly water intensive areas such as indoor swimming pools, public showers and commercial kitchens.

WaterShield, TruRock and TruRock HD are manufactured to high internal standards that meet or exceed the requirements for water resistant gypsum board within Australian Standard AS 2588:1998, Gypsum Plasterboard.

WaterShield, TruRock and TruRock HD are water resistant, however they are not waterproof. Direct contact with water over time must be avoided and if plasterboard has been water damaged, it must be replaced.

Precautions against condensation listed in Section 2.2 ‘Condensation and Ventilation’ must be followed.

WATER RESISTANT PLASTERBOARD FOR WET AREAS

Knauf recommends the installation of WaterShield to resist moisture in wet areas like showers, bathrooms and laundries. For areas that require a fire rating as well as water resistance Knauf recommends TruRock and TruRock HD.

WaterShield, TruRock and TruRock HD are ideal substrates for tiles as they are dimensionally stable.
### Impact Resistance

Areas subject to wear and tear need special consideration to reduce damage and maintenance costs. High traffic and wear areas are commonly found in:

- Shopping centres
- Hotels
- Correctional centres
- Garages
- Corridors
- Educational facilities
- Airports
- Hospitals
- Home gyms
- Rumpus rooms.

### TESTING OF IMPACT RESISTANT LININGS

TruRock and TruRock HD have been tested for both soft and hard body impact. Two conditions were measured for each of these tests:

- The damage on the face and back of the wall lining
- The depth of indentation.

#### Soft body impact

The soft body test involves swinging a sand filled bag into a test wall with studs at 600mm centres and simulates the kind of loads applied to a wall system by the human body.

Soft body impact was tested in accordance with NCC Volume One, C1.8, meeting the impact requirements for fire rated walls and fire isolated exits.

#### Hard body impact

Hard body tests were carried out by dropping a steel ball from different heights and measuring the depth of the indentation caused by the impact. Hard body tests simulate loads such as a trolley or swinging a heavy suitcase.

Large hard body impact resistance was tested with a 5 kg spherical steel weight, swung from a height of 300mm. It has about the same energy as a cricket ball travelling at 60 km/hr. This impact simulates a reasonable kick with a steel capped boot which makes a hole in standard 13mm plasterboard.

The number of impacts it took to penetrate the lining was recorded. Penetration was defined by the ability of a 10mm diameter probe to pass through the lining when applied with 2.5 kg of force.

13mm standard plasterboard was penetrated after 1 impact, 13mm TruRock withstood a further 3 hits before being penetrated on the 4th impact. 13mm TruRock HD was penetrated on the 10th impact.

Small hard body impact resistance was tested with a 50mm steel ball weighing 510 grams, dropped onto 400mm square plasterboard samples. The samples were placed on a 300mm square aluminium support sitting on concrete:

- Standard 13mm plasterboard was completely penetrated at a drop height of 2.4m while TruRock only sustained a dent 2mm deep
- At a 1.6m drop height, 13mm standard plasterboard suffered an impact more than 4mm deep, while TruRock showed only a minor dent 1mm deep.

### BENEFITS OF TRUROCK

- High resistance to marks, scores, dents and holes
- Twice as tough and hard as standard 13mm plasterboard.

13mm TruRock can be substituted for 13mm FireShield in any system and will maintain fire and acoustic performance. 16mm TruRock can be substituted for 16mm FireShield.

TruRock is not intended to safeguard against damage from deliberate attack with heavy tools or in areas where heavy moving machinery may contact the walls (e.g. unprotected forklift operating areas). Consider the following to minimise damage in high wear areas:

- Make thoroughfares as wide as practical
- Install doorstops on all door openings.

### FOR IMPACT RESISTANCE

Knauf recommends the installation of TruRock with a high density core and heavy duty face and back paper, to minimise wear and tear in high traffic areas.

TruRock HD is an impact resistant plasterboard reinforced with a continuous fibreglass mesh embedded in a high density core.