The science behind details

Have you ever wondered why we detail or construct buildings the way we do? Many of the actions we take may seem second nature, but there is a great deal of science behind the basic details.

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UNDERSTANDING THE REASON why details are designed the way they are is important to making sure you don't compromise the functionality during design or build.

Having enough drying potential is key

The risk of water entry cannot be removed completely. To manage water, the most important part of the design, material selection and detailing process is to get the balance right between wetting and drying potential.

Buildings should be designed so any accumulation of moisture is more than outweighed by the potential of the structure to dry that moisture.

4Ds foundation of E2/AS1 details

The 4Ds (deflection, drainage, drying and durability) are a practical implementation of this philosophy and are enshrined in the E2/AS1 details (see Figure 1). They are based on much of the science of water outlined here. There are a few driving

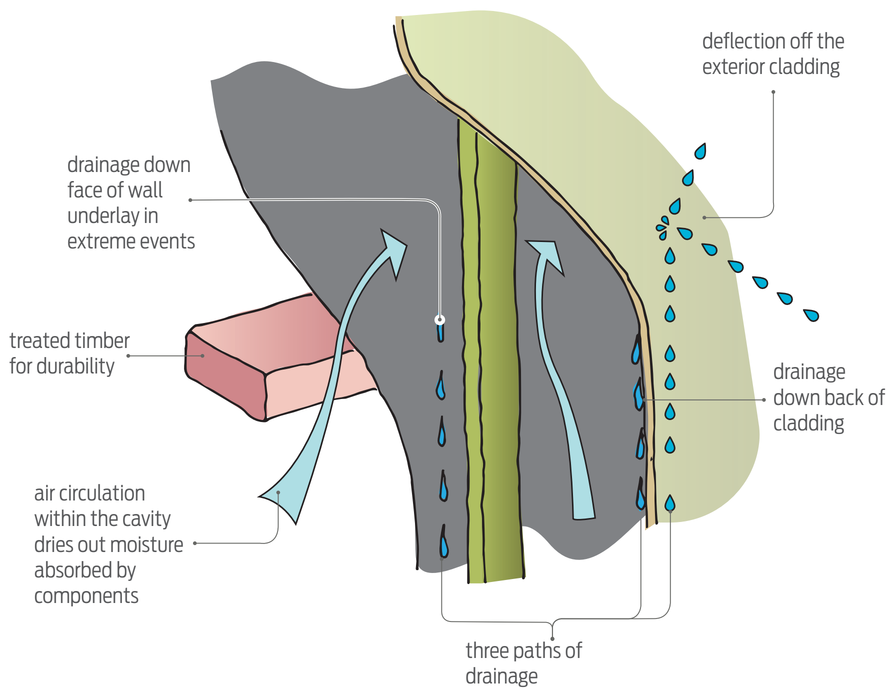

Figure 1: The 4Ds (deflection, drainage, drying and durability) are the basis of E2/AS1.

forces at play here and some basic physics and chemistry, so stay with me.

Let's consider the two forms of moisture - liquid water and water vapour. Liquid water can accumulate quickly, making it much more effective at wetting a structure. There are concerns with managing vapour as well, but the damage caused by liquid water tends to be faster and very costly to remedy.

Science behind surface tension

The water molecule is a polar molecule and has a high attraction to other water molecules, a phenomenon known as hydrogen bonding.

What does this mean in the practical world? A direct result of hydrogen bonding is the surface tension you can see in multiple ways such as a bead of water on your car's bonnet or water hanging from a drip edge.

Contact angle affects behaviour

The contact angle between a body of water and a material it contacts is related to surface tension. It's a complicated chemical relationship that depends on the material in question as well as any chemical contaminants on the surface or in the water or ageing of coatings.

The greater the contact angle, the more likely water will form beads or droplets and will usually not be taken up very quickly by the surface. Hydrophobic materials will tend to have a high contact angle (see Figure 2).

The opposite is hydrophilic, where the contact angle is low, and water is usually readily absorbed by a material.

Coatings reduce moisture absorption

Surface coatings also have a big influence, though they can weather over time, reducing their effectiveness at preventing moisture absorption.

A good example of the use of coatings is priming the back of weatherboards. They can be expected to have some liquid water on their surface in service, so the primer helps to ensure water is shed (usually out the next lap or two down the wall) (see Figure 3).

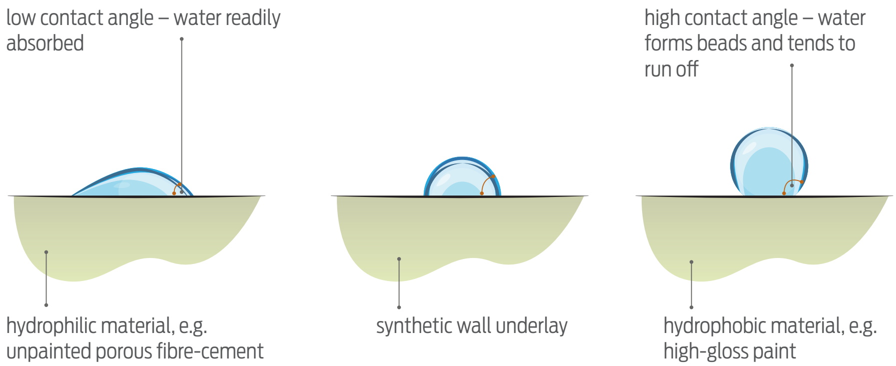

Figure 2: Impact of contact angle between water and material.

Gravity drainage a useful ally

The main mechanism of liquid water movement is gravity. While gravity is unavoidable, it is constant and can be used to enhance the ability of a structure to shed or drain water.

Think of how it works with:

- correctly lapped underlays
- drained cavities
- correctly aligned laps in horizontal claddings
- flexible flashing tapes
- upstands and cross-falls to head flashing and inter-storey flashings
- sloped cap flashings
- condensation and window channel drains
- pitched roof cladding and gutters.

Capillary transport

The other major liquid transport mechanism is capillary transport. It is where water can actually be lifted up inside a material or in a tight joint. A piece of timber is a great example of a capillary-active material – think of how rainwater got from the roots of a tree up to the top branches.

Other examples of capillary-active materials include:

- grouts
- mortar
- concrete masonry
- plasterboard
- fibre-cement
- building papers
- porous ceramic tile biscuits
- poor-quality concrete.

Examples of capillary rise

Capillary rise can be significant in some materials, for example:

- glass with a 0.5 mm gap - 15 mm
- glass with a 1 mm gap - 7.5 mm
- glass with a 3 mm gap - 3.5 mm
- weathered gloss paint with a 1 mm gap - 4 mm
- weathered gloss paint with a 3 mm gap - 2 mm
- new gloss paint with a 1 mm gap - 2 mm
- new gloss paint with a 3 mm gap - 0.5-1 mm.

Solutions to stop capillary movement

The potential for capillary rise in timber can be reduced by:

- painting cut ends
- ensuring the timber is not sitting in water
- providing a separation between the timber and an adjacent surface, such as a waterproof deck or paving.

Other options to prevent capillary rise are:

- gaps of at least:
  - 6 mm if hydrophilic material (attracts water)
  - 3 mm if hydrophobic material (repels water)

- sealing gaps not required for drainage
- hems or hooks on flashings
- weathergrooves in timber.

Movement of water vapour

Water vapour moves by two main mechanisms - diffusive and convective transport.

Diffusive transport

Diffusive transport of water vapour is simply the movement of water vapour from an area of higher vapour pressure to lower vapour pressure. An example of where this could be a concern is water transport through concrete in contact with the ground (though there is also a capillary component when the water table rises enough).

This is why:

- a damp-proof membrane (DPM) such as polythene is required under a slab
- a damp-proof course (DPC) is required under bottom plates or other framing in contact with concrete.

The DPM or DPC provides a vapour barrier, effectively stopping vapour and liquid transport across the concrete and hardfill interface.

Convective transport

Convective transport of water vapour is where moisture laden air is transported as a result of airflow from one area of a building to another. If that moist air happens to come into contact with materials at a temperature below the dew point of that air, condensation is likely to occur.

Recent BRANZ research published in Study Report 344 *Vapour control in New Zealand walls* and in *Build* 147, *Water vapour in walls* has clarified the processes describing vapour migration in walls.

Figure 3: Water draining from laps visible on weatherboard face in test sample.

Pressure differences

Air will always move from an area of higher pressure to lower pressure – wind is a classic example.

Managing wind-driven rain

If it is windy and raining at the same time, wind-driven rain will impact on a building with a force dependent on the wind speed and direction and the intensity of rainfall.

Wind-driven rain is managed by using:

- cover or laps such as the 32 mm bevel-back weatherboard lap or the laps in corrugate profile steel cladding
- the deflection and cover provided by head and inter-storey flashings
- clearances like those required between the bottom of a cladding and the ground or a flashing
- screening
- flashing
- sealing with sealant
- baffles
- rainscreens.

Capillary bridge

Another situation where air can carry liquid water is where water bridges between two materials as a result of capillary action. If enough pressure difference is applied across the gap, the liquid water can be forced up and over the top of any upstands present, across a weathergroove or through the lap in a weatherboard.

An example of this in application is a head flashing. Maintaining a 5 mm minimum clearance between the bottom of the cladding and the head flashing is crucial to ensuring that water does not bridge the gap and get forced inwards by wind pressure differences.

Air seals reduce airflow

A similar effect is where water entrained in air is pulled through a joint in the structure due to the airflow created by a path from the higher outdoor pressure to the lower indoor pressure.

This is why we install a continuous air seal around the back of window reveals. The cavity around a window is likely to get some liquid water in it during its service life, which will usually drain down to the flashing tape.

Without the air seal reducing airflow, the local air velocities can get high enough to carry these water droplets all the way to the inside of the building.

A step too far

You can take this too far though - a reasonable clearance still needs to be maintained around the reveal. Completely filling the entire gap around a window frame or reveal with expanding polyurethane or similar foam creates a very effective location for capillary-transported water to accumulate.