INTRODUCTION

Many people in NZ believe that concrete is the most durable material for the outside of the building. While that may be true in terms of impact resistance and structural strength, there are a lot of other things to consider when using it as cladding rather than structure.

HOW TO DESIGN DRY DURABLE PRECAST CONCRETE CLADDING

WHAT IS CONCRETE?

Let's start from the beginning: The concrete itself is made up of aggregate (sand and gravel), cement (the active ingredient that makes it solid), and water (to activate the cement). The ratio of those three materials in addition to admixtures such as fly ash, waterproofing chemicals, or superplasticiser is what changes the properties of the mix (higher or lower slump/viscosity) and it's what influences the solid concrete after curing to make it harder, softer, more or less dense, stronger or more waterproof, etc. Not all concrete is equal, and your mix design needs to be appropriate for where it's being used. Standard structural concrete is generally around 30MPa of 28-day strength with around 110mm of slump.

Most concrete you see day-to-day is also reinforced, which means there's a steel skeleton inside it to increase its strength in tension or bending, because concrete itself is strongest when it's being compressed. This steel relies on the concrete around it to keep it safe and dry to prevent the steel from rusting.

NOW THAT WE KNOW WHAT CONCRETE IS, WHAT IS PRECAST?

Well, the easy answer is that it's concrete that is cast before being brought to site. Formwork is built in a yard or warehouse, reinforcing steel (reO or rebar) is installed usually in a lattice pattern, and then the concrete is poured and allowed to set and cure for about a month to reach its design strength. Usually, steel mounting brackets are cast right into the concrete, and then those are secured to mounting brackets attached to the main structure of the building. Now that the concrete is attached to the building, job done, right? Not if you want it to be dry and durable, because you need to think about how those panels manage water from both the exterior and interior.

From the exterior, we need to prevent water from entering the building. That means choosing the right sealant joints, concrete junctions, and penetrations of course, and we also need to protect the reinforcing steel with enough concrete cover, but that's already standard practise. What we also need to consider is what happens to the concrete as it ages and naturally becomes more brittle. Cracks bring water into the concrete, and textured surfaces tend to make the concrete more absorbent, so choosing the right mix, texture, coating, and maintenance schedule is key to increasing that durability.

From the interior, we need to make sure that the relatively moist interior air doesn't go through the interior finishes to touch the cold concrete and form condensation. This issue could look like a leak that is impossible to fix, but the water source might be from the interior rather than rain.

HOW TO DESIGN DRY DURABLE PRECAST CONCRETE CLADDING

OUR GENERAL RECOMMENDATIONS ARE

ONE

Make sure the precaster knows the difference between structural precast and architectural aesthetic precast and has a different procedure for each. They should be able to help you specify a good quality exterior finish, because the way the concrete is mixed, formed, set, cured, and finished is super important. The better the concrete, the more waterproof and durable it will be and the better it will look long term.

TWO

Add a good coating and/or waterproofing admixture. For a coating, you want it to repel water but more importantly you want it to be vapour permeable. Over time, the coating will break down and the concrete will absorb water. If the coating is vapour permeable, it will last longer because it allows the concrete to dry out easily without creating the bubbles and blisters that you see on most painted concrete in NZ. We recommend paints with a vapour permeability of around 500ng/(Pa s m2) or around 10 US Perms or sd value of below 0.35m equivalent air layer. If you'd prefer a clear coating, we recommend a silane or silicone emulsion coating which look better and last much longer than the more common siloxanes. In terms of admixtures, there are plenty to choose from as a redundant backup, but we've seen some concrete that forms weird patterns on it when wet, so we generally recommend a coating to keep it dry to begin with.

THREE

Design good joints. Our preference is a dual stage sealant joint with drains (see next page). The interior joint is fully sealed for the airtightness, and the exterior one is for weathering, which means it needs to have drains for any water that might eventually leak through. For the exterior sealant which is exposed to the sun, always choose a 100% silicone because silicone is UV stable whereas hybrids and polyurethanes are just UV resistant and therefore eventually break down and need replacement.

FOUR

Maintain the assembly. The NZ concrete masonry manual states that precast needs to be inspected annually and repaired as soon as any deterioration is found. This is to catch small cracks and moisture issues so that they are repaired before they become a much more expensive and difficult problem. There should be a plan to repaint/reseal every 15 or so years, but if good assemblies and products are specified and installed, the wall could last much longer without any work.

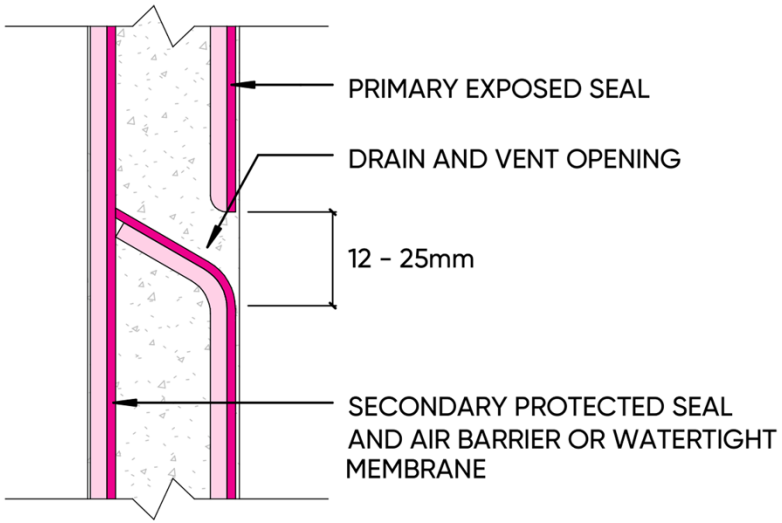
FIVE

Control condensation. Because concrete is a very effective thermal mass, once it gets cold overnight or during the winter, it stays cold for a while, and we all know that cold surfaces are where condensation likes to collect. So if you have a piece of cold concrete in your wall and interior air is able to get through the gypsum board and insulation to the concrete (like in a strap and lined wall), you'll get condensation inside the wall assembly. You can prevent that by either keeping the concrete warm (by moving the insulation to the exterior side), or by putting an airtight vapour control layer on the interior side to stop interior air from getting to the concrete. This could be with a vapour control membrane or it can be done with something like XPS or foil-faced PIR with taped seams, penetrations, and edges. A full layer of rigid insulation gets installed hard up against the concrete (see page 4), and then studs/straps get installed inboard of the insulation to create a service cavity. The interior side of the rigid insulation will be warm and above the dew point temperature, and the air seal keeps interior air from touching the concrete. Problem solved at the source.

DETAILING FOR E2 EXTERNAL MOISTURE

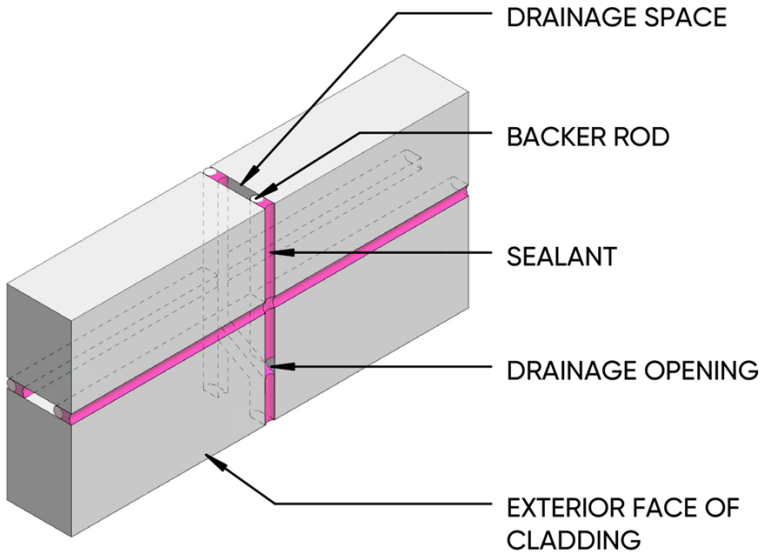
SECTION THROUGH VERTICAL JOINT

This type of dual-stage joint is standard in North America and popular in Europe. The light pink is the backer rod and the dark pink is the sealant. The joint on the left gets installed first from the exterior with a long nozzle and acts as the continuous air seal. The joint on the right is the silicone weather seal, which is discontinuous and has a sloped drain installed just below each horizontal joint to allow for drainage and drying.



ISOMETRIC

As you can see in this drawing, the precast panels do not have the sloped step horizontal joint or baffle chases that are typically used in NZ. This is because the interior side sealant is continuous (because it's installed from the exterior instead of being interrupted by the floor slabs or fixings), and because the exterior joint is properly drained. This may seem much more complicated because of the fancy silicone sealant joints, but it makes the precast concrete panels much more economical, because every turn, chase, and slope is extra time and formwork.



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CONCRETE CLD - DRAINAGE CAVITY

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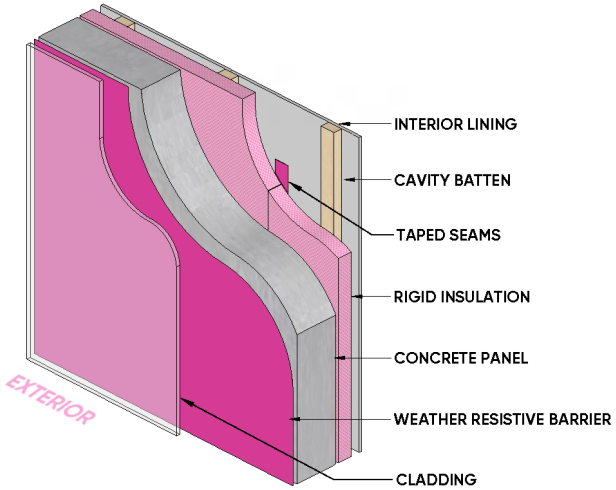
CONCRETE CLD - DRAINAGE CAVITY ISOMETRIC MODEL

DETAILING FOR E3 INTERNAL MOISTURE

INTERNALLY INSULATED WITH RIGID INSULATION

As mentioned on the second page, one way of controlling condensation in a concrete-clad wall is by putting an airtight and vapour-tight layer on the inside of the concrete to ensure interior air never touches a cold surface. As you can see, the insulation is continuous with taped joints, and a service cavity is formed with the timber (or steel) battens/studs holding the gypsum board. Another option would be using an insulated gypsum board, but that assembly doesn't accommodate electrical or plumbing very easily. In the detail below we've included an optional WRB and cladding, but the exterior finish is up to you.



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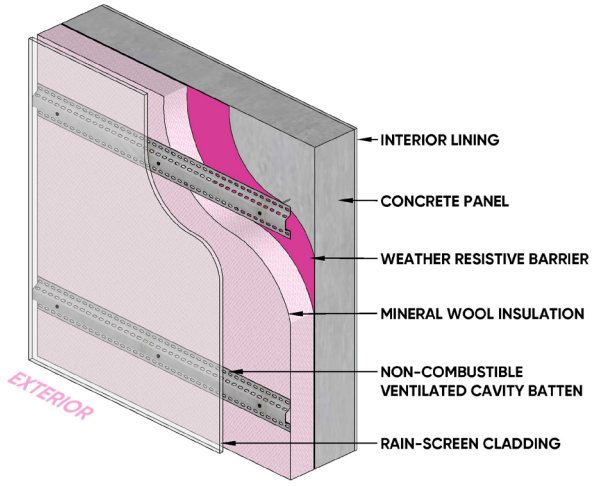
CONCRETE WALL ASSEMBLY WITH INTERNAL INSULATION

EXTERNALLY INSULATED WITH RIGID INSULATION PLUS CLADDING

As a bonus, we've also added in an externally insulated precast wall with cladding over it. (EIFS is another similar option). We've listed it last, but it's certainly not least (this is actually our preferred concrete wall assembly). With this assembly, the insulation is fully external, which keeps the concrete warm and dry and uses the thermal mass of the concrete properly. It also deletes the need for sealant joints in the concrete (unless you need them for fire), and it allows you to leave the interior side of the concrete exposed or plastered so your client can save money on gypsum board. This one is slightly more complicated to detail/consent because it's not shown in E2/AS1 yet (ask us if you need help), but it's the driest, most durable, and most comfortable assembly you can use on concrete walls.



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CONCRETE WALL WITH EXTERIOR INSULATION AND RAIN SCREEN CLADDING

OTHER TIPS AND TRICKS

Now, we acknowledge that there are a lot of ways to design and install precast concrete joints. Our suggestion of a dual stage drained sealant joint on page 3 isn't the only way. We just think it's a very efficient and durable methodology.

The typical installs we've seen here in NZ have stepped horizontal joints, an air seal from the interior, and on the exterior there is either a baffle joint or a face sealed sealant joint. This type of assembly works well enough, but leaves a lot to be desired in terms of airtightness and durability. Why? Well, if you install an air seal from the interior, it's very difficult to get a continuous sealant joint across a slab edge. And if you're face sealing from the exterior without any drains or weep holes, there's chance your walls will start to collect water once the concrete and sealants start to crack over time.

So if you can't convince the project team to get on board with the square edge panels and fancy sealant joints, here's a list of things to ensure while designing your concrete cladding:

ONE Ensure you have a redundant seal. Either two sealant joints or an interior sealant joint and exterior baffle, or a sealant joint and a compressible foam seal.

TWO Put drains in the exterior seal at or just below the intersection of the horizontal and vertical joints. Make sure infiltrated water can get out.

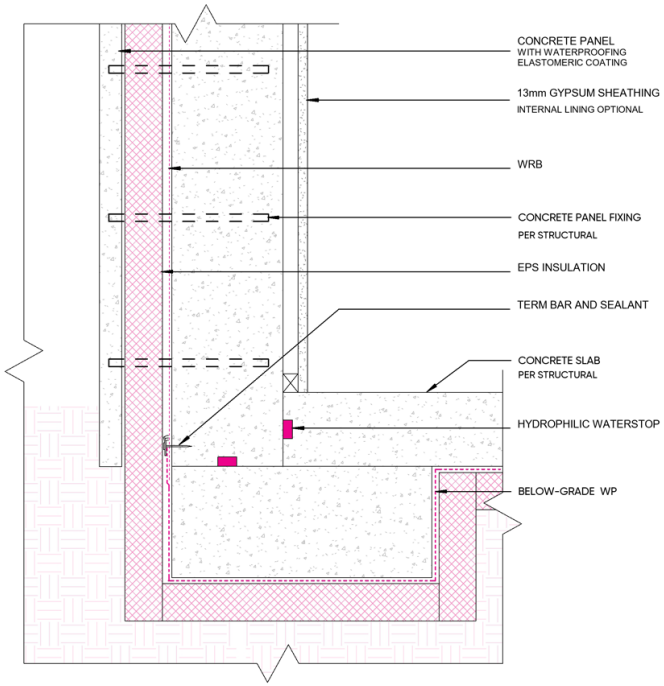
THREE Make sure that exterior seal is 100% silicone. The one most commonly used for facades is only rated for 10-15 years if it's painted.

FOUR Ensure the interior seal can be made continuous past the slab edge. Either with a gap or by sealing to other components.

FIVE Ensure you have a vapour permeable paint or seal on the outside, and make sure you sequence the coating and sealant properly depending on compatibility.

SIX Ensure that the owner of the building knows they must inspect the concrete yearly, and recoat it every 15 or so years (depending on coating)

SEVEN Consider using an insulated concrete panel, which has structural concrete on the inside, aesthetic concrete on the outside, and a layer of insulation between. (See below)



CONCRETE INSULATED PANELS

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PRODUCT SUGGESTIONS

You might be wondering if any of this stuff we've suggested is available in NZ. We wouldn't suggest products that are impossible to find, so here's a list of a few we've used before.

SILICONE SEALANTS FOR MASONRY

- ShinEtsu Admil 41LM
- Dowsil 790 or 791
- Tremco Spectrem 1 or 2
- Sika Sikasil C or WS605s
- Bostik All Purpose Silicone

VAPOUR PERMEABLE PAINTS

- Sto StoColor range of paints
- Sika SikaGard 550-W Elastic
- Other paints with water vapour permeability at or over 500ng/(pa s m2), over 10 US Perms, or a permeance below an equivalent air layer thickness (Sd) of 0.35m. If the data sheet doesn't say, ask the manufacturer for testing, or use a different product.

SILANE SEALERS

- Sto Stoclear
- BASF/Masterprotect H1000
- Sika Sikagard 740W
- Markham Aquaron 2000 (actually a silicate hydrogel, but works similarly)

STUCCO-STYLE COATINGS

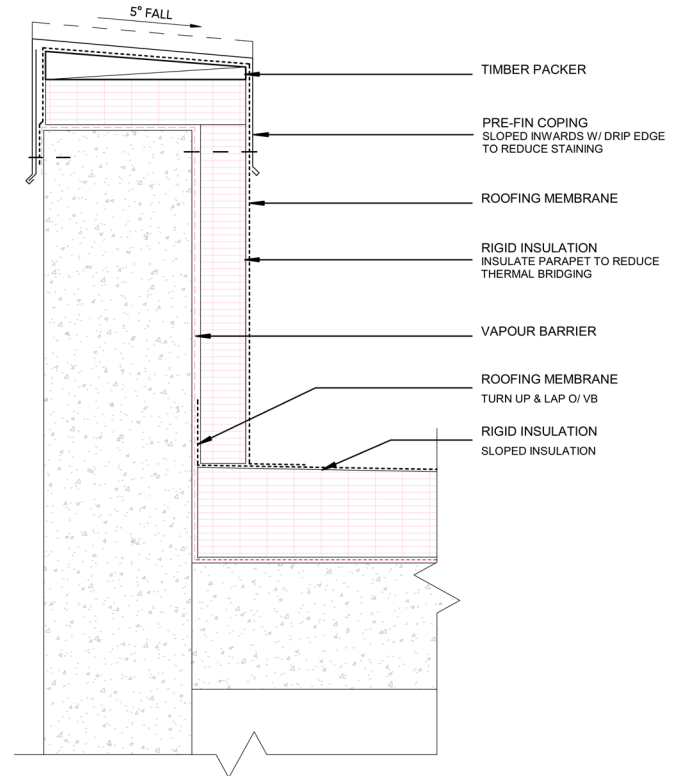
- Sto StoArmat or Stotherm

OTHER TIPS AND TRICKS

Other items that need to be considered for concrete walls are the penetrations and terminations. Some easy rules of thumb are:

ONE

If you have concrete projecting above the roof to form a parapet, take the membrane (both vapour barrier and roofing) over the top and put a cap flashing to protect it. Sloping the flashing inwards reduces the amount of staining on the exterior, and drip edges on both sides of the flashing help reduce staining even further.



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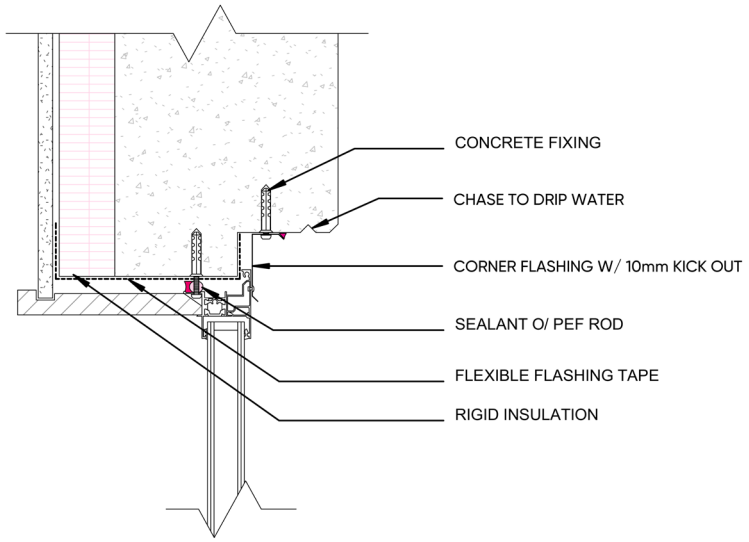
OTHER TIPS AND TRICKS

TWO

Carrying the insulation up and over the parapet reduces the amount of thermal bridging (less uninsulated surface area means less heat loss), and you always want to make sure your roofing membrane and vapour barrier membrane meet up at terminations to prevent air and moisture infiltration into the insulation.

THREE

You need drip edges or capillary breaks for horizontal overhangs (like the head of a window). This is to make sure water drips away rather than rolling back and onto your window joints.



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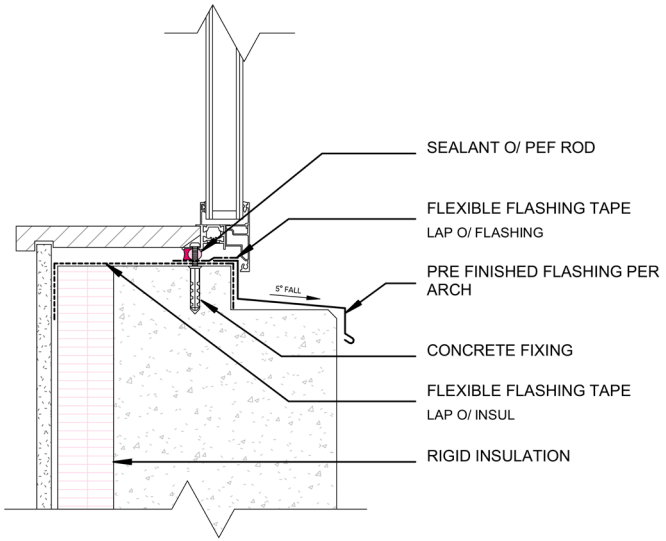
RECESSED CONCRETE WINDOW HEAD

FOUR

For the sill, it's best to have a drip flashing to minimise absorption and staining.



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RECESSED CONCRETE WINDOW SILL

Disclaimer: we don't really like this type of detail very much, because there still could be some interstitial moisture issues around the window. We've only included it because this type of install is asked for fairly often and we've tried to improve it as simply as possible. To make it even better, you could add a layer of insulation into the opening under the timber liner and use the flashing tapes to create a dam against any water or condensation entry.

For more information please contact
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