Dincel Compliance Brochure

Civil & Infrastructure

Dincel Structural Walling is an internationally patented permanent polymer formwork system which allows for easy placement of steel reinforcement and ready-mix concrete. The formwork system is delivered to site in panels and these are clicked together to construct the shape of the wall.

As Dincel is purely a formwork material, the concrete and steel reinforcement inside can be designed, ordered and placed to comply with the relevant transport concrete specifications and requirements (such as RMS B80, Vic Roads 610 and QLD Transport and Main Roads MRTS70).

This document herein provides details relating to the performance and compliance of the Dincel polymer formwork itself. If you require further information on how to comply with the requirements set by transport authorities, please contact Dincel Civil Solutions at:

enquiry@dincelcivilsolutions.com.au

1. Fire Performance

AS ISO 9705 Room Test

performed by Warringtonfire (NATA accredited laboratory)

- Group 1 Rating (the highest/best classification)
- SMOGRA of 14 (7 times under the NCC limit)
- Tested as an entire wall system (not just the PVC skin) to determine actual behaviour
- Video of test: https://youtu.be/X-45ymnRAl8

AS 1530.4 Fire Resistance Tests

- Exceptional Fire Resistance Level (FRL) of up to 240/240/240 – tested at CSIRO
- Joint and Penetration specific tests – tested at Warringtonfire. No requirement to remove skin underneath fire rated caulking and fire collars.

AS 5113 / BS 8414 Façade Test

performed by Warringtonfire (NATA accredited laboratory)

- Certified by Consulting Fire Engineers to be suitable for external façade walls which require to be non-combustible
- Tested as an entire wall system (not just the PVC skin) to determine actual behaviour
- Video of test: https://youtu.be/Ry4hXJDyN14

Bushfire Attack Level (BAL)

- Assessed by CSIRO and confirmed as suitable for use in bushfire conditions of up to Flame Zone (FZ), which is the most severe rating.

AS ISO 9705 Room Test
Constructed from Dincel walls (including slab over)

AS 5113 / BS 8414 Façade Test
Constructed from Dincel walls

2. Structural Performance

Dincel structural walling is a permanent formwork system which when filled with concrete will result in a structurally sound concrete wall. The concrete and steel reinforcement inside can be designed by an engineer to AS 3600, Eurocode or other relevant design codes. For design purposes, the presence of the polymer formwork is removed and the engineer designs with the remaining effective concrete thickness. Therefore, a structural engineer can design Dincel walls to meet project specific requirements in the same manner as a conventional concrete wall. This design methodology has been verified by:

- The University of New South Wales (UNSW). Refer to the full report on our website which also discusses how crack control streel reinforcement and crack control joints can be omitted with Dincel walling.
- The University of Technology Sydney (UTS).

Steel reinforcement arrangements in the wall can be catered to suit design requirements, including reinforcement each face both horizontally and vertically if required.

2.1 Earthquake Testing

Dincel Structural Walling has been put through an extensive testing and assessment regime in 2010 with The University of Technology Sydney (UTS) to determine the adequacy of the system (200mm profile utilised) in seismic regions. The tests include:

- Shake table simulations
- In-plane horizontal shear push over tests

The test results and accompanying analysis confirms the suitability of the Dincel system to resist large lateral forces and resulting displacement caused by major ground motions measuring up to 9.0 on the Richter scale. The permanent polymer shell achieves this by working in conjunction with concrete and steel reinforcement to provide ductile composite action to the wall. In addition, there is also further seismic testing currently underway at The University of Technology Sydney (UTS) utilising the 275mm Dincel profile to investigate the profile's substantially increased capacity.

2.2 Early Backfill Capabilities

The 275mm Dincel profile contains a unique cylindrical webbing which provides the formwork with superior strength and allows for walls to be backfilled incredibly early (within 24 hours).

The following tests were conducted to verify this:

No Concrete Infill – Test

- Simulates 3m high, 275mm Dincel with no concrete infill.
- Sandbags replicate loading of backfill (3 tonnes total).
- Replicates adequate bracing at bottom and two thirds of the wall.
- **Result – 275mm Dincel's unique webbing can resist 3 tonnes of weight without concrete infill.**

Concrete Infill after 24 hours - Test

Further to this, strength tests at The University of Technology Sydney (UTS) are currently being conducted. One test is outlined below:

- Simulates 3m high wall with significant loading.
- Test was carried out 24 hours after concrete pour. The concrete strength at this time was only measured as 5MPa (mix was 32 MPa @ 28 days).
- No steel reinforcement was inside the test specimen.
- **Result – Specimen was able to withstand a load of 58 kN (5.8 tonnes). In a non-test condition (i.e. vertical wall), the wall would have further capacity as there is no 'self-weight' which increases wall loading.**

3. Minimum 120 Year Life

Transport authorities typically require a long design life for products used on road and transport assets, sometimes up to 120 years. This requirement can be satisfied with Dincel walls. A Dincel wall is a concrete wall with an additional PVC skin. This skin is not only 'lost formwork' but also has the additional benefit of acting as a protective membrane. This means the predicted life of a concrete wall is only further enhanced with the Dincel skin.

As has been known for centuries, concrete structures have exceptionally long life-spans. In recent times, steel reinforcement has been added to concrete in order to increase the tensile capacity. However, once the concrete is subject to unavoidable cracks, the steel reinforcement is susceptible to corrosion and this can result in a premature lifespan of the concrete structure. As Dincel walls provide the concrete with a waterproof protective skin, it eliminates the risk of corrosion to steel reinforcement or concrete degradation and therefore allows for an exceptionally long life-span, which can conservatively be a minimum of 120 years.

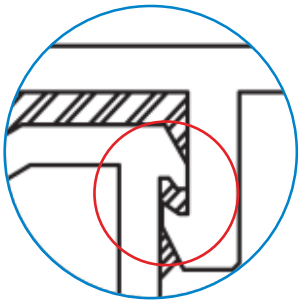
For the designer, the simplest approach is to design for the durability of Dincel walls assuming it is a raw concrete wall (i.e. using the same required concrete cover, concrete grade, etc as would be used for a conventional concrete wall). The concrete and steel reinforcement specified will be protected by the Dincel polymer skin, only further improving upon the original design life. This will provide the designer with assurance that the structure will exceed the durability requirements of the project due to the protective skin. It should be noted that this is a very conservative approach, as Dincel walls can in fact be designed to use much less embodied energy than a conventional concrete wall (i.e. less steel reinforcement, lower concrete grade and use of supplementary cementitious materials).

3.1 Waterproof Dincel Skin

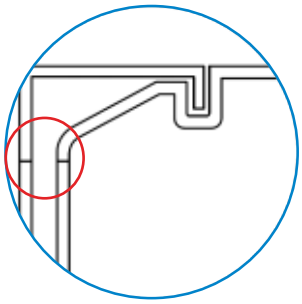
Raw Dincel panels along with snap-lock joints, when filled with concrete, are waterproof for up to 6m of water head pressure. The following tests were carried out by CSIRO to validate this:

- ASTM E514-05c: Water did not penetrate the unsealed panel joint. **Pass**
- AS/NZS 4347.1: 6kN head pressure, water did not penetrate the unsealed panel joint. **Pass**
- ASTM E 96/M: Water vapour transmission was found to be **180 times better** than the requirement for a waterproof membrane.

The watertightness at Dincel panel joints is attributed to the patented 'snap-lock' connection consisting of barbs. The joint mechanism ensures waterproofing through the following:



Patented Dincel barbs and slurry invasion proven to provide waterproof joint



6mm gap between panels only allows slurry to enter (not coarse aggregate) - slurry fills all possible gaps

Min 180mm slump concrete to ensure compaction and eliminate air voids

CSIRO were able to achieve the waterproof wall by using a 110mm concrete slump. It should be noted that Dincel recommend a minimum 180mm slump to alleviate any concerns over concrete compaction and subsequently ensure waterproofing. The Dincel 275mm profile is recommended for submerged conditions due to its tolerance to high-slump concrete.

Conservatively speaking, controlled micro-cracking can occur at panel joint locations within Dincel walling (refer to UNSW system certification on our website). These minute cracks are protected within the waterproof skin and joints of the system. However, even if water were to somehow penetrate through the joint, autogenous healing will always take place to protect the horizontal steel reinforcement. The horizontal reinforcement within would also have adequate concrete cover, just like a conventional concrete wall.

3.2 Durability of Dincel PVC Skin

In a recent independent study by the Sustainable Solutions Corporation in 2017, it was found that PVC used in the water and sewer pipe industries conservatively has a service life of over 100 years. This life expectancy will only be increased for the PVC used with Dincel walls as they are not subject to cyclical loading of water pressure. The key findings of the study are as follows:[1]

> "PVC pipe has a 100-year plus service life as verified by numerous studies and dig ups"

> "PVC gravity pipe has the lowest 100 year life cycle embodied energy – no replacements, no infiltration and no corrosion protection compared to other materials"

This demonstrates that the Dincel PVC skin will not deteriorate or dissolve even in underground or submerged settings and will achieve a 100-year life for most project conditions. In fact, some studies detail that under low stress conditions, PVC life can be over 1,000 years.[2]

[1] Sustainable Solutions Corporation, 2017. Life cycle assessment of PVC water and sewer pipe and comparative sustainability analysis of pipe materials, p. 72, Sustainable Solutions Corporation

[2] Janson, L.E., 1996. Plastic Pipes – How long can they last?, KP Council

Part of the reason why PVC has an exceptional life span is due to its known chemical resistance. The Dincel skin in particular has been tested against the following liquids and chemicals:

- Petrol
- Diesel
- Sulphuric acid, phosphoric acid, hydrochloric acid and nitric acid

This demonstrates that the Dincel polymer does not readily degrade or deteriorate even in the presence of harsh chemical exposure and thus suitable for applications which requires contact with acid sulphate soils.

For above ground conditions it is important to consider the effects of ultraviolet (UV) radiation. Resistance of the PVC skin against UV radiation is only a consideration when there is no finish applied. However, even when left raw the Dincel polymer does not readily degrade when exposed to UV due to natural inhibitors used within the PVC composition (titanium dioxide/ TiO2). UV radiation causes an excitation of molecular bonds to the exposed face, which only affects the first few microns of the 2500 micron skin. The effects of this are:

- Loss of gloss, progression to chalking and discolouration (yellowing). This is only an aesthetic concern, and easily mitigated if required by applying a finish.
- An increase in tensile strength, yield strength and moduli, which subsequently increases the possibility of a brittle type fracture. As Dincel walls contain solid concrete on the inside, any impact onto a Dincel wall is absorbed by the concrete infill and not the PVC (unlike a hollow pressure pipe subject to cyclic loading). Therefore, the skin of Dincel walls will be largely resistant to brittle type fractures (if it is even exposed to impact loads in the first place).

The above demonstrates that whether above ground or below ground, a minimum 100 year life can be achieved with Dincel walling. By ensuring no water or contaminants enters the wall, **the durable PVC skin further enhances the long 100 year life span already capable of being achieved by a conventional reinforced concrete wall.**

4. Concrete Compaction

Dincel walls can eliminate some of the air-void/ compaction issues associated with other types of permanent formwork systems:

- Dincel polymer forms are non-hygroscopic, meaning it does not absorb moisture from the concrete mix while it is being poured. This ensures no friction between the concrete mix and the formwork itself, allowing for the easy flow of concrete throughout.
- Dincel formwork allows for the use of high-slump concrete (180mm+). When coupled with adequate vibration, concrete compaction issues are not possible. Self-compacting concrete can also be considered.
- Segregation is eliminated by pointing the concrete pump nozzle towards the Dincel webs, which prevents the free fall of concrete. Alternatively, a tremie can be used if required.

The Dincel system has been proven over 15 years to demonstrate that air voids and segregation does not occur if the above measures are used (see below test images as an example). For critical applications, Ground Penetrating Radar (GPR) technology can be utilised to scan the walls and ensure that there are no air voids. If required, please contact us for further information on the QA processes surrounding concrete compaction.

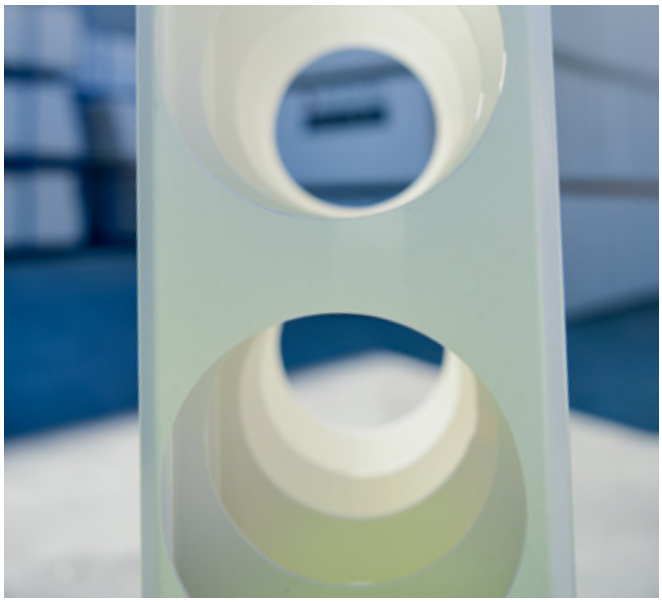
4.5m wall height, single pour, 200mm slump concrete. Concrete sample cored out.

Reinforcement each face, both vertically and horizontally.

No air voids, honeycombing or segregation.

5. Stray Current Corrosion Protection

Stray current corrosion is a known condition exhibited by structures close to electric railway systems. If the electrical current from the railway finds its way to steel reinforcement within concrete, corrosion can occur. This problem is eliminated with Dincel walls due to the protective, waterproof, and electrically insulating PVC skin acting as a membrane to the concrete and steel reinforcement inside the wall.



6. Environmentally Friendly Construction

- All Dincel polymer panels and accessories are BEP (Best Environmental Practice) certified.
- The polymer PVC used is heavy metal stabiliser and plasticiser free.
- Cement production is known as one of the largest contributors to carbon dioxide (CO_2) emissions on Earth. Dincel walls offer the option to replace some of the cement content in concrete with cementitious materials such as untreated fly ash, as the protective Dincel skin eliminates the durability concerns commonly associated with these substitutions. Previous Dincel projects have successfully replaced up to 50% of cement content with fly ash.
- Sustainability study has been completed by The Natural Step.
- Swinburne University has conducted a review of Embodied Energy benefits.

7. Health & Safety

- Volatile Organic Compounds (VOC) emissions are well under Green Star thresholds.
  - VOC of 0.02 when newly manufactured (limit is 0.5)
  - VOC below detection limit after 30 days (limit is 0.5)
- The lightweight formwork reduces requirements for heavy lifting. Panel weights are within WHS requirements for safe lifting by one person.

8. Concrete Curing

Dincel walling exceeds the strict concrete curing requirements often set from transport authorities by providing permanent polymer encapsulation and thereby preventing the evaporation of moisture. This allows for the maximisation of concrete strength and no plastic shrinkage.

9. Other Credentials

- ISO 9001:2015 Quality Management System

For more information

visit dincelcivilsolutions.com.au
or call 1300 DINCEL