DINCEL
STRUCTURAL WALLING

Australian Waterproof Basement Construction

Beyond British Standard BS8102-2022

Index.

This document has been prepared by Burak Dincel, Chairman and Founder of Dincel Construction System Pty Ltd, with the intent of providing pertinent information for specifiers and for consideration by the relevant Australian Authorities in the development of the proposed basement construction code.

A. Introduction.

Building walls above or below ground consisting of concrete and steel reinforcement require protection to prevent water/moisture ingress to avoid steel reinforcement corrosion (which leads to a premature building life). According to research from Curtin University of Technology, corrosion may be costing the Australian economy more than $30 billion annually.[1]

Water ingress also causes damage to stored goods, mould, mildew development and sick building syndrome (i.e., an internal environment is created which causes health complaints). [2 &] [3] Mould/mildew can grow in any place with sufficient source of moisture, organic feeding material and oxygen.

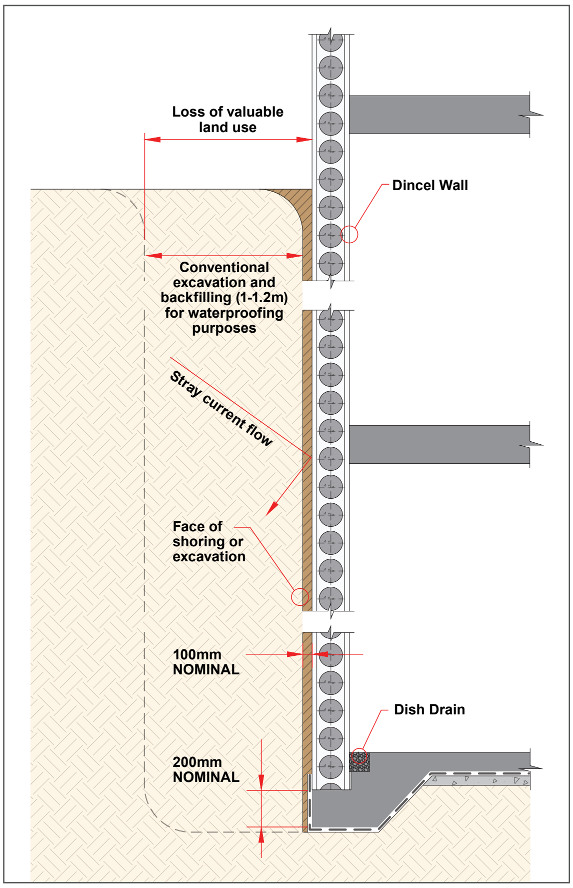
Water damage incidents account for almost a quarter (24%) of all home insurance claims, according to leading insurance provider QBE. [4]

Currently, Australia does not have a basement construction code/standard. Many Australian professionals have followed BS 8102:2009 – British Basement Construction Standard, which has subsequently been replaced with BS 8102:2022.

Australia is currently preparing it's own basement construction code. BS8102-2022 Type B, C and Grade 1 use as shown below allows water/moisture ingress into the basement area. The following isues are therefore NOT addressed in BS8102-2022:

- **Mould/mildew prevention which is a mandatory Australian NCC-2022 requirement since 1 October 2023.**
- **Basement pump-out systems are considered energy-inefficient and require maintenance.**
- **Basements functioning relying on maintenance generates significant sustainability problems.**
- **NSW Government Water Management Act 2000 (and similar acts in other Australian States).**

B. Typical Dincel Wall Basement.



A CORRECTLY DESIGNED AND INSTALLED DINCEL WALL CAN AVOID:

- Loss of 1.0m wide land use
- Waterproofing need for the wall
- Stray Current Corrosion damage
- Additional unnecessary excavation and backfilling
- Wall joints at normally 8m centres
- Agricultural lines, if wall is designed for hydrostatic pressure
- Conventional deep footings required for ground movements
- Horizontal wall reinforcement for crack control purposes
- Scaffolding when installed from a deck
- Painting of the internal wall face
- Cleaning costs, wastage
- Wall cracking, water ingress, rot, decay damage, termite treatment

DINCEL WALL ALSO ALLOWS:

- Minimum 120 years wall life
- Faster, Stronger and Cheaper basement walls in comparison to precast, in-situ concrete, reinforced masonry walls
- 275 Dincel allows backfilling up to 3m height 24 hours after concrete placement
- Waterproof Warranty up to 50 years

An appropriately installed Dincel Wall, in accordance with the Dincel Construction Manual, will satisfy British Standard B102:2022 as evidenced by the following reports.

TESTS AT CSIRO

The leading Australian Research Institution, CSIRO test report No:5091
confirms that a wall cannot be considered waterproof unless it complies with the following tests collectively:

1. ASTM E 514 – 08, Standard Water Penetration Test on Façade/Shower Walls.

2. AS/NZS 4347.1:1995, 6m Head Water Pressure Test at Dincel Panel Joints.

3. ASTM E 96/M, Vapour Transmission, Standard Membrane Test.

One of the CSIRO tests, which showed zero leakage with 6m head of pressure applied for 100 hours at the Dincel Panel Joint, was conducted on a 1800mm tall wall which was unrestrained at the top.

The test results demonstrate;

- ✓ That the Dincel PVC skin is at least 180 times less porous compared to the requirement for a conventional membrane.
- ✓ That the Dincel panel joint, subjected to 6m of water head pressure, did not display any water penetration on the opposite face of the test panel.

Scan or click the QR Code to download the full test report

ADDITIONAL TESTS FOR DINCEL UNDER THE SUPERVISION OF A NATA REGISTERED LABORATORY

In addition to the tests carried out by CSIRO, testing has also been carried out to AS 3735. The purpose of this testing was to confirm that under real life conditions the Dincel panel joints are waterproof, and that the Dincel Wall to footing/slab junction is liquid tight to the requirements of AS 3735.

3.3-metre-tall water tanks, of 2.3m x 2.3m in plan area were constructed, and the tanks were then tested under various conditions. In one of the tests the tank was filled up with 3 metres height of water, and as confirmed by the NATA Registered Laboratory, zero (0) leakage was demonstrated.

Scan or click the QR Code to watch the test video

Scan or click the QR Code to download the full NATA report

EXPERT OPINION - ACOR CONSULTANTS

Authored by Mr Sam Parker of ACOR Consultants, this report verifies the Dincel Wall in relation to water-tightness.

Scan or click the QR Code to download the full report

C. Understanding British Standards BS8102-2022.

BS 8102 is, by many experts, the most widely adopted guidance document used in Australia for the waterproofing of below-ground structures. The current version of BS 8102 is 2022. The British Standard is not a design Standard comparable, say to AS 3735 or BS EN 3:2, but it does nevertheless provide guidance on means of achieving protection using three different types of waterproofing techniques. BS 8102 advocates a risk-based approach to determining the recommended level of protection.

BS 8102:2022 – Clause 6.2.1 explains that one or a combination of the following types of waterproofing techniques are noted;

Type A (barrier) protection;

Waterproofing of basement structures is predominantly, but not solely, undertaken on the blind-side of the structure by placing a bonded or un-bonded sheet membrane on top of the ground stratum prior to placing concrete on top of and beside the membrane. The idea is that the waterproof sheets create a barrier between the concrete structure being protected and permanent and/or temporary water build-up in the ground.
The membrane system of Type A barrier covers both slab on ground and the basement wall. This system relies on the effectiveness of installed membrane system. This type of system is called a Type A barrier which is commonly referred as Full Tanking System in the Australian Construction Industry. This is the only true protection.

Type B (structurally integral) protection;

Type B systems are essentially structurally integral barriers. That is, the watertightness of a structure which contains a Type B system assumes that the structure itself is impermeable. Chemical additives are usually added to the un-hardened concrete mix to produce low-permeability, low-shrinkage concrete. It is typically supplemented with appropriate footing slab-wall joint detailing.

The most common cause of waterproofing breaches in Type B systems include poor concrete quality, excessive movement at joints, and flexural/shrinkage cracking. Therefore, special attention needs to be paid to joints and positioning of water stops. In addition, great care is required when placing and compacting the concrete. Placed concrete quality and effective vibrator use are considered as potentially major problems in concrete structures. To combat these issues Japan introduced Self Compacted Concrete (SCC) circa 1980 even when their workmanship skills were considered highly developed.

Type C (drained) protection;

Type C systems assume that water will enter the structure and aims to manage the ingress so that it does not manifest on faux (finished) surfaces. Type C systems rely firstly on water being resisted by the concrete structural elements, and where ingress does occur, it collects it in a formed cavity between the external wall and a "faux" internal lining/wall.

Type C systems typically remove water via a mechanical pump system, or occasionally by gravity to lower ground.

Historical records of these conventional attempts to restrict water ingress have failed regularly.

Table 2 — *Waterproofing protection – Grades of performance for below ground spaces*

Grade[A)]	Performance definition
1a	Seepage[B)] and damp areas[C)] from internal and external sources are tolerable, where this does not impact on the proposed use of below ground structure. Internal drainage might be necessary to deal with seepage.
1b	No seepage[B)]. Damp areas[C)] from internal and external sources are tolerable.
2	No seepage[B)] is acceptable. Damp areas[C)] as a result of internal air moisture/condensation are tolerable; measures might be required to manage water vapour/condensation[D)].
3	No water ingress or damp areas[C)] is acceptable. Ventilation, dehumidification or air conditioning necessary; appropriate to the intended use[D), E)].

A) The agreed grade should meet with the client's expectations for the intended use of the below ground space. Reducing the grade could increase the risk of not meeting the expectations of the client for the intended use of the below ground space.

B) Seepage (sometimes referred to as weeping) is defined in 3.15. If there is seepage, there is a possibility of mineral deposits forming.

C) Damp area is defined in 3.4.

D) The scope of this document is limited to detailing the process and best practices that can be followed when creating a waterproof or water-resistant structure below ground. The additional considerations that are required to achieve the required environment are beyond the scope of this document.

E) See BS 5454 for recommendations for the storage and exhibition of archival documents.

The above table is extracted from BS 8102:2022

D. Australian Authority Requirements Above And Beyond BS8102-2022.

1. National Construction Code (NCC) 2022 Requirement for Mould / Mildew ;

Authorities recognize that the ingress of water into a building could result in mould, mildew, and condensation development. As of 1st October 2023, the Australian National Construction Code has specific requirements targeted at minimizing and/or eliminating such eventualities. Australia aims to resolve mould/mildew issues, therefore the Seepage of water at the wall to slab/footing joints or vapour moisture/water ingress through the walls must be prevented.

The key to preventing mould / mildew growth at a basement is to prevent unwanted water entering a basement , limit the amount of water vapour released inside the basement and remove excess moisture by ventilation .

Mould/Mildew can grow in any place with sufficient source of moisture ,organic feeding material and oxygen, making particularly basement its little heaven. Mould produces tiny particles called spores. These spores are carried in the air until they attach themselves to airborne dust particles on a moist surface such as basement wall. The basements particularly used for carparking contain plenty airborne dust.

Compliance considerations the National Construction Code (NCC) 2022, a building is to be constructed to provide resistance to moisture from the outside and moisture rising from the ground (see Clause H2F2). The NCC does not make a specific reference to a standard for below- ground waterproofing. Above Table 2 from BS 8102 (2022) provides guidance regarding water ingress and dampness however, it does not appear to consider mould/mildew or other similar issues. **Particularly Grade 1, Type B and Type C without membrane protection of BS 8102:2022, contradict to NCC -2022 mould/mildew requirements as these walls most likely to produce excess moisture on the basement wall surface.** Considering NCC mould/mildew requirement that no water ingress should be allowed including carparking areas which will be more prone to mould development due to rather dust containing environment which is the source for mould spores at the presence of water/moisture. **Therefore, all Australian basements including carparking areas should be designed by adopting BS 8102 (2022), Type A (barrier) Protection to achieve Performance Grade 2 or Grade 3 to ensure there are no issues with building compliance or safety.**

2. Maintenance Affect Sustainability

- NSW Water Management Act 2000 requires licensing, and an ongoing maintenance program if water ingress into basement is allowed. On going Pump-out systems are considered energy-inefficient and require maintenance. The conventional concrete deterioration, leaking basement walls/slabs , agricultural lines , drainage systems, painting on the walls require maintenance

- The operation and maintenance phase of the building life cycle has the most significant environmental impact [see reference #12 in Science Direct report], accounting for the largest portion of embodied carbon emissions in the building sector, approximately 68% [see reference #13 in Science Direct report].

Therefore, the aim in the construction industry should be to minimize ongoing maintenance as much as possible .

Scan or click the QR Code to download the full Science Direct report

3. NSW Government (other similar State) Requirements:

The NSW Government document “Minimum requirements for building site groundwater investigations and reporting” highlights the importance of why ground water ingress into basements should be eliminated or minimized.

Scan or click the QR Code to download the full report

Paraphrasing the above report:

Constructing buildings with basements that require excavation will be aquifer interference activity if such excavation is below either the permanent or the temporary watertable level. Therefore, it is subject to the Water Management Act 2000, relevant water sharing plans and the NSW Aquifer Interference Policy. These apply even if the excavation does not intersect groundwater at the time of construction. For example, a building basement constructed under prevailing drought conditions – when groundwater levels are low – can receive substantial seepage inflows after completion if it is not entirely sealed and if prolonged wet weather causes the groundwater levels to rise. Similarly, climate change is causing water table levels to increase and basement conditions need to be considered for the life of the building.

Water ingress into the basement may be prevented by applying plastic sheet membranes. This is referred to as a fully tanked system which aims to provide Dry Basement Walls. The preferred solution of the Department of Planning and Environment (DPE), which oversees the Water Management Act, is a fully tanked system as outlined in Section 1.4 in the above document - “If a tanked basement design is impossible, and a drained basement design is adopted, then the developer and consultant should minimize the take of groundwater as much as possible. Any take of water after the basement has been completed - including during periods of high groundwater elevations - must meet relevant impact assessment criteria. It must also either be authorized under a water access licence or be exempt from requiring a licence.

An exemption from a water access licence does not exempt the applicant from the requirement for an approval as well as specific monitoring and reporting obligations. This means that if water is allowed into basements, and is subsequently pumped-out, specific monitoring and reporting obligations may exist for the life of the project (typically 100 years).

In the long term, constantly pumping out water from a drained basement will create regional issues for surrounding properties. Water is often pumped into the street gutters creating local issues and overloading local and state government stormwater and groundwater infrastructure. In addition, constant pumping out of groundwater may lead to long-term lowering of the ground water level, which may activate Acid Sulphate Soils with many resulting environmental issues.

Developments that impact the aquifer will have significant impact on the environment, neighboring properties, and local and state infrastructure. Because of these significant impacts it should not be left up to the builder/developer to determine short term (construction) and long term (life of project) treatment of groundwater. This is why any project with a basement that impacts either permanent or temporary water table levels is defined as an integrated development and must be referred by Councils to WaterNSW for review, comment and application of conditions. It should also be noted that WaterNSW seeks input from the DPE for any integrated projects that are referred. This referral and review process could potentially take a significant amount of time and ultimately result in significant and/or onerous conditions which may result in significant project redesign, further development delay and could result in difficult and detailed reporting requirements for the life of the project.

The author highly recommends that developers and builders educate themselves in the detail of the guidelines regarding aquifer interference, particularly in relation to design or potential ongoing testing and reporting requirements.

They should determine the highest potential groundwater table position (either temporary or permanent) for the life of the project and, based on this data, design the basement in line with the guidelines prior to submitting the Development Application. This will save time in the approval process and potentially avoid costly and time-consuming redesign. It should be noted that some councils have as a requirement that basements that impact groundwater must be tanked. The author believes that this will be a growing trend.

Builders and developers outside of NSW should take it upon themselves to determine if there is a situation similar to that of NSW applying in their jurisdiction.

It is worthwhile mentioning that the above NSW Government requirements, like BS8102, does not take into account mould/ mildew development if protection other than a fully tanked system is adopted. No doubt this requirement will be soon considered by NSW Government given NCC-2022 mould/mildew requirements became mandatory on 1st October 2023.

E. Australian Basement Wall Relevant Definitions.

The below definitions as referred in BS8102 appear to be derived from the widely accepted UK source document Specification for Piling and Embedded Retaining Walls, prepared by the UK Institute of Civil Engineers.

What is a "Damp Patch": When touched, a damp patch may leave a slight film of moisture on the hand, but no droplets of water or greater degree of wetness are left on the hand. On a concrete surface a damp patch is discernible from a darkening of the colour of the concrete.

What is "Weeping (Seepage) of Water": the state in which droplets of water form on the surface of the wall and coalesce with other droplets. The coalesced water does not remain stationary on the wall surface, but instead flows down the wall.

What is "Beading of Water": the state in which individual droplets of water (held by surface tension effects) form on the wall and adhere to the wall. The water beads do not coalesce with each other. The beads remain stationary and do not flow.

What is "Waterproof ":

(a) For habitable (i.e., Grade 3 from BS 8102 - Table 2 referred above) underground spaces: no seepage, no evidence of Beading of Water on the structural basement wall or in the dish drain and no evidence of a Damp Patch.

A dry wall can produce a basement wall which performs to Grade 3, in accordance with BS 8102, if a suitable inner-skin dry-wall is constructed beyond the dry wall, and if appropriate dehumidification and/or air conditioning is put in place by others. [Grade 3 performance does not permit any seepage. Furthermore, it does not permit damp areas on the inside of the structure caused by external water entry or dampness/condensation on the exposed inner dry wall surface caused by internal moisture sources] "

(b) For non-habitable (i.e., Grade 2 from BS 8102 - Table 2 referred above) underground spaces: No seepage, no evidence of weeping (seepage) of water on the structural basement wall or in the dish drain, damp patches as a result of internal air moisture/ condensation are tolerable, limited beading of water is permitted.

(c) For non-habitable (i.e., Grade 1 from BS 8102 – Table 2 referred above) car parking areas: No evidence of weeping (seepage) of water on the wall or in the dish drain, damp patches are tolerable because of internal/external sources, beading of water is permitted.

As explained in this document Type A barrier and Grade 2 or 3 protection are the most reliable way to avoid mould/mildew. Therefore, designer should question the allowance of Grade 1 protection of BS8102-2022.

What is "Ground Water Table Position": Ground Water Table Position (GWTP) means the highest potential ground water position which includes permanent (perched water table), tidal water position due to sea/river level movement, and storm water movement above each relevant wall to footing/slab junction. Excessive rainwater, together with a blocked or limited capacity AG line provision, can produce conditions like a submerged basement. Therefore, the designer must obtain specific advice from the project's geotechnical engineer.

The designer should also consider rising ocean levels affect due to climate change on the GWTP for the life of the structure.

What is "Shoring": Shoring may take place in the form of discrete concrete or steel piles to stabilise the basement soil excavation for a temporary period during construction until the permanent structure incorporating basement walls are erected. The excavation in sand or sandy soils or even medium to soft clay soils may require a continuous shoring system. This may consist of contiguous piles (piles as close as possible to each other) or secant piles (soft and hard piles overlapping each other which are normally used for construction below the permanent water table) or alternatively, a sheet piling system may be used. Sheet piling techniques highly developed in recent years, it is possible to use sheet piling in sandy, alluvial, and even soft clay soil materials with hydraulic rams which avoids impact/vibration affect on the nearby structures.

The role of AG lines at basement walls: AG lines are conventionally placed at the base of basement walls and they are normally used for where the ground water table position is NOT above the footing carrying the basement wall. AG lines have the following main functions;

- Collect and discharge any ground water seepage due to rainwater activity. AG lines must be built with inspection/maintenance points otherwise siltation blockage can end the functionality of the AG line in a very short time. Residential building design life is min. 50 years, and most AG lines have their functionality ending at 5 to 10 years depending on the silt content of the earth behind the basement wall.
- Eliminate hydrostatic water pressure on the wall by removing the water build-up. This particularly can be a structural issue for Besser Block type basement walls.

The reliance on AG lines should be seriously considered by designers. Non-functional and/or inadequate AG lines during seasonal fluctuations may push the Ground Water Table well above the AG line position, with foundation movements a common occurrence. These issues may result in water ingress into the building which can cause mould/mildew issues. **This question must be asked - if seepage leads to or cause mould/mildew, should Australian professionals rely on AG lines in any situation?**

Conventional Concrete WET Wall: BS 8102 allows Type B construction using additives to achieve water resistant walls (i.e., conventional concrete walls without a membrane system). Cracking and wall joints (for shrinkage, pour breaks, expansion) in a concrete wall are unavoidable. Such cracks may lead to corrosion of the steel bars and the leaking vapour, moisture, water through the cracks, or concrete simply sucking the moisture from the earth may cause mould/mildew within the wall without the membrane system on the earth face. This situation would fail to meet the Australian requirements detailed in Section D above. To meet the Australian requirements, concrete basement walls should not be constructed without a membrane system on the earth face, and a water stop at the wall to footing/slab junction.

Conventional water stops (most used types are hydrophilic water stops) are placed a minimum 50mm away from the earth face of the concrete wall as min. 50mm concrete cover is required to resist the expansion of the hydrophilic water stop (refer to section G below Figure-1 for further detail). Unless the water stop is located at the earth/water face, or a waterproofing bandage is installed to protect the wall to footing/slab joint, water will penetrate the concrete wall through the footing/slab joint, hence the wall becomes a WET WALL.

Conventional Concrete DRY Wall: This is commonly referred to as a FULL TANKED SYSTEM (i.e., Type A barrier of BS 8102) which most of the time is achieved by using sheet membrane systems at the earth face of the basement wall, covering the wall to footing/slab junction of the basement wall, and most likely also covering the soffit of the basement slab on ground. The intention here is to not allow any water ingress into the basement area. This type of system can be used for Grade 2 and Grade 3 performance of BS 8102 (subject to air conditioning/dehumidification requirements). A full tanking system would not necessarily incorporate AG lines, and normally the walls are designed for hydrostatic water pressure depending on the definition of "Ground Water Table Position" specific to the basement under consideration. The designer may accommodate AG lines to avoid possible hypostatic loads on the basement walls. **Construction professionals should be aware of historical and ongoing performance issues with AG lines that do not have maintenance/inspection points. However, maintenance/inspection points represent penetrations in a full tanking system; therefore, AG lines should be eliminated and walls should be designed for hydrostatic pressure when a full tanking system is adopted.** (Refer Section E - the role of AG lines at basement walls).

Dincel WET Wall: This will be equivalent of Type B performance of BS 8102 with the exception that the basement wall incorporates Dincel membrane protection. Significantly different to conventional concrete wet walls, Dincel walls come with the benefit of having waterproof* membrane skins on both faces. When properly installed, the Dincel wall provides a waterproof* barrier. However, the "cold joint" between the Dincel Wall and the footing/slab will provide an ingress point for water. The builder/installer must take necessary steps such as the use of conventional water stops at the Dincel Wall and footing/slab junction.

As noted above, conventional hydrophilic water stops are placed a minimum 50mm from the earth face (i.e. 50mm concrete cover is required), hence creating the potential for a wet wall. However, a wet wall can be avoided by providing a waterproofing bandage at the wall to footing/slab junction, provided there is access at the earth face.

Dincel DRY Wall: Dincel Wall + Dincel Water Stop (DWS) + injection system is an alternative to the conventional full tanking system to achieve DRY WALLS. Dincel offers a waterproof* membrane skin at both faces (as described above), and the DWS + injection system at the water/earth face of the basement wall provides a fully warranted barrier to water ingress. Please refer to the Dincel Construction Manual Waterproof Addendum Section for full details of the DWS + injection system. This type of system can be used for Grade 2 and Grade 3 performance of BS 8102 (subject to air conditioning/dehumidification requirements). Refer to the previously mentioned Expert Opinion by Mr Sam Parker of Acor Consultants.

F. Types of Basement Walls.

WET WALLS cannot cannot be considered as waterproof walls and can often result in mould/mildew problems.

Given elimination of mould/mildew is a key objective of Australian design requirements it would be very risky to allow WET WALLS. To eliminate this risk designers should only consider DRY WALLS. The following is a comparison between conventional concrete and Dincel Dry Wall systems;

1. A full tanked system with Conventional Concrete Walls (i.e., "Dry Wall" or Type A protection of BS 8102) basement solution:

This system consists of concrete walls (in-situ or precast) designed for hydrostatic pressure (refer Section E for "The role of AG lines at Basement Walls" and "Conventional Concrete DRY Wall") even for non-submerge conditions as these walls may be subjected to seasonal fluctuations. Having an appropriate membrane system covering the earth face of the wall and the wall to footing/slab junction. Such systems have the following drawbacks:

- Expensive and time consuming to install.

i. **Sites without shoring (sheet and/or shotcrete) systems** - A membrane directly applied to the face of the concrete wall requires:

- An additional minimum 900mm excavation as a safe working space behind the wall
- Conventional forming of two faces and construction of the concrete wall
- Application of the membrane system on the structural basement wall to comply with the confined spaces act
- Backfilling the excavated space with imported granular material
- Loss of expensive 900mm wide commercial space behind the wall around the basement periphery.

ii. **Sites with shoring (sheet and/or shotcrete) systems** - The shoring face is prepared by the application of shotcrete to attach the sheet membrane. This application consists of hanging the plastic sheet membrane from the shotcrete wall, and a reinforced concrete structural wall is poured against the sheet membrane. This option can also be considered as a full tanking system provided the sheet membrane on the shoring which is installed on the blind side of structural basement wall and the wall to footing/slab junction (the membrane is most likely also extended under the footing slab). This is one way of saving space for excavation and backfilling. However, the potential of damage/puncturing of sheet membrane is a real possibility in this option as the sheet membrane should be positively fixed to shotcrete wall to prevent any movement during the placement of concreting to the conventional concrete wall and during the life of the structure.

For sites with shoring incorporating shotcrete to attach sheet membranes, most of the time the shoring is independent of the structure. The shoring can move unless the shoring system is founded on stable foundation soil. This movement can occur due to many factors affecting ground movements such as seismic and/or ground water movement.

The basement excavation material may consist of a clayey material over rock/shale. This clayey material may have piles/shotcrete used for excavation purposes. The membrane applied to the rock/shotcrete in this application should extend up to the natural ground level in order to prevent seepage and/or stormwater ingress as a result of water penetrating between the membrane and the wall. Therefore, a failure in the waterproofing sheet membrane and / or a gap between membrane and structural wall is possible if for any reason the shoring moves away from the structural basement wall. Builders should seek the approval of design engineers for this alternative waterproofing system.

- There is no 100% guarantee for a successful installation of a conventional concrete fully tanked system even with a high degree of workmanship skill. In the event of a failure, the point of failure is all but impossible to determine.
  - The reliance upon high standards of workmanship for applied membranes has always been in question and continues to result in ongoing problems. There are many construction conditions that can override the limited warranty offered by waterproofing companies. All it takes is a small hole in the applied membrane (at the wall and/or under footing slab) system and it will be very difficult to find and costly to repair the problem.
  - Should the waterproofing membrane be concealed, the cost of exposure of the waterproofing membrane for purposes of investigation and/or repair, such as the removal and replacement of any concrete, paving, or backfill overburden will make the remediation nearly impossible and certainly very expensive.
- For the above reasons, warranty conditions offered for both supply and install must be carefully evaluated.

2. Dincel Dry Wall:

- Cheaper and faster

- there is no extra excavation or onerous backfilling requirements
- Membranes (sheet or liquid paint on membranes) are NOT required.
- The elimination of excess excavation/backfilling, vertical shrinkage/expansion wall joints, horizontal crack control reinforcement bars (except shear walls and two-way designed basement walls however majority of basement walls are designed one way and not used as shear walls), and the omittance of conventional removable formwork, makes a Dincel option cheaper and faster to install.
- Due to the Dincel membrane skins, evaporation of water within the concrete infill is prevented which ensures that hydration (i.e., autogenous healing) continues at least for many years instead of 48 hours. Dincel's crack inducers (i.e., the internal profile webs) ensure that concrete crack widths do not exceed 0.1mm, unlike with conventional concrete walls. Another benefit of ongoing hydration (i.e., on-going curing) is that the concrete becomes less porous and denser which results in up to a doubling of the concrete strength in the long-term.

- Maximum space gain in comparison to a conventional membrane system. The Dincel option only requires 100mm of space behind the wall instead of 900mm.

G. Discussion: Dincel vs Applied Membrane & Use Of Hydrophilic Water Stops & Crystalline Waterproofing.

1. Dincel Membrane vs Conventional Membrane

The Dincel solution incorporating Dincel Water Stop + re-injectiable injection, as explained below in item J(1), addresses the potential problem with waterproofing reliant on water stop cannot address.

2. Why hydrophilic water-stops can fail

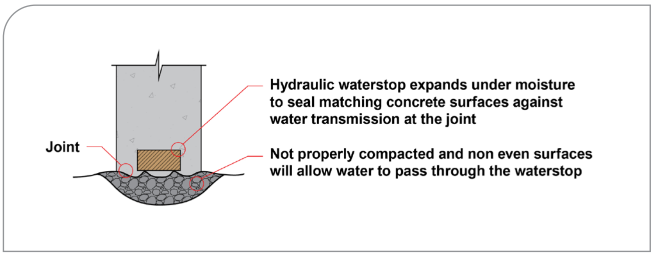


FIGURE 1 - HYDROPHILIC WATERSTOP AT WALL TO SLAB/FOOTING JOINT

The presence of honeycomb concrete, unevenness or improperly finished concrete surfaces, gaps between the water-stop butt joints particularly at the corners, are reasons why a hydrophilic water-stop may not function properly. Hydrophilic water-stops cannot be left exposed to the weather for extended periods of time (i.e., wet weather days, submerged site conditions). Concreting over the hydrophilic water-stop should take place as soon as possible otherwise it will dry, crack, and lose its functionality.

The following statement is taken from page 11, paragraph 53 of the report by ACOR Consultants (Sam Parker):

"It is noteworthy to mention that several materials used in basement waterproofing (such as dendritic, hydrophobics and hydrophilic) contain dynamic ingredients that require exposure to moisture for it to perform. In instances where exposure to water may be sporadically restricted (due to events such as droughts, dewatering, artificial decreases in local water table levels, etc), it can have the effect of passivating those materials temporarily, or even diminishing the efficacy of those materials in the long term. A usual side effect of this phenomenon is that water will enter the site temporarily (a few days to some months typically) until such time that those materials once again become active and capable of preventing water entry."

However, in consideration of the above, mould/mildew may possibly form in the meantime. This is why the waterproofing system adopted should have a solution for such a scenario. The Dincel solution incorporating Dincel Water stop + re-injectable injection, as explained below in item J (1), addresses this potential problem which waterproofing reliant on water stops cannot address.

Scan or click the QR Code to download the full report by ACOR Consultants

3. Waterproofing Additives / Crystalline Waterproofing

The above preceeding comment by Sam Parker of ACOR Consultants should also be relevant to this topic as well.

Concrete walls with cracks of more than 0.2mm wide (which is unavoidable in most cases) often cause leakage and premature structural life (through steel corrosion). Some waterproofing companies promote the use of additives to un-hardened concrete stating that they can seal crack widths up to 0.5mm. Conventional concrete wall cracking can exceed 0.5mm widths for many reasons. Autogenous healing can close small cracks in concrete however, autogenous healing only occurs in un-hardened concrete if the hydration process is continuing. Hydration in the case of conventional concrete walls stop when the wall formwork is removed which is typically no more than 48 hours after concrete placement. This means that additives will be all but useless after the cessation of the hydration process in the case of conventional concrete walls. The crystalline waterproofing will not be active unless a basement wall is built without a membrane on the earth face, that is only if there is enough moisture from earth face of basement wall for activation. In addition to this, flexural cracking under dynamic loadings (compacted backfilling, traffic loads, fluctuating ground water table position under tidal or seasonal effects) and further shrinkage cracking can also occur.

The effectiveness of waterproofing additives should also be questioned in the presence of air voids and/or segregated concrete which are totally dependent on the placement of the concrete, vibrator use and concrete quality (which can be seriously compromised if water is added to the concrete without the strict supervision of the concrete supplier). This is why Dincel highly recommends the use of self-compacting concrete with minimum spread of 680 mm to avoid air voids in above or below ground walls and to negate the need to use vibrators.

H. Is It Possible To Achieve Waterproof Basement Construction When Dincel Wall Is Used?

Waterproofing for basement construction can only be achieved when three (3) components, namely: Basement Wall – Basement Wall & footing/slab junction – footing/slab, are impervious to water ingress into the basement structure. The failure of one component will affect the overall intention of waterproofing for a basement structure.

The following fundamentals are required to be understood first to fully appreciate Dincel Waterproofing:

1. Dincel Crack Inducers (Refer Figure 2)

Total shrinkage in a concrete wall, if special grade of concrete is used, has two components which are drying shrinkage and autogenous shrinkage. Drying shrinkage at a decreasing rate will be dominant in the first instance and will cause cracking at the Dincel webs (for autogenous shrinkage to occur the w/c ratio would need to be less than 0.4 which is not the case for the concrete specified for use within Dincel Wall). A close analysis of a Dincel panel joint demonstrates that the barbs are like the clutches of conventional sheet piling, as shown in the diagram further below, which goes into tension in the in-plane direction under the concrete infill pressure, thus creating very small crack widths at the barbs. Thermal expansion in a basement context is expected to be insignificantly small due to stable thermal conditions. The expansion of concrete due to the ongoing hydration process will be greater than the drying shrinkage component in the presence of continuously available moist concrete.

Engineers using AS3600 – Australian Concrete Structures Standard (AS 3600 is virtually identical to the American and British Concrete Structures Standards in many regards) can calculate that the maximum concrete crack widths would be less than 0.1mm (Refer to Dincel Construction Manual Section E.9: Maximum Shrinkage = 810 x 125mm/1,000,000 = 0.1mm for 200mm thick Dincel wall) when the distance between the joints is 125mm (maximum distance between

Dincel's crack inducers is 125mm).
If, however for above ground walls the minimum shrinkage and maximum thermal expansion at 40°C is considered (this would be not applicable to below ground basement wall as the temperature in the below ground basement walls would not be 40°C) , the total relative movement is even less: Shrinkage – Expansion = 0.06mm – 0.055mm = 0.005mm.
Alternatively, engineers can refer to Dincel's Structural Engineering Design Manual (which has been certified by the University of New South Wales) which shows that the conservative crack widths are less than 0.1mm, which is allowed as the maximum limit in water retaining structures codes/standards. As explained above, Dincel wall is unlikely to have any shrinkage cracking due to ongoing hydration. However even if the effect of ongoing hydration is ignored the crack widths under worse circumstances would not exceed a width of 0.1mm.

The obvious conclusion is that the joints provided in the form of the crack inducers means that Dincel Walls do not need any crack control reinforcement or wall joints as is normally required for conventional concrete walls. A typical Dincel basement wall is restrained at the footing and slab over; therefore, it can be designed as a wall spanning in a one-way vertical direction, which will require vertical reinforcement to resist earth pressure. The horizontal bars in this case would only be required if the wall is designed for two-way flexural action (e.g., basement wall supported by buttress walls) and shear walls.

In regard to eliminating horizontal bars, scan or click the QR Code to download the UNSW Certification (Paragraphs 17 to 22).

THE ADVANTAGE OF DINCEL CRACK INDUCERS

Elimination of horizontal crack control steel which results in:

- ✓ Reduction in steel quantity, less CO2 production, and less cost
- ✓ Allows faster, safer installation which also reduces installation cost
- ✓ Eliminates shrinkage or expansion joint
- ✓ Reduces the potential for concrete voids

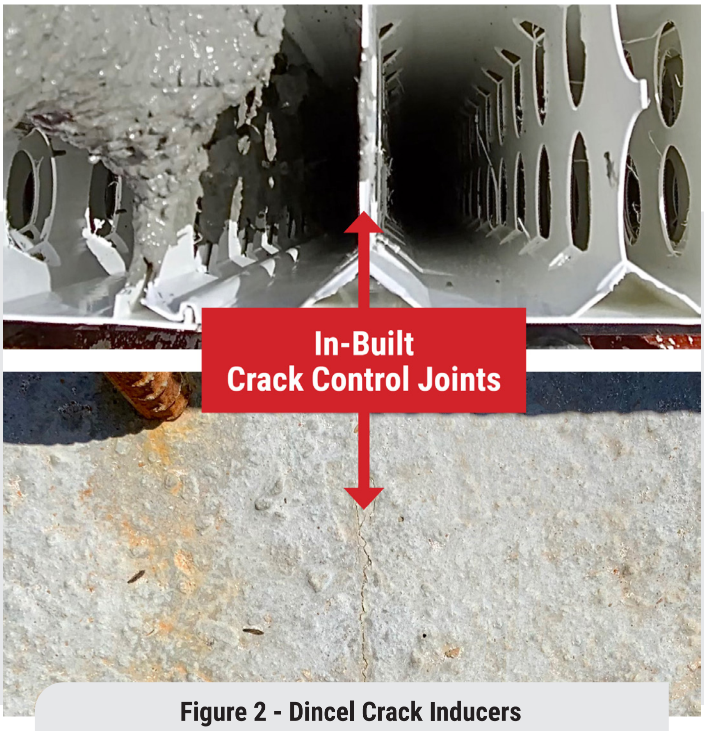


Figure 2 - Dincel Crack Inducers

2. Dincel Panel Joints

The patented Dincel panel joint has a special shape that incorporates patented barbs which are shown in the following diagrammatic detail.

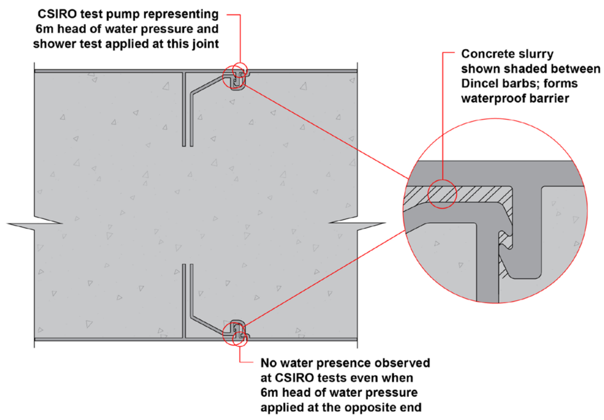


Figure 3 - Dincel Wall Cross Section - CSIRO Test Under 6 Metres Head of Water Pressure

The Dincel panel joints at both faces form very tight joints when they snap-connect to each other. The joints' tightness is further increased when the panels receive concrete infill. The concrete slurry consists of cement and water which further seals the snapped joints. In addition to all this, autogenous healing of the concrete slurry also occurs at the snapped joints where the barbs are located. As a result, a waterproof* Dincel Wall is achieved as proven by the testing to date.

3. The joint between Dincel Wall and footing/slab

Unless the earth/water face of the Dincel Wall to footing/slab joint is made waterproof, the joint will most likely leak particularly under submerged basement conditions. Dincel's new patented innovation, the DWS + injection system, prevents water ingress at the water/earth face.

4. Dincel Wall itself

The benefit which Dincel Wall is currently offering is that it can be used without the need of a conventional membrane at the water/earth face of a Dincel Wall.

5. The footing/slab

The footing/slab, particularly in submerged conditions, for several reasons (cracks, slab joints, inadequate design, concrete quality and placement, inappropriate membranes, etc.) may leak. The waterproofing of the basement footing/slab is not the discussion topic of this document as the basement footing/slab is to be treated by others to prevent water ingress. Dincel's patented invention, Dincel Water stop (DWS), allows for the appropriate membrane under the footing/slab to terminate at the DWS. Refer to the Dincel Construction Manual "Waterproof Addendum Section G-6" for details.

Scan or click the QR Code to download the Dincel Construction Manual

I. Dincel Wall Basement Construction Details.

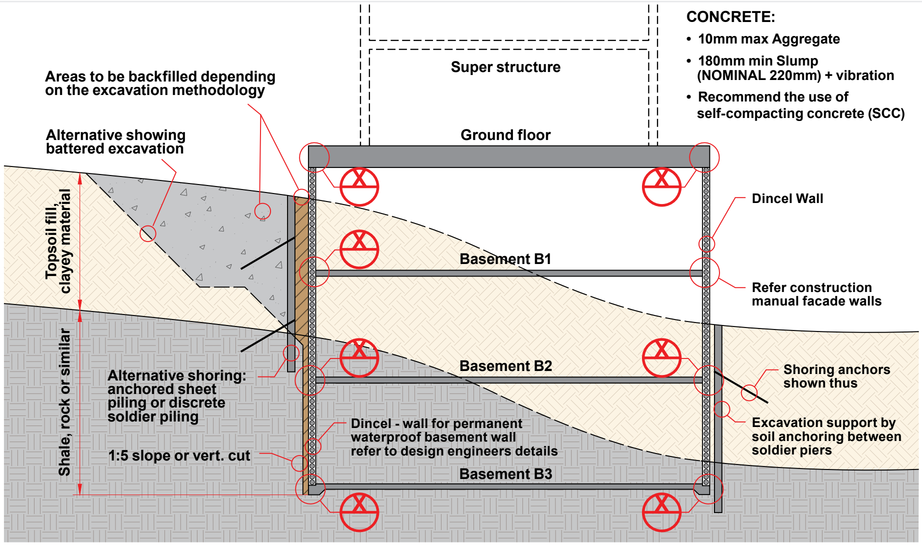
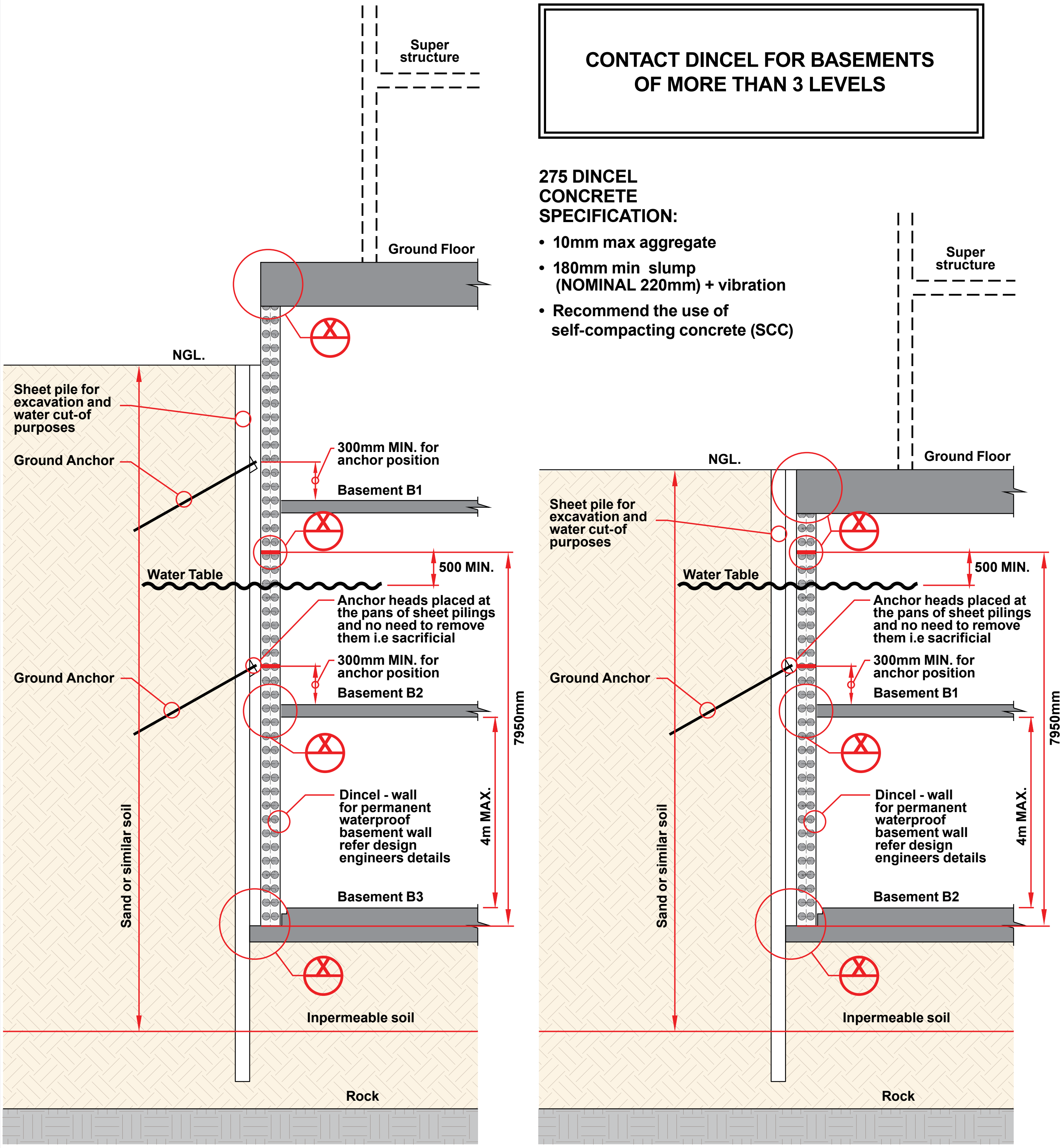


Figure 4 - Basement Construction For Permanent Or Tidal Water Table Below Footing Invert Level



3 LEVELS OF BASEMENT

The sheet piling need to be designed with only one row of anchor points if the second row of anchors shown are below the water table, unless second row of anchors and sheet piling are sacrificial.

2 LEVELS OF BASEMENT

The sheet piling need to be designed with only one row of anchor points.

SHORING-BASEMENT CONSTRUCTION IN SANDY SOILS WITH PERMANENT GROUND WATER

Figure 5 - Shoring

J. Conclusion & Dincel Warranty.

1. Why does Dincel offer less risk in comparison to the conventional FULL TANKING SYSTEM

- Dincel Wall incorporates membrane skins at each face of the concrete wall infill

- Dincel is a totally integral system with membrane skins + DWS, in comparison to conventional systems which are hybrids which can act totally independent from the structure (causing damage to the membrane system). A shoring system used in the Dincel option is totally independent from the membrane system, any movement of the shoring system (in fact, sheet pilings can be removed) will have no effect on the performance of the Dincel membrane system.

- Dincel Installations are undertaken by experienced installers trained by Dincel at the Dincel Academy, and further supervised by Dincel's own supervisors. Hence Dincel provides product and installation warranty as opposed to conventional full tanking where product and installation warranties are separate and independent (important to consider).

  If a leak occurs within the Dincel warranty period, the actual point of leakage is visible and the Dincel re-injection system can be applied only locally without any disturbance or cost to the building structure and owner (refer below FIGURE 6 and further notes).

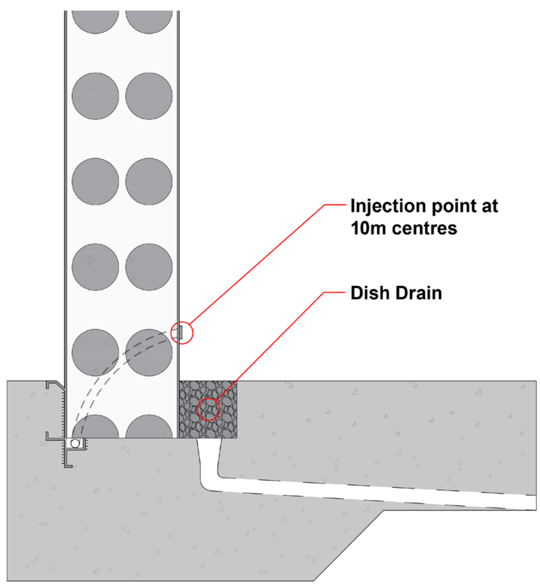


Figure 6 - Dincel Wall & Footing/Slab Joint

- If in the event the Dincel system were to leak at the wall to footing/slab junction:

✓ The leakage point will be easily identifiable at the dish drain. Comparatively, if there is a leak with a conventional membrane system, it is difficult to determine where the leak originates (which can be from a totally different area to where the leak is visible).

✓ Injection can be applied at either side of the point where the leak is visible (i.e., maximum 30m length for each leaking point rather than the entire basement area).

✓ The hose system is re-injectable, multiple times if required.

- If in the event a Dincel panel joint above the base were to leak:

✓ Injection can be applied to the leaking panel joint.

2. Why adopt a Dish Drain if Dincel offers a solution to comply with Grade 3 performance of BS 8102?

Dish drains are required for the following reasons:

✓ Construction sites may be subjected to rain water during construction. There must be no water present within the rebates prior to or during the pouring of Self-Compacting Concrete into Dincel panels. Thus the drainage system including dish drains at the rebates and pump out pit must be ready before installation of Dincel panels to address this potential issue.

✓ Car washing, potential failure of basement sprinkler system if used or any other building equipment, plumbing failure associated with water.

✓ The wall to footing/slab junction may leak until the Dincel resin injection is applied, which could be minimum 30 days after concrete filling of Dincel Wall or months later until all structural work is completed (Refer to Dincel Waterproof Warranty Terms of Conditions). In the absence of a dish drain, the basement slab finished surface may be subjected to ground water.

✓ Earthquakes, foundation settlement, accidents, etc. may cause leakage during or well after the finalisation of construction. Dish drains are required to protect finished surfaces, stored goods, furniture, electrical equipment, etc.

3. What is the gain for industry/consumers by adopting the Dincel Waterproof System Warranty:

- The safest, fastest, and cheapest basement wall construction.

- The Dincel Void Free Warranty is provided as a default when the Waterproof Warranty is provided.

- The Dincel Void Free Warranty ensures that structural-fire-acoustic integrity is maintained and steel corrosion of the wall reinforcement is eliminated.

- The Dincel Waterproof Warranty also ensures that termite treatment is not required.

- The fastest possible methodology to come out of ground conditions without being affected by inclement weather or groundwater conditions.

- Significant space savings in basements.

- Up to Grade 3 performance use of BS 8102, even below full ground water table conditions.

- 120 years structural life.
- Unambiguous, transferrable warranty of up to 50 years, fail-safe solution.

4. Dincel Warranty

Dincel Installation Pty Ltd, which is the construction/buildability extension of the manufacturing business, subject to the availability of resources and location of the project, can provide a waterproof warranty of up to 50 years to comply with Grade 1, 2 or 3 performance use of BS 8102.

Scan or click the QR Code for information on the Dincel Waterproof Warranty

K. The Issues In Basement Construction Should Be Considered By Designers.

1. Allowance of Non-Dry Walls at basements:
   - **Since 1.10.23 the NCC considers water/water vapour leaks and mould/mildew development as building defects. The designer may potentially be liable for the defect if "full tanking" is not specified. The designer should investigate if their PI insurance covers water/water vapour leaks and/or mould/mildew development.**
   - Any ground water intake into a basement should be treated under the requirements of the NSW Water Management Act 2000 (or similar in other States), potentially requiring licensing, and an ongoing maintenance program.
   - Long-term lowering of the ground water level may activate Acid Sulphate Soils with many resulting environmental issues.
2. Designer should be aware of Section G(2) and G(3) of this document.
3. Type 'A' (barrier) protection, BS 8102 is the only liability free system from a designer's point of view to address the issues raised in above section D, Australian Authority Requirements .
4. Grade 3 and Grade 2 (with appropriate dehumidification and/ or air conditioning use) of BS 8102 can be considered as the most effective solutions to combat aginist mould / mildew development.
5. Type A protection is required to address the issues raised in above section D, Australian Authority Requirements . The provision of AG lines having inspection/maintenance points requires penetrations in the Type 'A' protection, which defeats the purpose of having Type 'A' protection. Therefore, AG lines should be eliminated to address above section D, Australian Authority Requirements.

.6. With the elimination of AG lines the ground water position may be well above the wall to footing/slab junction due to seasonal rainfall changes, which will result in hydrostatic pressure on the wall. This situation of no AG lines and hydrostatic pressure requires very careful consideration if using Besser Blocks as a basement wall.

7. The elimination of AG line and application of Type A barrier should therefore eliminate the need for vertical drains, blue metal and granular backfilling at he back of the basement walls.
8. Designers and Development Approval conditions should consider viability of Type 'A' protection attached on the shoring system rather than directly attached to the building basement wall. The building structure, for many reasons, may move independently from the shoring system hence most likely resulting in damaging of the membrane system or providing a gap between structural basement wall and the membrane attached to shoring system. Water can travel long distances through this very ssmall gap until find a weak spot in the structural wall to leak.
9. There is no 100% guarantee against the following building movement failures resulting in water intake;
   - Earthquake/extreme wind cases.
   - Inadequate footing and superstructure design and/or construction.
   - Excavation of a nearby building causing settlement.

These types of movements can be minimal, however, only a hairline crack or a small gap between the structural wall and membrane system are required for water penetration. The designer should consider how such a failure due to building movements or system failure (as mentioned in item G (2) above), can be addressed without disturbing the structure and building occupants, and at minimal cost.

[1] Curtin University. "Research shows corrosion costs the local economy." CU. https://www.curtin.edu.au/news/media-release/research-shows-corrosion-costs-the-local-economy (accessed 19 July 2023).

[2] Basement Health Association. "Understanding Sick Building Syndrome." BHA. https://basementhealth.org/understanding-sick-building-syndrome (accessed 19 July 2023).

[3] Alexander, Helen. "Can basement mould make you sick?" Live Science. https://www.livescience.com/can-basement-mold-make-you-sick (accessed 19 July 2023).

[4] QBE Insurance. "Water damage insurance claims remain high despite more Aussies working from home." QBE. https://www.qbe.com/au/media-centre/press-releases/water-damage-claims-remain-high (accessed 19 July 2023).

DINCEL
STRUCTURAL WALLING

www.dincel.com.au 1300 DINCEL

Waterproof*
* Dincel products are waterproof, subject to certain qualifications and conditions. Refer to "To What Extent Are Dincel Walls Waterproof?" [https://www.dincel.com.au/theme_dincel/static/documents/waterproof/to-what-extent-are-dincel-walls-waterproof.pdf] for details of waterproof qualities, the results of the testing that has been performed, and the qualifications, conditions and limitations on those waterproof qualities.

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