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Industry CPD

Structural waterproofing by design

This CPD module, sponsored by MAPEI, explores the addition of waterproofing admixtures to concrete in order to build a watertight below-ground structure.

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1 hour of verifiable CPD

Introduction

When building watertight below-ground structures in concrete, there are many factors that need to be taken into consideration:

- the ground type and its condition before, during and after construction
- the water table – high, low or variable, perched or hydraulic
- the presence of old watercourses
- allowance for burst watermains
- the presence of any ground gases or contaminants (and, if so, which ones?)
- the type of excavation/construction – secant, contiguous or sheet piles
- expected weather conditions at the time of construction
- sequence and allowed time for construction
- installation costs for the waterproofing solution.

Any of the above *not* being considered carefully could result in failure to meet the required structural waterproofing expectations.

Waterproofing code of practice

The recently revised BS 8102:2022 standard for the *Protection of below ground structures against water ingress* is a code of practice which takes the form of recommendations and guidance.

When applying this code, assumptions are made that its execution will be carried out by appropriately qualified and experienced people.

Types of waterproofing systems

Within BS 8102:2022, there are *three* types of waterproofing system: Type A, Type B or Type C.

Type A systems are 'barrier' or 'resistive' systems. Pre- or post-applied, they can be in the form of renders or physical fully bonded membranes. They are normally applied externally and are designed to work under positive pressure. These systems can also be applied internally; however, internally applied systems tend to be less effective, having to work under negative pressure and relying entirely on their ability to bond to existing substrates.

In cases where existing basement structures need to be waterproofed, the external structural element of the basement will likely be inaccessible, so an internally applied membrane, often of the polymer-modified cement variety, is a common approach.

Type B systems are integral to the structure itself. The concrete of the structure acts as the resistive 'barrier' to water under pressure. Waterproofing admixtures can be added to make the concrete waterproof.

Type C *cavity drain systems* are the exceptions to the above. Designed to accept the presence of water, these systems rely on Type A or Type B barrier systems to prevent water entering the drained cavity under pressure. Water entering the structure is directed by a series of channels to a sump and pump system, where it is pumped away, normally via non-return valves, to an external serviceable drain point. A Type C cavity drain system is *not* designed to withstand water pressure and should only be regarded as an internal *water management system*.

This article focuses on Type B protection systems.

Type B protection

Waterproofing admixture concrete

Using a concrete with a waterproofing admixture added is a very effective strategy for waterproofing a below-ground structure,

provided the project is suitable and all of the constraints of installing concrete can be taken into account.

Depending on the grade of waterproofing required, using an admixture waterproof concrete to form a Type B system negates the need for membranes to be used.

Although adding a waterproofing admixture to concrete does not enable reinforcement steel to be reduced or removed altogether, it does provide an extra level of assurance that the concrete surrounding the reinforcement steel will be more resistant to water and will, in the event of a crack occurring during the structure's life, enable 'self-healing' to occur in the presence of water, much faster and more effectively than with standard concrete. Any episodes of water ingress during the life of the structure are more likely to come and go unnoticed.

Waterproof concrete used on its own as a Type B system is generally suited to Grades 1a and 1b only. Higher grades require additional measures to be taken, as detailed within the following extract from BS 8102:2022:

'Where some seepage is tolerable (as Grade 1a), the provisions in tightness class 0 of BS EN 199211 may be adopted.

'Where Grade 1b is required, the maximum permissible through crack width of the concrete should conform to BS EN 19923:2006, tightness class 1.

'Where higher waterproofing performance grades are required, additional measures (such as a combined protection, water resisting admixture, pre- or post-tensioning) should be used.'

Tightness class 0 = maximum crack width of 0.3mm.

Tightness class 1 = maximum crack width of 0.2mm.

It is also a common prerequisite from insurers for *two* forms of waterproofing to be used.

Types of waterproofing admixtures

There are essentially two different types of waterproofing admixtures available in the open market. These are often referred to as:

→| pore blockers
→| crystalline-based admixtures.

All concrete has pores which, depending on the thickness of the concrete section, can present opportunities for water to ingress into a structure. The thinner the section, the greater the risk of water penetration over time, especially when the water is under hydrostatic pressure.

Pore blockers are exactly that. They are added to the concrete mix and, when the concrete sets, the pore-blocking admixture blocks the pores to enable the concrete to become a resistive waterproof barrier.

Crystalline-based admixtures are added to concrete in the same way as pore blocking systems. When the concrete sets, the admixture crystals block the concrete pores. However, in the event of a crack occurring, any water attempting to ingress through the crack will cause the crystals to swell **(Figures 1 and 2)**, typically over a seven to 10-day period, enabling the 'self-healing' process to occur, a process that remains and continues throughout the life of the structure.

With regards to sustainability and the need to reduce embodied carbon within concrete structures, the use of GGBS (ground granulated blast-furnace slag) or PFA (pulverised fly ash) within concrete mixes to replace proportions of the required cement content is beneficial on *three* counts:

1) Less Portland cement is required per m^3 concrete = a reduction of embodied carbon.
2) Adding GGBS or PFA reduces heat of hydration = a reduction of the risk of thermal cracks occurring, especially during winter pours.
3) Waterproofing admixture concretes, being more dense, tend to be more durable than standard concretes.

As with any waterproof concrete solution, they are only as good as the practices applied and the quality of workmanship by the people installing them. When engaging with water, especially water under pressure, attention to detail is everything.

For a successful Type B waterproofing project to be achieved, it is vital that attention be paid to:

→| concrete quality
  - hot and cold weather pours
  - strike times
  - 'free fall' heights
  - curing methods

→| waterbar installation
→| pre- and post-applied service penetration detail
→| movement joints.

↓FIGURE 1: Action of crystalline-based admixture on water penetration

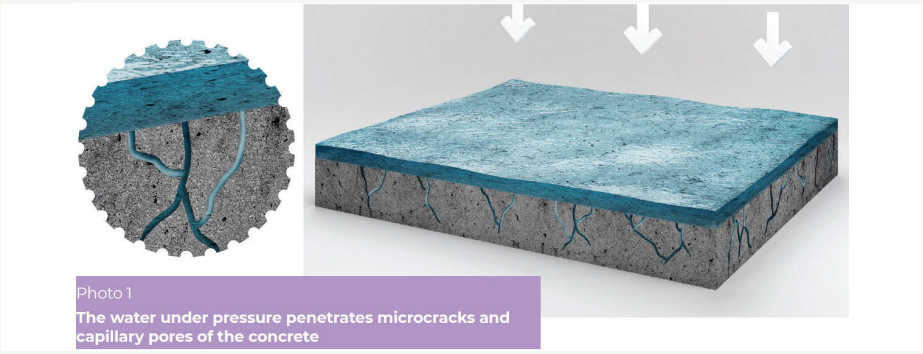
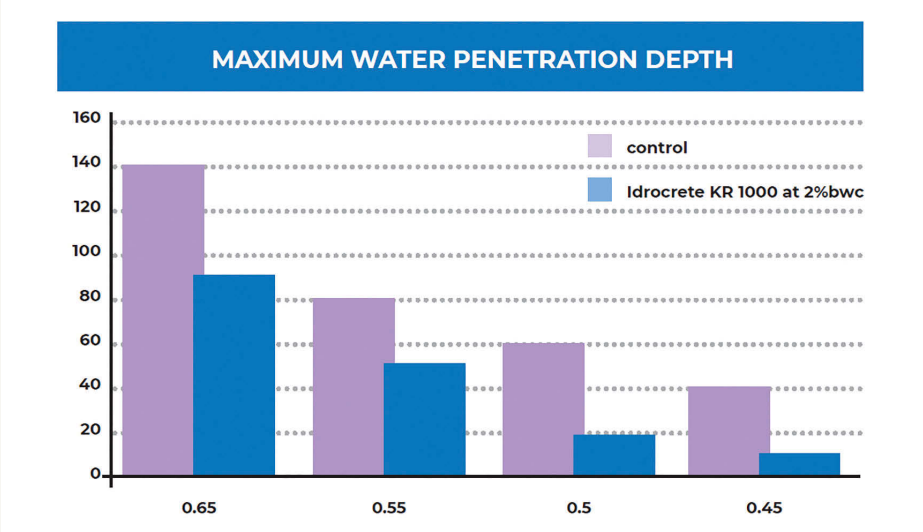


Photo 1
The water under pressure penetrates microcracks and capillary pores of the concrete

Photo 2
Idrocrete KR 1000 reacts with water to fill microcracks with crystalline deposits

Photo 3
Cracks have been reduced and pores have been progressively blocked. Concrete watertightness is improved

↓FIGURE 2: Penetration depth of water when crystalline-based admixture is added to concrete



Crack widths – with or without waterproofing admixtures

When designing below-ground structures or structures such as tanks or swimming pools in concrete, designers are under pressure to ensure crack width design code criteria are achieved throughout the structure being built. However, although it is accepted that watertightness for, typically, a swimming pool can be achieved by meeting the designated tightness class of 0.2mm with the correct application of reinforcement steel, the responsibility of ongoing watertightness usually falls somewhere between the structural engineer, the ready-mixed concrete supplier and the contractor charged with the building of the pool.

From experience, ready-mixed concrete suppliers are normally primarily concerned with ensuring that their concrete delivered to site meets the required 28-day strength and is of the required mix design and consistency to enable it to be correctly poured, compacted and cured.

If during the life of the structure the contractor ceases to trade, the customer or end user is potentially left exposed to the prospect of having to rectify, at their cost, any issues of failure of the concrete structure element of the waterproofing system.

By adding a waterproofing admixture to the concrete mix, the manufacturer of the admixture is able to provide additional reassurances to the end user by offering either a product warranty or a guarantee of watertightness for periods typically of 10 to 20 years, providing it can be shown that the correct reinforcement steel design/tightness class for the structure was applied and achieved and that the installing contractor correctly poured, compacted and cured the concrete in accordance to BS 8500 and Concrete Society guidelines.

The manufacturer of the admixture should have technical presence on site at various stages during the construction phase to ensure that *all* freshly poured concrete containing its waterproofing admixture arrives on site with the correct level of consistency and is being poured correctly in the correct places, compacted and cured to both Concrete Society guidelines and in line with the admixture manufacturer's warranty or guarantee requirements.

The manufacturer should also be present to check, verify and photograph the correct installation of *all* waterbars or waterbar systems used within any construction or movement joints and around any service penetrations before any concrete is poured.

Subject to a final inspection, a transferable product warranty or guarantee of watertightness is then issued to the installing contractor and can be forwarded to the structure owner on completion.

All elements of the waterproofing strategy should be discussed and agreed upon right at the beginning of the project, to confirm who is going to do what, when and how, and most importantly, to verify what the client/building owner will receive on completion in terms of the waterproofing warranty or watertightness guarantee they require for their project.

Concrete pour length ratios and pour sequence

Advice and support should be provided to the installing contractor in regard to concrete pour ratios. Any planned pour layouts or pour sequences should be discussed and agreed upon with the manufacturer prior to the actual concrete pours.

Generally, the rule of thumb is square is good, long and thin is bad.

This especially applies to podium decks and suspended slabs. For ground slab pours, ratios of 2:1 or less are advised. For wall pours, a ratio of 3:1, and for suspended slabs (non-ground-supported slabs or slabs where the underside will be visible after pouring), ratios of 1:1 to 1:1.5 should be applied. The squarer, the better.

If possible and to further help reduce the risks of cracks occurring within suspended slabs, a tighter steel design class of 0.2mm should be considered.

With the aim of lowering the risks of cracking, all advice relating to pour ratios should be in line with Concrete Society best practice guidelines.

'Chequerboard' slab pours should be avoided as well as 'hit and miss' wall pours, as both of these methods greatly increase risks of restraint cracks occurring.

Any advice before and during the building construction by the admixture manufacturer to help mitigate the risks of cracks can only be a good thing, especially when the overall objective is to achieve '*a watertight concrete structure, one which can be confidently adopted and a warranty or guarantee of watertightness be issued upon it*'.

Land drains

In line with current waterproofing design practice, a below-ground structure should have a suitable external land drain installed to remove water. Although this is not always possible, the installation of a land drain helps alleviate water pressure away from the structure and your chosen single or combined waterproofing system.

Land drains need to be both accessible and serviceable. Consideration should also be given to where the water is to be drained to, as it is not permitted for groundwater to be drained into public sewers.

Professional indemnity and design responsibility – how are they dealt with?

Often, the question arises as to who will be taking design responsibility for the structural below-ground waterproofing element of the project. Design responsibility and professional indemnity (PI) cover for the designs used throughout the below-ground element are usually left to the architect or structural engineer for the project.

Under normal duties, the overall responsibility falls to the architect and the structural engineer is responsible for the design of the concrete if this is part of the system. Clients often ask the structural engineer to take responsibility for the entire below-ground waterproofing.

Where a specialist is involved, they will take on responsibility for the detail design. Given the number of parties involved, the design responsibilities should be clearly defined.

PI insurance protects against claims for loss or damage made by clients or third parties as a result of the impact of negligent services provided or negligent advice offered. However, cover may be restricted, so the engineer should check this, ensure consistency with their appointment and inform the client.

FIGURE 3: Watertight concrete pour in progress

FIGURE 4: Typical below-ground site – ready for concrete slab pour

FIGURE 5: Below-ground site – prior to watertight concrete pour

Should either the appointed architect or structural engineer choose to decline responsibility for the design of the waterproofing system, design responsibility and PI insurance can be provided via an independent third-party waterproofing specialist capable of providing this type of insurance for below-ground projects.

That said, following the latest BS 8102:2022 recommendation to appoint, at the earliest opportunity, a waterproofing specialist such as a **C**ertified **S**urveyor in **S**tructural **W**aterproofing (CSSW) to provide further advice, helps to mitigate any risks of poor waterproofing design.

Product warranties and watertightness guarantees – what's the difference?

Most waterproofing products are covered by product warranties. Waterproofing product warranty periods vary, typically ranging from 10 to 20 years.

A product warranty is the guarantee a manufacturer provides to customers regarding the quality of its products and what compensation will be given if the product does not perform as advertised. These tend to have exceptions that are limited to both the value of the product and the manufacturer's obligations to customers.

A watertightness guarantee covers all aspects of the installed solution including design. Normally, in the form of an insurance-backed guarantee, it provides an all-encompassing level of cover and peace of mind to customers that in the event of the original installing contractor ceasing to trade, the customer has this option to call upon to rectify any issues during the guarantee period. This type of cover is usually limited to the total contract value of the below-ground element.

At the earliest opportunity, confirm the extent of the warranty or guarantee cover that will be provided on completion.

Avoid split warranties or liabilities.

It's a good idea to ensure that the warranty provided covers the single system or dual system as a *total* waterproofing solution. In the case of a dual system, to have manufacturer X supplying the Type A and manufacturer Y supplying the Type B system is likely to cause pain and confusion if an issue arises at a later date and a warranty claim has to be made.

Pressures on quality

As waterproofing specialists, we need to be conscious of some of the 'pressures on quality' that can occur on site. What does this refer to?

Contractors are often under immense pressure to deliver projects on time and within budget. Sometimes there are situations that occur on sites which are beyond anyone's control, and lead to unplanned delays or additional costs. These situations can result in poor decisions being made, the consequences of which lead to the failure of the waterproofing system. Worse still, some decisions may lead to the manufacturer warranty or watertightness guarantee not being issued on completion.

When deciding on a Type B waterproofing solution, make sure the appropriate level of quality assurance checks and site inspections/verifications can be made throughout the build to ensure the waterproofing strategy is consistent and maintained as agreed.

Questions

To claim your CPD certificate, complete the module online by 30 November 2022 at: **www.istructe.org/industry-cpd**

1) Which is the current structural below-ground waterproofing code in the UK?
- ☐ BS 8201:2009
- ☐ BS 8102:2022
- ☐ BS 8120:2022

2) What are the three types of below-ground waterproofing system?
- ☐ Types 1, 2 and 3
- ☐ Types X, Y and Z
- ☐ Types A, B and C

3) What type of external drain should be used for below-ground structures?
- ☐ Sump drain
- ☐ Land drain
- ☐ Main drain

4) What recommended specialist should be appointed at the earliest opportunity?
- ☐ Specialist architect
- ☐ Specialist engineer
- ☐ Certified surveyor in structural waterproofing

5) Which of the following is true?
- ☐ Product warranties cover product only
- ☐ Product warranties cover product and workmanship
- ☐ Product warranties cover product, below-ground structure waterproofing and design

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