CROSS REPORT

WATERPROOFING EXPOSED CONCRETE SLABS

(CROSS-AUS 25 NOVEMBER 2021 REPORT 959)

OVERVIEW

This report highlights that water ingress into buildings continues to be a problem and discusses the role of the structural engineer when dealing with waterproofing of exposed concrete slabs.

It shows how this can be achieved by careful design and detailing of the reinforced concrete structure and by close collaboration of all parties involved.

Key Learning Outcomes

For construction professionals:

- A successful waterproof concrete slab can be achieved when there is close collaboration between the architect, structural engineer and hydraulic/drainage engineer in the design and by the contractor and their subcontractors during construction
- Where a concrete slab is exposed, ensure there are adequate falls and drainage outlets to remove the water as quickly and efficiently as possible

For structural design engineers:

- Pay careful attention to crack control in the design and detailing of reinforced concrete slabs
- There is good practical advice available, such as the Concrete Institute of Australia Current Practice Note CPN28 Watertight Concrete Structures
- Thin reinforced concrete slabs are not waterproof without special consideration

Water ingress continues to be a major issue with many buildings, and although architects or building designers generally have responsibility for specifying waterproofing, the reporter notes that structural engineers have an important role especially when exposed concrete slabs are being used. The reporter's experience is that some structural engineers mistakenly believe that thin suspended concrete slabs exposed to the weather are watertight or waterproof without any form of additional waterproofing.

For reinforced concrete slabs, even with a large amount of reinforcement, watertightness cannot be guaranteed without very special detailing and very specific attention paid to construction. Although post-tensioned slabs can be used to provide a water-resistant (watertight but not waterproof) slab, considerable design and detailing effort is required for the slab and the joints to minimise any leaks. Experience suggests that, even with the most careful design and construction, some local water staining and minor leaking from the underside of slabs is still possible.

The reporter also notes that deflections of horizontal suspended slabs exposed to rain or water can lead to ponding of water, and this, in turn, may result in additional load, possible leaks and unsightly staining on the underside of the slab.

Code Compliance

The NCC[1] covers the requirements for damp- and weather-proofing in buildings. For non-habitable areas (such as car parks and some types of industrial buildings) slabs generally do not need to be weatherproof. The reporter notes that although this may not be a problem for such buildings there is still the possibility of unsightly leaks and staining on the underside of exposed slabs. Often the visual appearance of such staining will cause significant concern and this should be addressed and accepted by way of confirmation in writing at the time of design by all involved including the developer, the client and preferably the final end-users. In considering this issue all parties should agree on the method for identifying stains (e.g., at the time of crack inspection) and for determining non-compliant stains (i.e., of a certain measurable size). If certain stains are to be considered as non-compliant with the design or construction of a concrete structure, then the parties should specify in writing which party is responsible for remediation.

Where watertightness and waterproofing are required for habitable areas (and for non-habitable areas if staining and some leaking from the underside of the slab are unacceptable) other measures need to be considered e.g., an applied waterproof membrane or a separate watertight roof constructed over the slab.

There may be situations when the ingress of water can lead to long term corrosion problems so interpretation of the NCC and whether a waterproof structure is required needs careful consideration as the consequences of reinforcement corrosion can be catastrophic.

[1] NCC Volume 1, Australian Building Codes Board, May 2019
[2] Concrete Institute of Australia CPN 28 –Watertight Concrete Structures, 2005

Practical advice

The reporter draws attention to the Concrete Institute of Australia Practice Note CPN 28 on *watertight concrete structures*[2] that provides a valuable resource on this topic for engineers, architects, building owners and construction managers.

Expert Panel Comments

As the reporter notes, water ingress continues to be a major issue with buildings. For example, the 2019 report An Examination of Building Defects in Residential Multi-owned Properties by Johnston and Reid examined 212 building defect reports from New South Wales, Queensland and Victoria. These reports identified 3,227 building defects of which at least 20% were related to water ingress.

Water ingress may be the result of several factors and can involve any part of the building envelope. In many cases it may not be considered a structural issue. However, this report deals with one situation that does involve the structural engineer, i.e. waterproofing of exposed concrete slabs.

An important question when dealing with exposed concrete slabs is to determine how watertight or waterproof the slab needs to be. Water ingress into habitable spaces is certainly a matter for health and safety; it may also result in corrosion of reinforcement and deterioration of other structural elements leading to distress and/or potential failure.

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NCC Section E Compliance

The National Construction Code (NCC) Volume 1, Section F Health and Amenity, Part F1 Damp and weatherproofing, simply states:

FP1.2 Preventing rainwater from entering buildings

Surface water, resulting from a storm having an average recurrence interval of 100 years must not enter the building.

FP1.4 Weatherproofing

A roof and external wall (including openings around windows and doors) must prevent the penetration of water that could cause (a) unhealthy or dangerous conditions, or loss of amenity for occupants; and (b) undue dampness or deterioration of building elements.

It then gives exemptions for certain classes of building where these requirements do not apply and that are "based on the belief that the use and safety levels of the exempted buildings will not be significantly diminished by surface water entering them." Also, that "it is the responsibility of a building proponent to satisfy the appropriate authority that the exemption should apply".

Design and detailing

As the reporter notes, it is possible to achieve a watertight concrete slab but this does require careful design, detailing and construction to be successful.

To achieve a fully weatherproof design that is compliant with the NCC a layered approach is suggested

1. If possible, prevent the water from reaching the concrete slab in the first instance, e.g., for some buildings it may be more cost-effective to provide a separate weathertight light steel roof over the concrete roof slab.
2. Where the concrete slab is exposed, remove the water as efficiently as possible by providing adequate falls to a correctly designed roof drainage system with outlets at its low points. This requires close collaboration between the structural engineer, architect and hydraulic/drainage engineer to ensure that the falls and drainage outlets take into consideration building movements and long-term deflections of the concrete slab.
3. Pay close attention to crack control, particularly from restraint to shrinkage and other building movement. The risk of cracking can be reduced by:
    a. Judicious location of service cores and other stiff building elements;
    b. The location of permanent and temporary movement joints;
    c. Provision of adequate and correctly detailed reinforcement;
    d. Use of post-tensioned concrete slabs;
    e. Correct concrete mix design, possibly with shrinkage-reducing admixtures.
4. Provision of a correctly specified, detailed and installed waterproof membrane.
5. Good construction and an understanding of the waterproofing requirements by the contractor and their subcontractors.

Waterproof membranes

Where a waterproof membrane is to be applied, it should comply with AS4654 Parts 1 and 2 - *Waterproofing Membranes for External Above-Ground U*se. However, adequate falls must still be provided and attention paid to crack control, as in steps 2 and 3 above. The membrane should be installed by a competent and experienced specialist contractor to ensure it performs as intended.

As the Masters Building Association of New South Wales website points out "waterproofing tops the list of the '10 most common defects' in every State and Territory" and it has produced a series of Waterproofing Guides for use throughout the building industry and by training institutions.

Construct New South Wales has recently commissioned a course titled, "Waterproofing Design Principles" to prevent water leaks and leaching in buildings. Although the course focuses on residential apartment buildings (class 2) the principles apply to all building types.

The Australian Institute of Waterproofing also provides technical advice and training and as a 2017 presentation to a Queensland Building and Construction Commission (QBCC) seminar on Preventing Waterproofing Defects concludes:

Successful waterproofing systems rely on:

- Design (compatibility chain)
- Specification (compatibility & installation)
- Membrane Application
- Adherence to specifications and standards
- Maintenance (other contractors)
- Common sense

To verify the membrane installation the specification should include the following hold points:

- Slab preparation
- Priming
- Testing of membrane thickness (for liquid membranes)
- Corner and turnup preparation.

Flood testing is also advisable for critical applications.

Non-habitable spaces

As noted above the NCC does allow some exemptions for certain classes of buildings involving non-habitable spaces, e.g., car parks and some industrial buildings, provided "the use and safety levels of the exempted buildings will not be significantly diminished by surface water entering them" and that "it is the responsibility of a building proponent to satisfy the appropriate authority that the exemption should apply". This requires careful consideration at the design stage as water seeping through a concrete slab will not only cause unsightly staining, it may also damage car paintwork and other stored goods. One approach is to classify the end usage such as that in the UK Concrete Centre's publication Basements: Waterproofing that can be used to agree the expected level of performance with all parties and for the contractor to have a clear level of delivery expected.

THE RELIABILITY OF TECHNICAL DATA FOR PROPRIETARY PRODUCTS

(CROSS-AUS 25 NOVEMBER 2021 REPORT 959)

OVERVIEW

This report highlights the importance of verifying technical data provided by the manufacturer or supplier of proprietary products.

Key Learning Outcomes

For structural design engineers:

- When using technical data provided for proprietary products it is important to check that the product has been tested to the appropriate AS/NZS standard by a NATA/IANZ registered laboratory
- When using an unfamiliar product, request the product supplier to confirm in writing how the product was tested and the relevance of the testing conditions to the actual application

A reporter has raised concerns about the technical data provided for some products that are used to brace non-structural elements (such as suspended building services within ceiling spaces) in Australia and New Zealand.

Test Results

When tests were performed by an independent testing laboratory on three random samples of each of two products, the published Ultimate Limit State (ULS) was not able to be achieved in all but one of the tests. The results obtained were 92%, 93% and 96% of the published ULS for one product and 97%, 98% and 109% for the other product.

Use of published data

These products are installed in buildings around Australia and New Zealand and engineers rely on the published data being correct. The reporter is concerned that if an engineer uses the published ULS ratings to carry out their seismic design for the bracing of non-structural services, then the engineer may produce a design that could fail in the event of an earthquake. This failure could potentially lead to death or serious injury.

It is the reporter's opinion that the published ULS ratings have either been based on incorrect testing or the testing has been undertaken on a product that is different from that supplied.

Expert Panel Comments

The panel thanks the reporter for bringing this matter to their attention as there are several aspects to be considered. It is not CROSS policy to name manufacturers so these comments are generic and apply to all safety-critical products.

It is possible that values given by product manufacturers for any component or system are not confirmed when independently tested. Structural engineers should be mindful that when safety-critical components or systems are being used it is good practice to have sight of the original test data and confirm that the testing has been carried out in accordance with the relevant Australian and/or New Zealand Standard and by NATA or IANZ registered laboratories.

Reporting of results below expectation

Where test results fall short of expectations, as stated in the report, this should be reported by the company who carried out the tests to the manufacturer and, if deemed necessary, to the relevant authorities so that the matter can be investigated. It may be that differences between the manufacturer's quoted test values and those of an independent laboratory could be due to reasons associated with testing procedures.

Check for current datasheets

When choosing capacities from technical data sheets it is important to check that the latest version of the technical data sheet is being used and that the values provided are for testing under the relevant conditions and to the appropriate AS/NZS Standard.

When using an unfamiliar product, or where there is some doubt as to the reliability of the published information, it can be worthwhile to make a comparison with similar products from other manufacturers. If doubt still exists then the prudent engineer will consider using a larger capacity reduction factor depending on their assessment of the robustness and criticality of the overall system. Alternatively, independent tests may be commissioned to verify any data considered incorrect or dubious.

USE OF TEMPORARY BARRIERS TO CONTROL ACCESS TO HAZARDS

(CROSS-AUS 25 NOVEMBER 2021 REPORT 959)

OVERVIEW

This report highlights the risks associated with the use of temporary barriers to control access to unsafe workplaces.

It discusses the issues when scaffolding is used as a barrier, and that this should only be considered for use as a short-term temporary barrier.

Key Learning Outcomes

For asset owners, contractors and managers:

- Be aware of your duty to ensure the health and safety of workplaces that are under your management or control (to any extent), including when temporary barriers are moth-balled or temporarily out-of-use and including the risk of access by unauthorised persons
- Recognise the importance of clear communications and good record-keeping with respect to any risk controls that have been put in place and ongoing review of those control measures

For structural design engineers:

- Understand the hierarchy of risk control measures and that eliminating or removing the hazard should be considered first, wherever possible, prior to considering other controls to minimise risks
- Recognise that the use of temporary barriers to control access to structural (or other) hazards is dependent on good record-keeping and is, therefore, an administrative form of control
- When carrying out any site inspection, undertake your own risk assessment and always ensure that there is safe access to the area to be inspected

The reporter has been involved with a number of mining sites and port facilities where temporary barricades (e.g. scaffolding) have been used to control risk due to structural hazards such as unsafe flooring, missing handrails, etc. In many cases these barricades have been left in position for months or years and the reporter is concerned that this is not an appropriate long-term control for structural risks. The following examples are given:

1. A scaffold barricade was placed to prevent access to a corroded walkway. At some point in the following 12 months the barricade was removed. During a subsequent site visit the reporter inspected the walkway from below and decided that, due to its poor condition, it required a closer and more detailed inspection. Whilst testing the soundness of the first-floor mesh panel from a ladder the mesh gave way and collapsed. Only the fact that the reporter was holding on to the ladder saved them from serious injury.
2. The owner of a moth-balled plant requested that a structural engineer inspect a number of areas of the plant that had been barricaded off as structurally unsafe prior to the moth-ball process. However, no record had been kept of why the barricades had been placed. In some areas the reporter was able to identify structural defects that may have explained

the barricade; however, in other areas there was no obvious reason why the structure was not sound. It was therefore unclear whether the barricades had been placed incorrectly or whether the reporter had missed an important issue jeopardising the safety of the structure and personnel.

Risk control

Using the hierarchy of risk controls, many people assume that barricading would be a high-level control (equivalent to an engineered control) in that it prevents exposure to the hazard. However barricading actually depends on an administrative control (which is at the low end of the hierarchy of risk controls) for its implementation. Usually there would be some level of "paper tag" system to indicate why the barricade had been put in position and a record kept that the barricade had been installed, both of which are, nonetheless, error-prone administrative systems. For example, if the tag blows away or is damaged there is nothing to indicate the purpose of the barricade. With scaffold and other types of hard barricades, these tend to be removed for re-use elsewhere as part of general site clean-ups. This could explain what happened in example 1 above.

Even if the tag remains in place, the reporter's experience is that it usually does not contain enough detail about the hazard being controlled, leaving uncertainty in the future as to the nature of the hazard. This exposes personnel to hazards when trying to inspect or identify the problem and raises the risk that the issue could be missed and the barricade removed without addressing the underlying issue (as in example 2 above).

Discourage the use of temporary barriers

It is the reporter's opinion that engineers and others involved in the operation and management of industrial and similar facilities should discourage the use of temporary barricading to control access to structural (or other) hazards and should encourage more direct (and appropriate) means of controlling these issues. These could include rectification of the original issue or installation of permanent handrails or guarding. If temporary barricading is required it should be considered to be a short-term administrative-type control only, until more permanent means of addressing the issue are implemented. Additionally, a clear reason for installing the short-term barricade should be recorded somewhere easily accessible to other personnel and someone made responsible for ensuring it is inspected and maintained until the hazard is addressed permanently.

Expert Panel Comments

Owners of assets have a duty to ensure the safety of these assets and the safety of anyone who might have access to them. This report highlights the importance of clear communications and good record-keeping with respect to any controls that have been put in place.

At the sites that the reporter describes it is very likely that there had been a safety management team with Job Safety Analysis (JSA) and Safe Work Method Statement (SWMS) and other similar administrative controls in place. However, as the reporter notes, records cannot always be relied upon. They are a low-level risk control at best because they may rely on retention of people and site history.

Owners of assets have a duty to ensure the safety of these assets and the safety of anyone who might have access to them.

Always ensure a safe form of access

Ultimately, this report highlights that persons accessing a dilapidated structure have an obligation to themselves to ensure that the structure is in fact safe to access (noting that the person(s) with control and management of the site and/or the particular area also have this obligation). They should undertake preliminary inspections using a safe form of access or from a safe vantage point before entering any area that may potentially have hazards, whether structural or otherwise. If this is not possible, the matter should be referred back to the asset owner before access is effected.

The risk of unauthorised access

Besides intentional and authorised access, there is always the risk that unauthorised persons may obtain access to structures. Therefore, removal and making safe is always preferable to precluding access and letting a structure continue to deteriorate as it will only become more expensive, dangerous and time-consuming to rectify in the long term.

Scaffolding should only be used as a short-term temporary barrier

As the reporter notes, scaffolding should only be used as a short-term temporary barrier. The assumption made by scaffolding manufacturers and suppliers is that it is disassembled after use, inspected for damage and readied for re-deployment. This process does not allow for permanent or long-term installations and therefore it poses risks the suppliers never considered, such as:

- Corrosion under long-term build-up of by-products. This is especially prevalent on mine sites and port facilities.

- Internal corrosion not identified as the parts are not stripped and inspected as intended.
- Loosening of fastenings and couplings due to fatigue and corrosion.

Where scaffolding is used as a temporary short-term barrier the following mitigating steps are suggested:

- Keep registers on-site of when the scaffolding was installed and ensure it is removed, inspected and rebuilt at regular intervals or replaced with permanent suitably-designed barriers.
- Keep scaffolding clear of any spillage encrustation.
- Avoid using scaffolding as a makeshift barrier in damp, corrosive areas or where there are dynamic loads present.
- Use a modified metal scaffold tag which includes the reason for the barrier, contact phone number of responsible engineer or inspector and the date of next inspection.

A risk assessment should always be undertaken to control a hazard or risk according to the hierarchy of controls. If a risk assessment determines that a control measure higher up on the hierarchy of controls (for example, a control measure that eliminates the hazard all together) other than a temporary barrier is reasonably practicable, then that control measure should be implemented.

IStructE strengthen CPD guidance on structural safety

(Reduced version – full version https://www.cross-safety.org/aus/news-and-events/istructe-strengthen-cpd-guidance-structural-safety)

John Veares, Chair of the Institution of Structural Engineers (IStructE) Professional Development Panel, introduces the changes that the IStructE have made to Continuing Professional Development (CPD) reporting on structural safety.

Regular CPD is generally a vital part of maintaining registration and structural safety should be considered as a significant part of this.

From 2019, the Engineering Council (EC) decreed that all Professional Engineering Institutions would be required to introduce mandatory CPD audits with appropriate sanctions. The foresight of IStructE meant that such a system was already in place and its membership in step with the EC requirements. However, this did not mean that we could sit back and not develop the system. Having engaged the membership, it is important to now look to improve the quality of CPD returns submitted.

Structural safety CPD

The IStructE recognised the importance of safety-related CPD for its members. Therefore, since 2019, the IStructE has suggested that members include aspects specific to structural safety in their CPD activities and returns. In 2021 there has been a campaign to further promote the importance of structural safety CPD. It is now suggested in the guidance that members should aim to gain at least six hours (of the recommended 30 hours) of structural safety-related CPD each year. It is hoped that this approach will have the same effect as mandatory CPD reporting and will put the membership in a good position to satisfy current requirements and any proposed new legislation.

It is noted that with the upcoming changes to licensing for engineers in New Zealand that more stringent requirements for CPD will be introduced. It is likely that professional engineers will be required to complete minimum attendance to courses and certain readings to meet the new upcoming CPD requirements in New Zealand

Editor

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