Number 10

MAINTENANCE MATTERS

BC HOUSING RESEARCH CENTRE

At-Grade and Below-Grade Assemblies

Most multi-unit residential buildings today include multiple levels below ground level. These below-grade spaces are typically used for automobile and bicycle parking, storage, and mechanical and electrical rooms. Conditioned, occupied spaces below-grade are less common. Water ingress into below-grade spaces is one of the primary building performance issues, can be a nuisance to occupants, and may result in damage to the reinforced concrete structure over the long term.

A typical courtyard at-grade assembly. This courtyard features many different types of overburden, making access to the underlying membrane difficult.

What are At-Grade and Below-Grade Assemblies?

A typical at-grade assembly comprises overburden materials, a waterproofing membrane and a concrete slab forming the roof above the below-grade portion of the building. The concrete slab is often referred to as the podium. Examples of overburden materials include hard landscaping (patios, walkways, roads, stairs and planter walls) and soft landscaping (grass, shrubs and trees). Water features are also becoming increasingly common. Given these overburden features, it can be difficult and expensive to access the waterproofing membrane on the concrete podium slab for review, maintenance and renewal.

Membranes installed on podiums are protected from some of the forces that cause degradation, such as sunlight and extreme temperature variations. However, these membranes are frequently wetted due to a combination of precipitation, irrigation and absorptive overburden. Membranes are also prone to damage from vegetation root penetration.

Maintenance Matters

This series of bulletins and companion videos is designed to provide practical information on maintaining residential buildings. Produced by BC Housing, in collaboration with Polygon and the Condominium Home Owners' Association (CHOA), this bulletin was prepared by a consortium of building envelope experts.

The below-grade assembly consists of foundation walls, interior suspended concrete slabs, and the slab-on-grade that forms the bottom floor of the structure. At a minimum, below-grade foundation walls are coated with a damp-proof coating to control water movement from the soil into the concrete. Waterstops installed at construction and control joints are installed to resist the infiltration of bulk water at cracks and joints. A free-draining material is also installed on the exterior of the dampproofing to encourage drainage away from the wall, and to eliminate hydrostatic pressure. Waterproof membranes are used instead of dampproofing when the consequence of water ingress is greater (for example) and if there is a likelihood of significant water flow in the drainage layer, or there is a risk of hydrostatic pressure.

Suspended concrete slabs within parking structures are required to be waterproofed to limit the penetration of de-icing salts, chemicals and water into the concrete slab. The most common waterproofing system is a polyurethane vehicular traffic membrane. These membranes are multilayer systems typically consisting of specialty primers, a waterproofing layer and a wearing surface. They are primarily affected by physical damage and vehicular traffic wear.

The slab-on-grade is a concrete slab usually poured on a polyethylene sheet, over free draining material placed in the excavation with a suitable dewatering system to eliminate the risk of hydrostatic pressure on the underside of the slab. In cases where there is hydrostatic pressure, a waterproofing membrane can be used under the slab-on-grade, provided the slab and structure are designed to resist the hydrostatic pressure. This type of waterproofed slab-on-grade is common in elevator pits that often extend below the level of the building drainage system.

Why Must At-Grade and Below-Grade Assemblies be Maintained?

At-grade and below-grade assemblies are typically constructed of reinforced concrete which is durable and intended to last for the life of the building. Waterproofing and dampproofing membranes are installed on the exterior of the concrete to limit the ingress of water, and reduce the potential for corrosion of the reinforcing steel within the wall or slab. These membranes are difficult, if not impossible to access for maintenance and renewals due to the level of overburden and adjacent infrastructure. As a result, all membranes used in these assemblies should have a long service life.

In practice, there are no waterproofing systems with life expectancies that ensure performance over the entire life of a modern building. As the membranes age, the combination of membrane and concrete performs as a two-stage system with a primary layer consisting of the membrane, and a secondary layer of reinforced concrete and waterstops. Both of these layers can be reasonably water resistant. Together, these layers provide some

Water ingress through a crack in the concrete slab

Cracks in a suspended concrete slab membrane

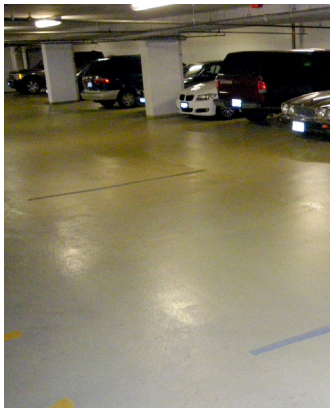
Corroding reinforcing steel and delaminated concrete

redundancy on their own. For example, if the membrane has a small hole and the concrete is continuous, then leakage to the interior may not occur. Conversely, if the concrete has a small crack, the membrane may often bridge the crack and prevent water ingress. Over the life of the building, settlement, seismic movement and corrosion will act to induce cracks in the concrete structure. These cracks may sometimes extend up through the membrane and allow water ingress.

Water ingress is an indication that maintenance is required. If left unchecked, the constant flow of water through the concrete will bring moisture to the reinforcing steel, which will eventually result in corrosion of the steel. In the short-term, this corrosion results in rust staining on the interior surfaces. Rust staining is an indicator that maintenance is required. If maintenance is not carried out at this time, the corrosion may eventually expand and cause the concrete covering it to delaminate, spall and dislodge. Spalling and delaminating concrete can be dangerous to occupants, cause damage to property and is an indication that maintenance is required immediately.

The cost of performing maintenance to below-grade assemblies increases exponentially the longer it is deferred. When addressed early, the costs for maintenance may be limited to reducing water infiltration, whereas deferred maintenance may include expensive concrete repairs in addition to controlling the water infiltration.

Delamination of suspended concrete slab membrane



Targeted repairs to a suspended concrete slab membrane

What Maintenance Must be Performed?

Leaks and Staining

Annual reviews for water ingress should also be conducted. If water leakage has caused visible rust stains on the concrete, the areas around the stains should be sounded by tapping the concrete with a hammer and listening for hollow sounds. Hollow sounds indicate delaminated concrete. If water ingress is increasing in frequency and severity, or if concrete delamination or spalling is occurring, a knowledgeable contractor or consultant should be retained to investigate the issue.

Membrane Repairs

It is preferable to repair the discontinuity in the waterproofing membrane from the exterior. If the waterproofing membrane can be economically exposed, then an investigation and exterior membrane repair strategy should be developed and implemented. Test methods such as die testing, and smoke testing under pressure can be effective in finding membrane discontinuities. A review and estimation of the remaining service life of the membrane should also be performed at this time.

If it is not economical to access the membrane – and the extent of the water ingress, steel corrosion, and concrete delamination is acceptable – water ingress can be managed by sealing the leaking cracks in the concrete from the interior. A qualified contractor can be retained to inject the crack with epoxy or urethane, or the crack can be routed out and sealed with hydraulic grout. The goal is to try and push the injection material through the crack in the concrete and through the discontinuity in the waterproof membrane so that a seal is made on the wet side of the membrane. This provides the maximum protection for the reinforcing steel. However, care must be taken not to blow the waterproofing membrane completely off the concrete with the pressure of the injected material, thus creating an even larger path for water ingress.

Injection Repair Techniques

Often it is not possible to repair the membrane with injection and the focus is on making the concrete watertight to control water ingress. Injection repair techniques are iterative and often take several applications before water ingress can be managed to an acceptable level. In many cases, the successful sealing of one crack may redirect water to an adjacent crack that will require subsequent repairs. In some cases, such as at movement cracks, the effectiveness of crack injection is relatively short-term and successive applications are required on a cyclical basis to adequately manage water ingress.

Drains

Drains for at-grade and below-grade assemblies should be reviewed and cleaned. Leaks commonly occur at drain locations. In these instances, rather than attempting to seal the leak through injection techniques, excavating locally from the top surface and reconnecting the drain body to the podium waterproofing can be effective.

Traffic Membrane Repairs

Unlike membranes on the podium and the foundation walls, the polyurethane traffic membrane on suspended concrete slabs is visible and can easily be reviewed and maintained. This system should be reviewed annually for signs of distress, such as tears, cracks, delamination and discolouration. Distressed areas, or areas with water leaks, can be repaired by a qualified contractor. The main areas of wear are typically drive isles and turning areas. In these areas the wearing surface, consisting of the top layer with embedded granules, will wear down over time. It is important to inspect this layer and renew it on an as-needed basis to prevent damage to the relatively fragile waterproof portion of the membrane below.

Water Runoff Control

The control of ground and drainage water runoff is also critical. It prevents water build-up in the foundation drainage system which can create hydrostatic water pressure on foundation walls. It is important that the foundation drainage system is reviewed and cleaned out on a regular basis. A mechanical contractor should be retained to visually scope and clean the foundation and belowgrade drainage system using the cleanout ports if water ingress is occurring or increasing. Annual maintenance of the mechanical sump pumps and dewatering equipment is also required.

Landscaping Considerations

The planning and maintenance of the landscaping on the podium slab area and the area adjacent to the foundation walls is also critical to the longterm success of the at-grade and below-grade assemblies. Vegetation root growth is one of the primary failure mechanisms for waterproofing systems. It is important to select species that do not have aggressive root systems that can damage membrane systems. Species such as oak and alder, whose strong root systems may permeate the membrane, should be removed. They are often seeded on-site by birds and wind. If landscaping includes species with aggressive root systems, a suitable root barrier is required to prevent roots from damaging the membrane. Maintenance of this type of system should include exposing the drains and some sample areas around the perimeter of the root barrier annually to ensure that root systems are not damaging the membrane or plugging the drainage system.

Irrigation systems and pools can also contribute to problems on podium slabs. Maintenance should include a semi-annual review of the irrigation nozzles and drainage systems. This will ensure that they are not wetting enclosure interfaces or causing excessive erosion or drainage adjacent to the below-grade walls.

Renewal of Waterproofing Membranes

Eventually water ingress and concrete delamination may become systemic. In such cases, renewal of the waterproofing membranes on the podium or the suspended slabs is necessary. Podium membrane replacement will require removal of overburden, removal of the existing membrane, repair of the concrete slab

and reinforcing steel, and installation of new membrane. Attention must be paid to waterproofing transitions, such as the base of the building walls.

Suspended slab membrane renewal does not require overburden removal, but careful coordination may be required to keep the parking garage operational during waterproofing.

Replacement of the below-grade wall membranes is not usually possible. Renewal of these systems can include extensive concrete rehabilitation, management of water leakage with gutters and ongoing wall injection or grouting.

Action Plan Tips

- Conduct annual reviews for water ingress and concrete delamination, preferably by a knowledgeable contractor or consultant.
- Review landscaping, irrigation and surface drainage annually to ensure root systems are not damaging membranes and water runoff is directed away from foundation walls.
- Review drains and cleanouts annually and keep clear.
- If water ingress is systemic, increasing in severity or if concrete delamination is occurring, retain a professional engineer with structural and building enclosure expertise.
- Retain a qualified contractor to seal the waterproofing membrane from the exterior to address incidental water ingress. If the area is not accessible, inject leaking cracks from inside the below-grade space.
- Review the polyurethane traffic membrane on the suspended concrete annually for signs of wear, distress (such as tears, peeling, delamination and discolouration) and repair as required.
- Plan for the renewal of membranes in the future and budget for this renewal in your contingency reserve fund.

More Information

› Deterioration of Parking Structures: Extent, Causes and Repair Considerations, available at www.cmhc.ca

› Poured in Place Concrete Residential Construction: Moisture Management Strategies, available at www.bchousing.org

› Building Envelope Design Guide – Below Grade Systems, available at www.wbdg.org

› Review your building's maintenance manual

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