How to protect hollow-core slabs in parking structures from deicing salts

Dominic Lemieux and Chad Van Kampen

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- This paper provides guidance on how to protect hollow-core slabs from premature deterioration in parking applications to improve the life span of the structure.

Parking structures are among the most challenging types of structures to design with regard to durability, especially in colder climates, where deicing salts are used. Chloride ions contained in deicing salts quickly deteriorate concrete and may cause concrete slabs to reach a critical condition less than 10 years after being constructed.

Precast concrete parking structures are common throughout the United States, and their floor assembly typically consists of prestressed concrete double-tees bearing on prestressed concrete inverted-tee beams. Although this type of construction has proved to be a particularly efficient way to build a parking structure due to its extra-long spans, the overall depth of the floor assembly might not be suitable for all applications. In mixed-use buildings where parking is required, reduced floor-to-floor height might be favored. In these types of applications, hollow-core constitutes a great alternative and provides superior span-to-depth ratios because of its prestressed reinforcement and reduced weight due to its voided cross section.

In parking structures, precast concrete hollow-core slabs, just like any other concrete slabs, need to be protected against chloride ions to reach their desired life expectancy. To accomplish this, parking structures must be detailed, constructed, and maintained to ensure that water and deicing salts are not allowed to penetrate the slab or cores to prevent corrosion of the stressing tendons and premature failure (**Fig. 1**).

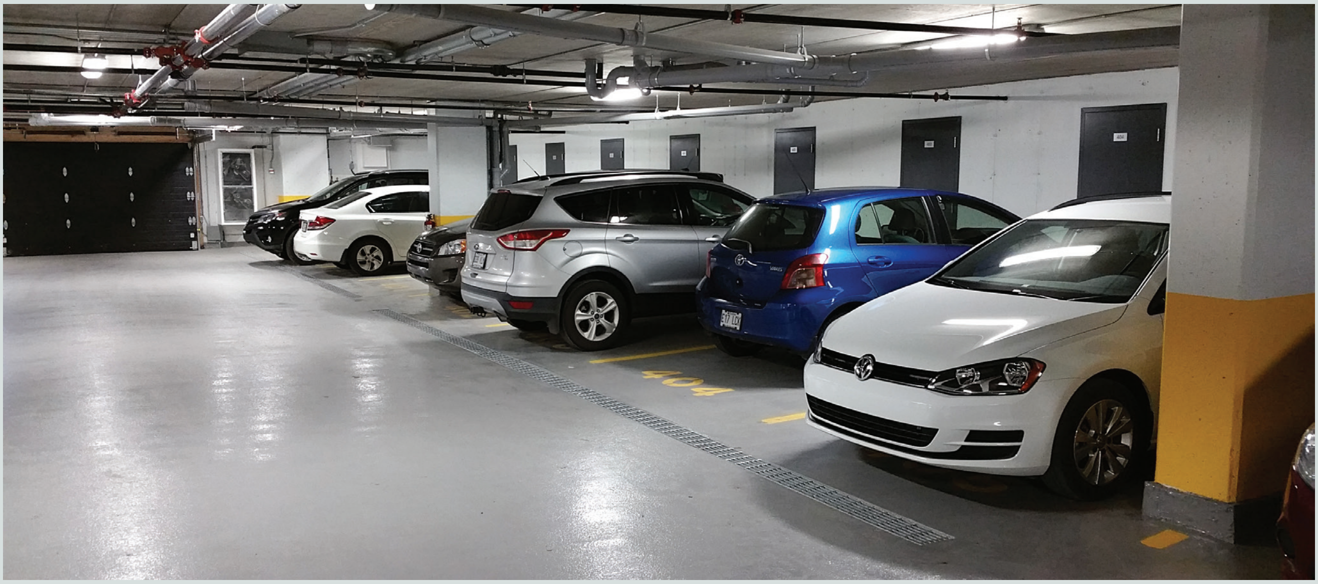

Figure 1. Top surface of a parking structure constructed with hollow-core slabs with drains inside the voids.

Membranes and waterproofing sealants

The most reliable way of preventing infiltration of chloride ions in a concrete slab is by using a waterproofing membrane or sealant. The durability of this protective barrier will have a direct impact on the durability of the parking structure itself. Although protective materials might initially appear costly in the budgeting phase, they remain a great investment compared with the exorbitant costs of prematurely repairing a concrete slab. Many factors can influence the type of product chosen to protect the parking structure: slip resistance, durability and service-life requirements, temperature cycling, ultraviolet light exposure, and any anticipated movement within the structure.

Multiple types of protection are available, and different assembly combinations are also possible (**Fig. 2**). Polyurethane, methyl methacrylate, and resin-based coatings are typically applied on top of the wearing surface. These liquid-applied types of sealants have proved to be effective at preventing water infiltration but must be reapplied approximately every five years to maintain impermeability.

Although polyurethane-based deck-coating systems are most common, acrylic methyl methacrylate systems are increasingly being specified. Methyl methacrylate deck coatings offer fast-cure installation to keep disruption of operations to a minimum during renovation. In addition, the performance of these systems is significantly better compared with polyurethane deck coatings, allowing recoating when maintenance is required to preserve the integrity of the system.

Highly resistant, resin-based deck-coating systems can be used to prevent the early onset of corrosion, providing a protective barrier between the contaminants and the host substrate. Resin-based deck-coating systems provide protection by accommodating thermal movement to prevent thermal cycling over a 24-hour period or seasonal changes that could lead to eventual damage. Pigmented resin coating systems will transform a parking structure, protecting it over time while simultaneously brightening the environment with the addition of color, improving lighting levels through their reflective properties, and enhancing the overall ambience of the parking structure to make it a safer and brighter place for people to park.

Waterproofing through crystallization admixtures added to the concrete topping can also be an efficient and permanent way to protect hollow-core slabs from chloride ions. Crystallization admixtures lower the permeability of concrete and are used in place of surface-applied waterproofing membranes. When added to concrete, crystallization admixtures react with water and unhydrated cement particles to form insoluble, needle-shaped crystals that fill capillary pores and microcracks in the concrete to block the pathways for water and waterborne contaminants. Any moisture introduced over the life span of the concrete will initiate crystallization, ensuring permanent waterproofing protection.

Elastomeric waterproofing membranes (like roof membranes) can also be used to prevent the penetration of chloride ions into concrete slabs. Although elastomeric waterproofing membranes might initially appear to be impassable, their position in the floor assembly can be a determining factor in their durability. When an elastomeric waterproofing membrane is welded on top of the wearing surface, it protects the topping slab and hollow-core slabs underneath. However, a car can potentially rip the membrane when turning its wheels without being in motion. To protect the elastomeric membrane, it is possible to weld it on top of

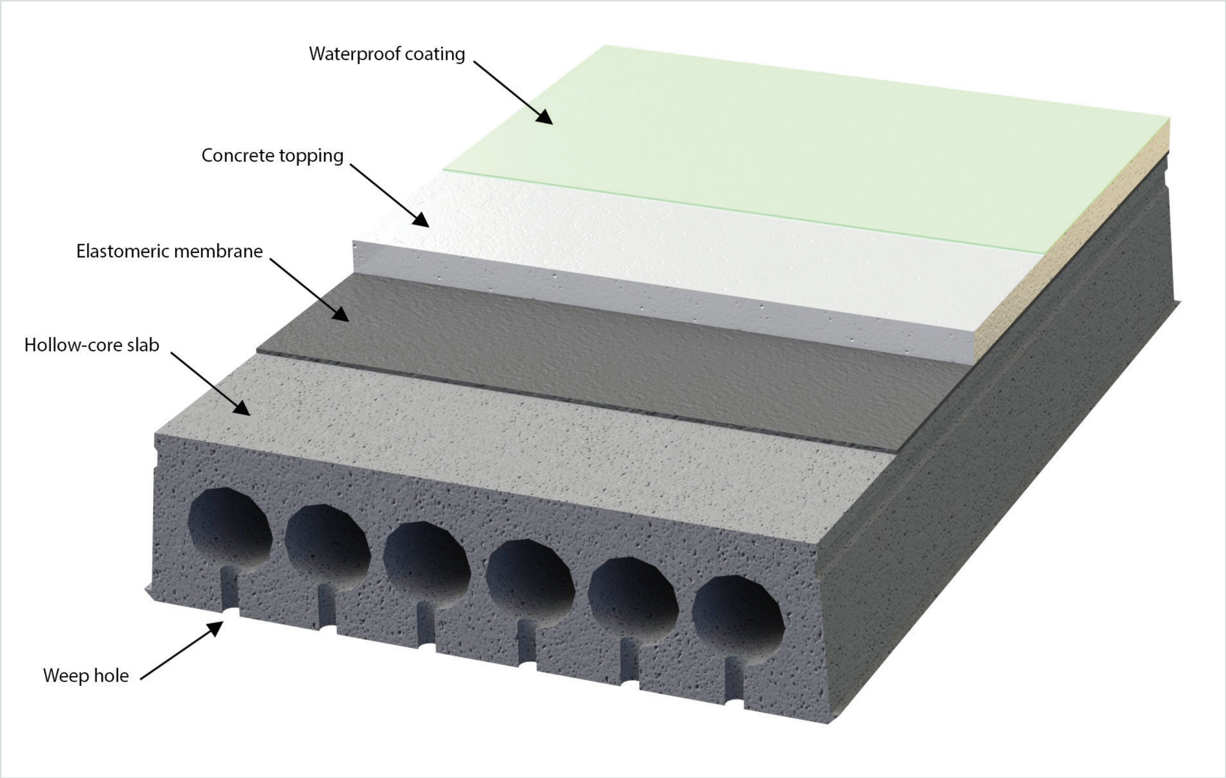

Figure 2. Hollow-core slab floor assembly with multiple protections against premature deterioration.

the hollow-core slab and place concrete for the topping slab over it. Although it protects the membrane, this assembly has two drawbacks. First, it separates the hollow-core slab from the topping slab, eliminating the possibility of designing a composite topping to increase bending moment capacity and potentially simplify the diaphragm's design. Second, having the membrane underneath the topping slab means that the topping slab will inevitably suffer from chloride-ion infiltration if not protected by a second protective barrier applied on the wearing surface.

Because hollow-core slabs require a topping slab, it is possible to take advantage of the on-site second placement to double the protection against chloride-ion infiltration. While the waterproof sealant on the top of the topping slab is already a great first line of defense, the topping concrete can act as physical protection for an elastomeric membrane located between the hollow-core slab and the topping slab.

The problems that affect the performance of waterproofing membrane systems fall under three main categories:

- application factors, such as mixing of components at cold temperatures, poor mixing of the components, incorrect proportioning of the components, and delayed application of the mixed components
- substrate conditions, such as moisture in the substrate and poor surface preparation
- ambient weather conditions, such as variations in humidity and temperature

Weep holes

The voids inside hollow-core slabs reduce the slabs' dead weight and allow for longer spans. However, if the hollow-core slabs do not have weep holes, the voids can potentially fill with water and break the concrete during freezing temperatures. Freezing water in the cores can expand and cause cracking, which in turn allows more moisture to enter the cores.

Weep holes also help to identify water infiltration through the protective barrier at an early stage and make it possible to repair the membrane or sealant before chloride ions cause irreversible critical damage to the structure.

Slopes

In the design phase of a parking structure, it is important to consider how water will travel to the drains. Stagnant, contaminated water increases the risk of infiltration in the slab and early deterioration of the structure. The designer needs to ensure that drainage and slopes are in accordance with local codes. Different techniques can be used to create slopes with hollow-core slabs. Slopes with small height variations (a few inches) can be accomplished simply by using a variable topping thickness (for example, 4 in. [100 mm] going down to 2 in. [50 mm]). For greater variations, it is common to vary the elevation of the two bearing members supporting the hollow-core slabs. In such a case, the beam at the first end of the hollow-core would be several inches lower than the beam at the second end of the hollow-core slab (**Fig. 3**).

If the slope needs to be in the other direction of the span, it is also possible to increase the camber in the beams and offer an arc-shaped bearing support that will produce slopes on both sides of the drive aisle. In such a case, the voids of the hollow-core slabs can also be used to incorporate the drains.

Transfer level

Aside from the parking consideration in projects such as these, there is most likely a need to have a transfer level where the parking ceases and living or retail space begins. This transition level has some unique requirements in addition to those of the typical parking levels. Most likely the parking cap or roof will be required to carry a high fire rating. The method used by each producer varies and should be explored on a project-by-project basis to ensure that all local code requirements are satisfied.

Another consideration is insulation requirements between the parking level and any occupied space. There are a few ways this can be addressed, and the method chosen will depend on the needs of the client. Insulation by spray foaming the underside of the precast concrete is an option that is easy to implement but may introduce additional fire protection and maintenance concerns. If plumbing is hung on the underside of the slab, this option may cause access to these elements to become limited.

Another option is to place the insulation on the top of the hollow-core slab. This can be done either before a topping system is placed or after a structural topping system is placed. If used prior to topping, the overall floor plate system will be noncomposite and will affect how diaphragm loads are distributed. If applied after a structural topping system, there may still be requirements for an additional topping coat for a wearing surface that can be a more budget-friendly material, such as gypcrete or another leveling system required for the use of the space above.

Quality of detailing, construction, and maintenance

Regardless of the type of concrete slabs used for a parking structure, the quality of the detailing, construction, and maintenance will have a major impact on the durability of the structure.

Concrete slabs will maintain their original structural integrity for as long as they are protected from contaminants—chloride ions in particular. Depending on the type of protective barrier chosen, the frequency of the maintenance may vary. If hollow-core slabs in parking structures are well protected and drained during their entire life span, they should last 50 years or more.

Figure 3. Beam installed at an angle to accommodate the required slope in a parking structure.

About the authors

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Abstract

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Keywords

Corrosion protection, deicing salt, hollow-core slab, parking structure, waterproofing concrete

Review policy

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