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Design of Parking Structures for Reduced Maintenance

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Summary

Unique characteristics of parking structures affect their design and maintenance. Moving loads and severe environmental exposure require that special durability features be provided in the design of parking structures. Time tested good design practices and internal and external protection methods are available to the designers to minimize future maintenance of parking structures.

Keywords: parking structures; maintenance; durability; design.

1. Special Characteristics of Parking Structures

When not enclosed, parking structures are subject to ambient weather conditions, which may vary widely based on the geographical location. In cold climates, they are often exposed to snow, ice and water, and to corrosive action of deicing salts. Unlike a bridge deck, the inside of a parking structure is not rinsed by rain, and its exposure to chlorides may be aggravated by poor drainage.

The parking structures are primarily subjected to the loads from moving vehicles and their roof levels exposed to weather similar to bridge decks. Since they are frequently very large in plan view, they experience greater volume changes (temperature, shrinkage and creep) than the enclosed structures, which are usually smaller and are exposed to more uniform temperature, humidity and moisture.

2. Commonly Encountered Problems

The most common types of deterioration and undesirable performance in the parking structures are the corrosion of reinforcing, cracking, spalling, freeze-thaw damage, leakage and ponding of water.

When the protective concrete cover is reduced or when the chlorides are present in sufficient quantities, the reinforcing steel will begin to corrode. The volume of corrosion by-product (rust) is many times the volume of the original metal. This increased volume results in an expansive force which causes the concrete to fracture. Also, the loss of cross-sectional area of reinforcing will reduce the structural capacity of concrete elements. When the corroding bars are closely spaced, horizontal fractures may

form parallel to the surface, but remain invisible on the surface. This subsurface fracture creates a concrete delamination at the level of reinforcing steel. Finally, the delamination will spall creating potholes on the top surface or a large piece of concrete may fall from the underside of the deck.

Many problems observed in parking structures are related to inadequate considerations of volume changes. They include variable height columns due to sloping ramps, tying structural floor to the stair or elevator shaft, nonfunctional sliding bearing joints for the floor beams and at expansion joint locations, shortening of the first supported floor framing in relation to its fixed foundations, differential movements of the different areas of the structure built partially below grade, etc.

3. Good Design Practices

The structural system should, in addition to its load bearing function, primarily be designed to minimize the cracking and to accommodate expected volume changes. Properly spaced and sealed expansion joints will allow for the movement of the structure as a whole and will not allow the water leakage through the joints. Post-tensioned concrete decks may also have pour strips, which have to be continuous vertically and horizontally through the entire structure.

In addition to a required concrete strength, low permeability of concrete will help it resist the penetration of water, chloride and oxygen. Silica fume (microsilica) concrete is more dense than regular concrete and is known to be more resistant to chloride intrusion. The proper concrete mix for the garage slabs should have a water-cement ratio of 0.40 or less and its aggregates should not be porous or reactive. Where freeze-thaw protection is required, the concrete should be air-entrained by adding an air-entraining admixture to the concrete mix. However, calcium chlorides and admixtures containing calcium chlorides should not be used in concrete for parking structures.

Parking structures with initially built-in protection systems are more durable and have significantly less future maintenance. The internal protection measures include coating of steel reinforcement, protection of post-tensioning tendons, and corrosion inhibitors in concrete mixes. One of the most important measures for reduced maintenance is to specify an appropriate concrete cover over reinforcing bars, particularly in the top of the floor slab. The external protection systems include application of concrete sealers, traffic bearing membranes, and joint sealing systems, including special expansion joint seals.

4. Conclusions

The unique loads and characteristics of parking structures require special design features to reduce their future maintenance. In addition to selecting an appropriate structural system, a proper material selection, specifying adequate concrete cover for steel reinforcement, and installation of internal or external protection measures will reduce future maintenance. Also, the cost of future maintenance will be minimized when a regular periodic maintenance program is implemented.