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REHABILITATION OF THE PLAYGROUND AT THE COOK COUNTY TEMPORARY JUVENILE DETENTION CENTER, A WATERPROOFING CHALLENGE

By:

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1.0 BACKGROUND

Constructed in the 1970's, the Cook County Juvenile Temporary Detention Center in Chicago, Illinois is a 5-story steel framed building with composite concrete and steel deck floor slabs, and steel and glass curtain walls. A 378-foot by 210-foot (79,000 square feet) courtyard is located in the center of the building at the third level and surrounded on four sides with three additional floors of the structure. This courtyard serves as a playground for the detainees. Below the playground are a gymnasium and classrooms for the detainees. The structural deck supporting the playground consists of a composite concrete and steel deck, and was originally topped with a waterproofing system, rigid insulation and a concrete topping slab.

The only access to the playground are four access doors into the courtyard, two each on the east and west sides. The doors are located in structures referred to as "Cores" which extend approximately 22 feet into the playground. The steel and glass curtain wall panels, referred to on the original design drawings as "steel skin", are located 1 foot 4 inches in from the playground perimeter column lines. Steel plate partition walls running east-west between the core structures divide the playground into north, central and south sections. There are a total of ten drains on the courtyard deck - three in the north section, three in the south section and four in the central section.

For several years, the playground concrete topping (wearing surface) had exhibited scaling, cracking and spalling. A rubberized athletic surfacing was added over the concrete topping more than 10 years age to provide a soft surface suitable for activities. However, the athletic surface had delaminated in several areas and was partially removed in 1996.

Building management reported concerns with persistent water leakage below the play ground area in some classrooms and the gymnasium. There were also concerns regarding trip hazards due to the deterioration of the concrete topping and the athletic surface.

To address these concerns, in 1996 the County commissioned a comprehensive program to evaluate the condition of the playground deck components, explore rehabilitation options, and to provide recommendations for repairs. Remodeling of some interior spaces was to be included in the scope of the rehabilitation.

A local architectural firm with extensive experience in design of detention facilities was retained by the County to head the task. In turn, the architectural firm retained a Chicago area consultant with expertise in the evaluation and rehabilitation of roofing and waterproofing systems to address the County's concerns regarding the playground deck.

2.0 SCOPE OF INVESTIGATION

An investigation was performed to assess the condition of the playground deck components including the waterproofing membrane and its concrete topping, and to evaluate causes of water leakage. The investigation included the following tasks:

1. Original architectural and structural drawings were reviewed to determine design intent and construction details.

2. The playground topping slab and joints between the topping slab and adjacent curtain walls were visually reviewed.

3. Exploratory openings were made on the playground deck to review components of the deck. At each exploratory opening, the topping slab was removed in a 2-foot by 2-foot area to expose underlying components.

4. Relative elevations of the playground topping slab and structural slab were established along the building perimeter and at each exploratory opening.

5. Samples of the topping slab, structural slab, waterproofing membrane, perimeter cant strip and insulation were removed for laboratory testing and examination.

6. To assess extent of damage due to continued water leakage, ceiling tiles in the areas below the courtyard were removed to visually review the framing and steel decking at several selected locations.

7. Laboratory tests of samples were performed to evaluate moisture levels in the insulation and perimeter cant, acid-soluble chloride levels in the structural slab, and presence of asbestos in the waterproofing membrane.

8. Field and laboratory data were analyzed. An investigation report was prepared that included several conceptual alternatives for repairs along with order-of-magnitude cost estimates.

After preparation of a report and conceptual rehabilitation schemes, the County participated in the evaluation of the options, and selection of the most suitable repair option for the project.

3.0 FINDINGS OF THE INVESTIGATION

The investigation revealed the following regarding the deck and its components:

1. The existing concrete topping slab was severely deteriorated. Visually observed cracking and scaling was due to freeze-thaw deterioration of concrete and improper placement of control joints. Previous patch repairs were also typically cracked and delaminated.

2. Overall condition of the waterproofing membrane was judged as poor to fair. Two layers of built-up bituminous waterproofing membranes were found over the structural deck. Although condition of the membrane material itself was typically fair, it was improperly installed at several locations. Perimeter flashing was improperly installed and was ineffective in keeping water out of the building. The intersection of the joints between curtain wall panels and the waterproofing system were typically improperly sealed. In addition to the leaks reported on the level below the playground, several leaks were found around the perimeter of the playground at the base of the curtain wall on the same level.

3. Drainage slope was provided for by sloping the top of the structural deck at 1/16 inch per foot. The drainage slope was relatively inconsistent. In combination with vast distances between the drains, local ponding on the waterproofing membrane occurred.

4. A considerable amount of standing water was observed in four of the five exploratory openings indicating inadequate drainage at the waterproofing membrane level.

5. The drain assemblies were severely rusted and clogged with debris.

6. Except for some minor rust stains on the metal decking, no significant deterioration of the structural deck due to prolonged leakage was found. Chloride levels within the structural slab were below the minimum level generally considered necessary to initiate corrosion of embedded steel in concrete. Therefore, corrosion of the galvanized steel deck was not expected.

4.0 REPAIR ALTERNATIVES

Based on the observed conditions, it was evident that a major rehabilitation of the waterproofing system on the playground had to be undertaken. This rehabilitation would include the complete removal of the topping slab and waterproofing system and installation of a new waterproofing system and a wearing course.

Rehabilitation of the waterproofing system over the playground posed several interesting challenges. These challenges had to be considered in developing a suitable solution to the water leakage problems.

First Challenge – Drainage

Improving the existing drainage system was the first challenge. The following alternatives for improving the drainage were carefully considered:

1. A lightweight insulating fill overlay could be placed over the structural slab (and below the new waterproofing membrane) to provide improved drainage slope. However, the insulation layer below the waterproofing membrane would create condensation potential underneath the membrane, would result in unacceptable flashing height along the playground perimeter and doors, and would pose problems with drying time before installing the membrane. Therefore, this approach was deemed impractical.

2. A bonded lightweight structural concrete overlay could be placed over the structural slab (and below the new waterproofing membrane) to provide improved drainage slope. This approach would also result in an overlay thickness of approximately 6 inches around the perimeter of the playground. The additional dead load imposed by such an overlay could not have been accommodated within the design capacity of the deck. Therefore, this approach was deemed impractical.

3. Additional drains could be installed between existing drains. However, due to the existing drainage pattern, these drains would not serve a large drainage area. In

addition, modification to the 5-foot-deep plate girders below the deck would have been needed to accommodate new drain lines. Therefore, this approach was deemed impractical.

4. A tapered insulation system could be installed over the structural deck to improve surface drainage at the level of the topping slab. This system would result in an insulation thickness of approximately 6 inches at the perimeter of the courtyard. A 2 to 2-1/2 inch concrete topping could not overcome the buoyancy of the insulation in the event the insulation became submerged. Therefore, this approach was deemed impractical.

5. The surface drainage slope of the structural deck could be revised to provide improved drainage. However, this approach would have required the removal of portions or all of the structural deck concrete and was not considered economically feasible.

In order to improve drainage over the membrane, a layer of prefabricated drainage composite was recommended to be placed over the protection course that was placed over the waterproofing membrane. This would improve water drainage at the membrane level. To minimize surface ponding over the topping slab, strict flatness and slope requirements for finishing the concrete topping slab were incorporated into the design documents. Despite all these, the owner was informed that due to reasonable construction tolerances, some local ponding may occur on the concrete topping.

Second Challenge – Owner's Requirements

Before proceeding with the final design of a new waterproofing system, the project team discussed alternatives for various waterproofing systems along with their advantages and disadvantages, costs considerations, and construction concerns were discussed with the owner. In the final analysis, the waterproofing system that was selected was one that could address all of the owner's concerns and requirements.

Owner's requirements and concerns included the following:

1. The facility is a temporary juvenile detention center. Operations of the facility and the safety of the building occupants could not be jeopardized. As such, repairs had to be designed to minimize exposure of the occupants to construction elements such as smell, dust, debris, etc.

2. The exact time when funds would be available and a contract could be issued was not certain. However, the owner desired to minimize construction duration in

order to put the playground back to service. A total construction time of only 3 months was established.

3. Since the facility serves as a detention center, certain security concerns during construction had to be considered. For example, the owner could not provide the contractor unhampered access to the playground through the building. Furthermore, no tools, cameras, or construction materials could be transported within the building. Due to these limitations, an average trip from the from entrance of the building to the playground was anticipated to take over 30 minutes. During the construction phase, getting from the playground back to the entrance door could sometimes take over 2 hours!

4. Due to the nature of the facility, the owner also expressed a desire to avoid having any components of the waterproofing system or the playground deck that could be tampered with. This precluded the use of exposed fasteners, etc. Special details had to be designed to ensure that counterflashings and benches installed over the deck would be durable.

5. As with other owners, the County's budget for the rehabilitation of the playground was limited. Any rehabilitation program that could meet the other challenges would not be implemented if it did not fall within the established project budget.

Third Challenge – Flashing Details

Figure 1 shows a typical original design detail around the perimeter of the playground and the interface of the waterproofing system with the adjacent curtain walls. One of the areas that was suspected to provide the water path that led to the leaks on the same level as the playground is shown in Figure 1. As can be seen in this figure, this detail posed several challenges.

1. The elevation difference between the interior slabs and the playground deck was not sufficient enough to provide adequate flashing heights, and the height required to accommodate all the components of the new waterproofing system and an adequately thick topping slab.

2. The substrate on which the flashing materials had to be terminated consisted of heavy steel members. This would make the installation of a termination bar difficult. Furthermore, the membrane termination would be overshadowed by a protruding steel façade panel that made access to the termination bar difficult.

3. The membrane termination detail had to prevent passage of water through the path indicated in Figure 1. If the membrane was terminated on the façade panels, differential thermal movement between the panels would cause stress concentrations at the panel expansion joints and result in the need for routine maintenance. If the membrane was terminated on the lower steel angle, the membrane termination would not close the water path.

Forth Challenge – Partition Walls

The two full-width partition walls that separated the playground into three sections were constructed of 3/8-inch-thick steel sheets with fully welded connections. The partition walls were supported on irregularly-shaped structural steel pedestals and base plates onto the structural slab. The original waterproofing membrane was run directly underneath the walls and was continuos throughout the entire deck. However, the membrane penetrations at the partition wall supports were suspected of water leakage. If a loosely-laid single-ply waterproofing membrane was to be selected, the partition wall support pedestals would pose a detailing challenge to ensure a positive water seal that would not require routine maintenance.

Fifth Challenge – Logistics

The design of the new waterproofing system and its associated components had to take into consideration several logistic difficulties that would have to be resolved during construction.

Due to the configuration of the building, the only access route for getting construction debris out of the playground was up three levels, over the roof of the 5-story structure, and down 5 levels. This sequence had to be reversed for bringing construction materials into the playground area.

Considering the large quantities of debris generated by removing the existing concrete topping slab and other materials, this limitation could significantly impact the overall project cost.

Other limitations during construction included the live load capacity of the structural deck that could not be exceeded. Therefore large piles of debris or new materials could not be stored on the deck.

5.0 OTHER ALTERNATIVES EXPLORED

Due to the challenges of designing and constructing a new waterproofing system over the playground deck, two other alternatives were considered. These alternatives included construction of a large skylight structure, or a tensioned fabric roofing system on the fifth floor roof and covering the entire playground area.

Both of these alternatives would render the playground a protected interior space eliminating the need for a waterproofing system. The added advantage of these system would be a more controlled environment for use of the playground in the winter.

After some consideration, it was evident that installation of a skylight or a tensioned fabric roofing system would require extensive structural modifications to the building since the snow loads over the entire playground would have to be transferred to the columns surrounding the area. Also, the initial cost of such alternatives would be far in excess of the cost of replacing the waterproofing membrane. Therefore, these alternatives were abandoned in the early stages of design development.

6.0 THE RECOMMENDED SYSTEM

After careful consideration of the alternatives and challenges, the waterproofing consultant finalized its recommendations for the rehabilitation of the playground. The recommended repairs were as follows:

1. Remove the existing concrete topping, insulation and membrane from the deck.

2. Clean deck surfaces to receive new materials.

3. Place a layer of felt underlayment over the entire deck surface to isolate the new waterproofing membrane from the underlying bitumen-contaminated concrete deck.

4. Provide a loose-laid reinforced 79-mil PVC waterproofing membrane over the entire deck.

5. Install a layer of protection course and drainage composite over the membrane.

6. Install high-density extruded polystyrene insulation over the drainage composite.

7. Cast a new 2-1/2 inch thick concrete topping over the insulation.

It should be noted that several other types of waterproofing systems including hot-applied bituminous, modified bitumen sheet membranes, and cold applied liquid membranes were

considered for use on this project. In evaluating all of the above factors and the owner's concerns, the loose-laid PVC membrane was selected as the best available option.

To minimize disruptions to the building occupants, materials were selected with their installation methods in mind. For example, hot-applied bituminous membranes were ruled out due to the need for transportation of large kettles onto the playground, the need for a relatively dry concrete substrate and potential for unpleasant odor during installation.

To address the details at the perimeter walls, doors, core structures, benches, drains and partition walls, a set of details were developed that would address durability and water leakage issues discussed above. Figure 2 shows the design detail for the rehabilitation system at the outer curtain walls. To resolve the detailing problem at the partition wall supports, the membrane was terminated on both sides of the partition walls and sealed against the steel surfaces as shown in Figure 3.

Due to height limitations around the perimeter of the playground, the topping slab thickness was limited to 2-1/2 inches. To control shrinkage cracking of the new topping slab, control joints were specified on 4-foot centers in both directions. Expansion joints were also incorporated at maximum spacing of 52 feet. As mentioned before, strict quality control and finishing requirements were incorporated into the specifications to ensure a durable topping with minimal ponding.

Finally, an engineering cost estimate was prepared that showed the project could be accomplished within the owner's budget.

7.0 CONSTRUCTION

The contract for rehabilitation of the playground (and the interior remodeling work) was awarded to a waterproofing contractor with prior experience in rehabilitation work. Installation of the PVC membrane was subcontracted to an applicator approved by the membrane manufacturer.

Construction activities began in February 1997 due to the County's desire to have the playground area available to building occupants in the Spring months. Since the initial construction activities involved the demolition and removal of the existing concrete topping slab, demolition sequence and methods had to take into consideration the need to maintain the integrity of the existing waterproofing membrane. The existing membrane was to serve as temporary weather protection until the new membrane could be installed. As a result, extreme care had to be taken by the contractor during the concrete demolition phase to ensure that major sections of roof area were not left unprotected during rainstorms or snow melt.

As previously stated, several logistic problems faced the contractor. Specifically, particular attention had to be given to the live load capacity of the structural deck, the challenging access route for bringing materials on to the playground and removing debris from the same area, and dealing with the presence of two 12-foot tall steel partition walls that divided the playground into three sections.

Several different options were considered by the contractor to effectively remove demolition debris from one end of the playground to the other, and then up and over the five story structure surrounding the playground. The methods considered for transporting construction debris and materials over the surrounding three floors included conveyors and cranes.

After significant evaluation, the contractor decided to remove sections of each of the two steel partition walls to allow for an uninterrupted path from one end of the playground to the other. These sections were cut by torch, and were later reattached by fully welding all cut portions, grinding the welds smooth, and painting.

A small “Bobcat’ with pneumatic wheels was utilized for transportation of materials from one end of the playground to the other. Utilization of the “Bobcat’ required an analysis of its weight distribution over the slab and evaluation of the deck live load capacity. This task was performed by a structural engineer retained by the contractor.

A 200-foot crane was mobilized in the street area immediately adjacent to the building. All debris and materials were transported in and out of the playground using the crane. Concrete demolition began in the northern most section of the playground and, upon completion, moved to the center section of the deck. At that time, the work in the northern most section shifted to removal of the existing waterproofing system and subsequent installation of the new system.

Concrete removal was performed by carefully sawcutting the concrete topping slab into small manageable sections, and removing them one section at a time. Care had to be taken not to stockpile debris on the deck to avoid exceeding its live load capacity.

The existing waterproofing membrane was left intact until all concrete topping in each section was removed. This enabled the existing membrane to serve as temporary weather protection.

Concrete removal was then followed by removal of the existing waterproofing membrane. Two layers of built-up bituminous waterproofing membranes had to be removed without causing damage to the concrete deck below. This was performed using power roof removers. Significant clean-up and hand removal was performed to prepare surfaces to

receive the new waterproofing system. The surface preparation did not completely remove the existing membrane. This was anticipated in the design phase by incorporating a felt underlayment to isolate the PVC membrane from residue of the existing bituminous membrane (PVC membranes are not compatible with bituminous materials). Due to a time lapse between removal of the existing membrane and installation of the new PVC waterproofing membrane, a modified bitumen membrane was torched directly to the concrete deck to serve as temporary waterproofing.

The new PVC waterproofing membrane was laid over felt underlayment and all seams, with the exception of detail work, were welded with a power welding machine. Installation of the perimeter termination bars and sheet metal accessories required extensive preparation and hand work.

After installation of the waterproofing membrane, each section of the playground was isolated with temporary water stops and water tested by ponding for a minimum period of 48 hours. The areas below were monitored during that time to identify leaks. No leaks were detected during any of the water tests.

Membrane protection layer and drainage composites were installed next. This operation was followed by placement of a layer of extruded polystyrene insulation and the topping slab. The concrete was transported to the playground in buckets via the crane, where it was placed in motorized buggies and transported to the point of placement.

During concrete placement, quality control testing and sampling were routinely performed in accordance with the project specifications. Control joints were sawed in the topping slab, within 12 hours of placement, to minimize shrinkage cracking. Expansion joints were cast using pre-molded joint materials, and later sealed with sealant.

The above construction sequence continued through the center and southern most sections of the deck. Upon completion, the sections of steel walls which had been removed were welded back to their original position and the deck was turned over to the County on schedule.

8.0 SURPRISES

Perhaps the biggest surprise of the project was that it was completed within the owner's schedule and budget, and without a single change order related to the playground deck (there were a few unanticipated change orders for the interior remodeling portion of the project). The success of this project reinforces the notion that:

1. Every rehabilitation project should start with a thorough understanding of the problems, their causes, and project challenges.

2. Usually, there are several alternatives for repairs. When the advantages and disadvantages of each alternative are carefully weighed against the owner's objectives and limitations, the best alternative will emerge.

3. It is better to resolve challenging details on the drawing board that to wish they will resolve themselves during construction. Design details and specified materials should address all anticipated field conditions with practicality in mind.

4. Owner's involvement in the design and construction stage is crucial. Owners cannot make educated decisions if the consultants do not provide them with the information they need to make those decisions.

5. A contractor is part of the project team and their qualifications and willingness to cooperate with other team members is priceless.

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