Renovation of Baltimore's Historic Hippo Theater

By Tarek Alkhrdaji and Robert Charles

Dealing with unexpected job conditions midway through a project is a challenge for any contractor, especially when there's not enough time or money to make the changes. Because of its extensive experience and by using creativity and management skills, Structural Preservation Systems, Inc. (SPS), one of the specialty contractors for Baltimore's historic Hippodrome Theater renovation, was able to meet the challenge head-on. By performing structural concrete repairs on this $56 million project, SPS helped set the stage for success.

Plans had called for the renovated 2200-seat performing arts complex to become the prime Baltimore venue for Broadway shows and large, locally produced entertainment events. In addition to the theater itself, several adjacent historic buildings (dating from as early as 1887) are part of the plan to develop a performing arts complex stretching for almost an entire block. The complex will incorporate a completely new stagehouse behind the existing stage area; a restored auditorium area, including orchestra level and balcony seating; retail box offices; administrative offices; a loading dock; and flexible multipurpose spaces. The list of projects associated with this undertaking is long and includes relocation of site utilities, excavation, demolition, foundation work, structural steel, cast-in-place concrete and masonry work, curtain wall and storefront systems, exterior and interior historical restoration, and interior finishes.

From divine to decline

This handsome structure, built in about 1914 as a vaudeville house, is one of the remaining historic Thomas Lamb theaters. Once the pre-eminent venue for popular performers like Frank Sinatra and Rosemary Clooney, the Hippodrome Theater followed many other entertainment venues of its kind, first presenting live entertainment from the 1920s to

1940s and then featuring blockbuster first-run movies beginning in the 1950s.

By the 1970s, the theater was on its last legs, showing second- and third-run films to a steadily diminishing clientele. Portions of the Hippodrome's once opulent interior had been covered by paint or ignominiously draped with yards of garish pink curtains—all attempts to modernize the theater's appearance. Although the Hippodrome closed its doors in 1981, it had managed to outlive most economic activity in the immediate area, including four major department stores that once anchored this historic shopping district.

Fortunately, the Hippodrome property sits squarely in the middle of an area that Baltimore economic development officials have targeted as a prime opportunity for renewal—the area where the city's popular Inner Harbor and the

Left: Strengthening the typical 8.5-foot-span tread slab involved removing the existing slab topping and casting a 4-inch-thick bonded lightweight concrete overlay with steel reinforcement. Below: After the balcony slab was strengthened, scaffolding had to be erected on the balcony for another contractor to reach the 60-foot height needed to repair and restore damaged decorative plaster.

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New reinforcement technology sets the stage for the future

central business district connect with the University of Maryland's medical campus to the west. Thus, the theater became a critical anchor in a 10-year plan to redevelop the 18-block downtown west side area. The Hippodrome itself is a single building; however, the performing arts complex under construction also includes two historic bank buildings to the north and a newly built structure to the south.

While beautifying a historic structure can bring life to an area, it also must be economically viable. Today, instead of motion pictures, the focus is on live performances, including all of the high-tech wizardry needed to support these large productions. Whether it is an opera, a play, or a Broadway musical, the soundstage requirements are now far more sophisticated and complex, so it is not enough to simply spruce up the existing property. In fact, integration of new technology often requires significant structural and acoustic modifications, and sometimes, completely new space.

In addition, a new generation of patrons must have easy and safe access to and from these restored spaces. Equally important, historic properties must meet today's considerably more stringent structural and safety requirements. Consequently, theater renovation projects are a major financial investment for all involved, so it's important to use the most cost-effective solutions to ensure economic viability.

Fully restored and structurally sound, the historic Hippodrome Theater is poised to anchor a revitalized performing arts complex.

Anatomy of the existing structure

In any renovation project, understanding the existing framework is crucial. The Hippodrome structure consists of load-bearing exterior brick masonry walls with interior steel columns and beams. The upper balcony slab is supported by the exterior masonry walls at the north and south, while the steel framework supports the interior of the slab. Since original construction occurred in the early 20th century, all structural steel connections were riveted. The structural steel was in very good condition for its age and showed little to no sign of deterioration. The concrete balcony stairs, however, were constructed of poorly consolidated cinder concrete and needed extensive repair.

Structural upgrade strategy

The renovation plans called for additions to the grand lobby that would create more open space and connect the original structures. In the auditorium

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To guard against cracking due to movement under loads, Hardwire reinforcement was bonded to the back of the balcony risers with epoxy adhesive, using the wet lay-up technique.

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itself, the focus was on restoration rather than on renovation, bringing the space back to life in all of its former glory. Whiting Turner, the general contractor for the project, contracted SPS to carry out the concrete repairs for the Hippodrome's main theater and balcony seating area. The original plan called for concrete repairs that were more aesthetic than structural. Upon investigation, however, SPS discovered that there was insufficient reinforcing steel in the balcony and that, therefore, structural strengthening would be required besides the superficial concrete repairs.

Morabito Consultants, the strengthening engineer for the project, helped develop a structural strengthening design that would be easier to construct, less labor-intensive, more time-efficient, and hence, less costly than other alternatives. This strengthening method focused on upgrading the stair treads only by assuming that all the design loads, including the dead weight of the stair risers would be carried by the treads alone. The treads would be treated as continuous beams on intermediate supports. Using this approach, the risers would no longer be considered structural components, so vent openings could be installed in the risers without affecting the system's structural capacity.

For the typical 8.5-foot-span tread slab, the new strengthening method involved removing the existing slab topping and casting a 4-inch-thick bonded lightweight concrete overlay, reinforced with continuous 4x4-W7xW7 steel wire mesh or equivalent steel bars. The additional (overlaid) structural concrete slab increases the bending capacity between the supports by increasing the effective depth of the existing bottom reinforcement. At the slab supports, the embedded steel reinforcement in the overlay increases the bending capacity. Further, the reinforcement in the overlay limits cracking that could be caused by volumetric changes of the overlay (from thermal expansion/contraction or from shrinkage), thus avoiding steel corrosion and possible delamination.

The steel reinforcement was positioned at mid-depth of the overlay to provide sufficient clearance below the bars for adequate flow of concrete. Because the overlay replaced the existing topping, there was only a small increase in dead load, which was offset by using lightweight concrete. The composite behavior of the existing slab with the overlay could be taken into account only if monolithic structural action (between the overlay and the existing slab) was ensured. At the Hippodrome, adequate surface preparation achieved the needed bond.

For the typical 5.5-foot-span tread, the existing capacity at the supports was sufficient. However, SPS recommended that the capacity be increased to provide a margin of safety similar to that achieved for the 8.5-foot spans. To accomplish that, SPS placed externally bonded fiber-reinforced polymer (FRP) composites to increase the slab's bending capacity. The system selected for this application consisted of carbon fabric sheets that were applied using the wet lay-up procedure. The FRP composite system was externally bonded to the bottom side of the slab.

Inventing Success

The risers also required additional reinforcement to guard against cracking due to movement under loads. SPS used an innovative strengthening system known as Hardwire. Introduced in 2002, the Hippodrome project is the first commercial application of this technology. Similar to FRP fabric, Hardwire is a low-cost reinforcement system made of ultrahigh-strength steel wires twisted together to form reinforcing steel cords. The steel wires have a tensile strength of 450 ksi, approximately 10 times the strength of conventional structural steel, and the same elastic modulus of approximately 29,000 ksi. For this application, Hardwire was bonded to the back of the risers with epoxy adhesive using the wet lay-up technique. The Hardwire system reduces costs by using less expensive, but high-strength, material.

Essentially, Hardwire works as additional reinforcement to provide tensile strength. It can be used to strengthen reinforced and prestressed beams, gird-

ers, and slabs to provide additional flexural strength. It can also be used on the sides of beams and girders to provide additional shear strength. Hardwire can even be used on structural steel members to increase their capacity. Because the system is made of steel wires, it is more compatible with two of the most common construction types: reinforced or prestressed concrete and structural steel.

Protecting history

Although the advanced strengthening systems provided a solution, this unique project faced many additional challenges. For example, repair crew members worked on their hands and knees on special scaffolding constructed and hung off the beams to reach the repair location without damaging the Hippodrome's impressive dome ceiling. Then, during two concrete pours, a total of 112 yards of concrete were pumped through a very small window in the top of the theater. In those areas where the overlay wasn't needed, 400 square feet of carbon fiber were placed below the tread on the balcony. In addition, 1700 feet of L-shaped Hardwire cuts were placed under the risers, and more than 310 linear feet of epoxy injection were used in the repair.

Because many of the necessary repairs were discovered only after the project began, both time commitments and dollar resources were important factors in deciding the best repair strategy. SPS completed the repair project in six weeks, while taking precautions to preserve the existing plaster, exterior walls, façade and decorative materials. To prevent any damage to the original plaster, no water was allowed to contact it. The project team could not wash down the concrete before installing the Hardwire and carbon-fiber, and minimal water was used during the concrete pours.

Several other key repair initiatives for the Hippodrome hinged on SPS' completing this project as quickly as possible. After strengthening, scaffolding had to be mounted on the balcony slab in order for another contractor to reach the 60-foot height needed to repair and restore damaged decorative plaster. Also, air vents had to be drilled through the repaired balcony slab to accommodate a completely new HVAC system.

A harmonious balance

The renovation of the Hippodrome performing arts complex was completed in January 2004. This complicated undertaking involved the creation of new architectural designs to meet the needs of 21st century artistic productions, as well as the safety and comfort requirements of today's audiences. The project required a wide range of specialized contracting skills for translating these designs into reality. But, the effort is paying rich dividends in preserving the historical integrity of this priceless property, which is now poised to serve the Baltimore metro area again in a new century. ■

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