RENOVATION OF THE ROOF TERRACE PLAZA AT THE KENNEDY CENTER FOR THE PERFORMING ARTS

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SUMMARY

The John F. Kennedy Center for the Performing Arts, a national presidential monument and living memorial in Washington D.C., hosts approximately 4 million theater patrons and visitors annually. It is estimated that more than 60 million patrons and visitors have come to the Center and attended performances since the monument opened in 1971. After almost 25 years of operation without a comprehensive program for capital repairs, however, the facility had deteriorated and systems such as the roof terrace and main roof that were in need of repair. This paper addresses the design and construction of repairs to these elements of this monument.

1. INTRODUCTION

The construction of the John F. Kennedy Center for the Performing Arts was authorized by the National Cultural Center Act of September 2, 1958. Created as an independently administered bureau of the Smithsonian Institution, the Center was named as a living memorial to the late President John F. Kennedy in January 1964, and is the sole monument to President Kennedy in Washington D.C. In 1972, Congress authorized funds through the National Park Service (NPS) to provide the Kennedy Center Board of Trustees assistance with maintenance, security, and operation of the Presidential monument. In 1994, Congress transferred to the Board of Trustees all responsibilities for the Center previously fulfilled by the National Park Service.

Set on a 17-acre site on the banks of the Potomac River, the building measures 630 feet (192 m) by 300 feet (91 m), and is 100 feet (30 m) tall [2]. The building contains 1.5 million square feet on six floors above grade and three levels below grade. The main public level of the building is the plaza level that houses concert facilities including the Opera House (2140 seats), Concert Hall

(2448 seats), Eisenhower Theater (1142 seats) [3]. Two grand halls, the Hall of States and the Hall of Nations, separate the three main performance spaces. The Grand Foyer, a 60 foot (18.3m) tall space, extends the full length of the west elevation with lobbies of each of the three main performance spaces opening into the Grand Foyer. The upper level houses the Terrace Theater (500 seats), Theater Lab, and two public restaurants. Support spaces, located primarily below grade, include offices and a three level parking garage for 1454 cars. Approximately 4 million visitors and patrons pass through the building every year.

Two public plazas, one at grade and the other approximately 60 feet (18 m) above grade surround the building. The main plaza at grade is a mortar set marble system covering almost 70,000 square feet (6500 sq. m). Vehicular drop-off and pedestrian entrances are located along the east side of the plaza. Garage entrances are located below the plaza at the north and south ends of the building. The west end of the plaza, adjacent to the Grand Foyer, overlooks the Potomac River. Continuous planters define the north, south and west edges of the plaza.

The roof terrace is 80,000 square feet (7450 sq. m) and was originally covered with a terrazzo paving system. The roof terrace is divided into four areas defined by two building expansion joints that extend perpendicular to the east and west elevations through the entire building. A continuous planter defines the outside perimeter of the roof terrace. The original paving system did not perform well and was replaced in the early 1980s with a mortar set precast concrete paving system. The replacement system consisted of 18 inches (0.46 m) square, 1 1/2 inches (38 mm) thick pavers set on a 1 1/2 inches (38 mm) reinforced mortar setting bed. The precast pavers were steel reinforced, exposed aggregate, vacuum pressed units intended to replicate the appearance of the original terrazzo paving. The mortar bed was placed over a 1 inch (25 mm) gravel drainage bed that was set on a sloping reinforced concrete acoustical isolation slab. The thickness of the slab varied between 2 inches (51mm) and 8 inches (191 mm). The sloped slab was cast on a layer of insulation for acoustical isolation. The paving system was sloped to drains at the continuous perimeter planters. A waterproofing membrane was installed on top of the original structural slab. The increased thickness of the 1980s replacement system necessitated raising the elevation at the entrances approximately 3.5 inches (90 mm). Interior ramps were installed that sloped from the roof terrace down to the interior floor level.

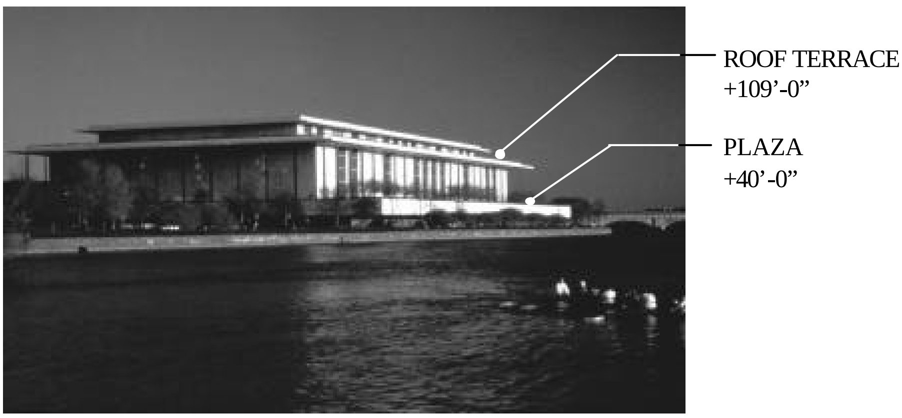

Figure 1: Overall view of the Kennedy Center looking from the northwest

2. INVESTIGATION

In 1992, Wiss, Janney, Elstner Associates, Inc. (WJE) performed a condition assessment and investigation of the exterior envelope of the Kennedy Center. The investigation consisted of visual observations and documentation of distress and representative disassembly of specific components of the various systems. Complete mapping of distress conditions was analyzed to determine patterns and causes of the observed distress. Inspection openings were created to evaluate concealed conditions, remove test samples, and document existing construction.

The investigation revealed that the distress of the roof terrace was the result of several factors including differential thermal expansion/shrinkage and freeze-thaw damage. The deterioration of the joints and inadequate provisions for proper and expeditious drainage also contributed to increased water infiltration and subsequent accelerated deterioration of the paving system.

3. RENOVATION

Following the 1992 investigation of the exterior envelope of the building, a long-range comprehensive plan for the entire facility was developed. This included prioritization of restoration, expansion, and renovation of the various spaces of the building. The initial scope of the repair work, performed between 1997 and 1998, included the replacement of the roof terrace paving and waterproofing systems, removal and replacement of the main roof, and the repairs to the marble fascias.

Difficulties in accessing the work areas and the logistical complexities of working in an occupied building necessitated special care in the design and installation of the replacement roof terrace and main roof systems. The Kennedy Center is sited on the flight path to Ronald Reagan National Airport; therefore, special acoustical issues had to be addressed in the design to minimize disturbances within the performance spaces during the work. As a result of the building geometry, significant portions of the roof terrace are directly above performance spaces. Therefore, the roof terrace had to be acoustically isolated from the main structure to prevent noise from entering the main performance spaces. In addition, overall depth limitations necessitated extreme care in the design of the drainage and in the selection of appropriate waterproofing and paver support systems.

3.1. Replacement system

Based on the investigation and recommendations, a restoration of the roof terrace was authorized. The existing roof terrace paving and waterproofing were to be removed to the level of the structural slab and a new system installed.

One of the most critical decisions for the restoration of the roof terrace was the selection of an appropriate paving material and support system. The critical design issue was the available depth for the system; 12 inches (0.3 m). Within the 12 inches (0.3 m), the system had to include provisions for acoustical isolation, appropriate slope for drainage, waterproofing, paver support, and the pavers.

Three support systems were considered. In most paving designs, the loading criteria and function of the plaza dictate the selection of a system. In the case of the roof terrace, the loads were limited to 100 pounds per square foot (45 kg/sf) and a concentrated load of 500 pounds (225 kg). A sand-set system, consisting of thick paving blocks on a sand bed and sloped concrete fill, was ruled out because of the potential for the system and individual units to shift and because this system would have an appearance significantly different from the original. A mortar set system consisting of thinner pavers on a mortar bed and sloped concrete fill was considered but not selected because of the susceptibility of the system to deterioration. The adjustable pedestal system offered many advantages, both functionally and aesthetically. An adjustable pedestal system with open joints, installed on a sloped concrete drainage slab, enabled the finished surface of the roof terrace to be flat with no surface drains. Further, the unbonded system provided easier maintenance of the pavers, waterproofing membrane, and drains.

Granite was selected as the paving material because of its durability, appearance, and successful history of use on plazas. Precast concrete units were considered; however, their susceptibility to freeze-thaw damage and warping made them less desirable than granite. A paving pattern was developed that was consistent with the building's structural module and the original design. The pattern was created with 20 inch (0.5 m) square, 2 inch (51 mm) thick black granite from Minnesota and white granite from Vermont. The size of the paver had to be small enough to allow for removal by maintenance personnel without special equipment or lifting devices and large enough to approximate the original pattern and to control fabrication and installation costs.

The finish on the pavers was required to have a minimum coefficient of friction of 0.6 to conform to ADA standards for slip resistance [4]. A thermal finish of granite provides an adequate slip resistant finish at the expense of microcracking that results from the flaming process. The presence of microcracking reduces the effective structural depth by approximately 1/8 inch (3.2 mm) [5] and increases the potential for surface deterioration from freeze-thaw damage. However, the low porosity of the stones selected, as well as the use of 2 inch (51 mm) thick pavers, minimized these concerns.

The pavers were installed on high-density rubber pads set on concrete filled adjustable plastic pedestals that were centered at each crossing joint. The rubber pads incorporated 1/8 inch (3.2mm) wide separation tabs to maintain a consistent joint width and prevent adjacent pavers from shifting into each other. A very narrow joint was necessary so high heels would not catch in the joints. Joint tolerances were specified to limit the maximum allowable joint width to 3/16 inch (4.8 mm).

The pedestal system was placed on a hot applied rubberized asphalt waterproofing system installed on a cast-in-place concrete acoustical isolation and drainage slab. Acoustical isolation was accomplished by incorporating a 1 inch (25 mm) air cavity between the original structural slab and the new acoustical-drainage slab. Two options existed for creating this space. One option consisted of a system of rubber "pucks" with formwork set on the pucks and a concrete isolation slab cast on the formwork. The other option is a jack-slab system. The jack slab is a concrete slab with embedded steel castors that is cast on a slip-sheet over the structural slab. The castors consist of a rubber puck fit into a steel casting. Seats for reinforcing steel are located around the perimeter of the casting at quarter points. The concrete slab is cast and allowed to fully cure with the bottom of the castings still in contact with the slip-sheet. At the center of the casting is a threaded rod that engages the casting and bears on the puck. Once the concrete has cured, the slab is raised the specified height in small increments by successive turning of the threaded rods. The jack slab technique was selected to minimize the depth of the acoustical slab and thereby maximize the depth available for drainage.

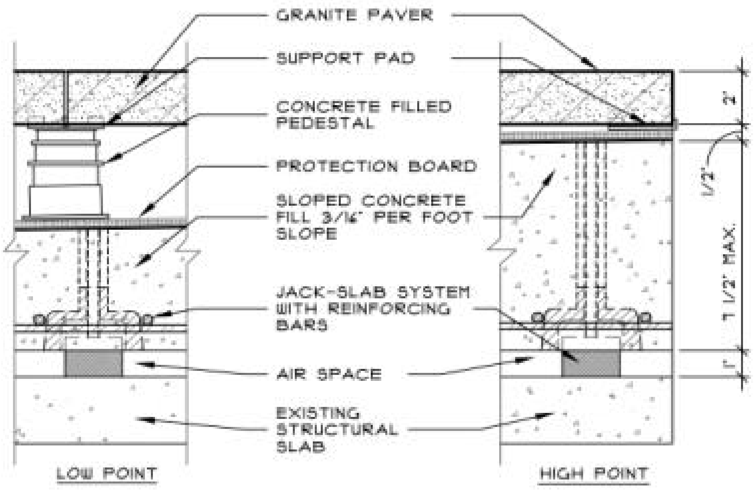

Figure 2: Representative sections of the replacement plaza system

Repetitive sections of the roof terrace were designed to correspond approximately to the perimeter column grid of the building. A line of two tier drains was centered within each section roughly two-thirds of the distance to the perimeter planter from the building wall. These new drains were added by coring through the structural slab and tying the drain into the existing stormwater drainage system.

Joint lines, perpendicular to the building, were intended to correspond to column centerlines. Pavers adjacent to the centerline were trimmed as necessary to make up for slight variations in the column to column dimensions. Edge restraint of the system, intended to reduce and control shifting of the paving system, was accomplished by the installation of stainless steel clips at each perimeter paver. The building expansion joints were carried through to the plaza surface and covered with a seismic cover allowing horizontal movement in all directions.

4. CONSTRUCTION

The entire restoration of the roof terrace and roof areas was to be performed without closing any performance space in the building and was further complicated by the proximity of residential and hotel facilities to the site. This combination of circumstances prevented night work, required special systems to minimize fumes from the waterproofing and roofing system installation, and demanded careful scheduling of demolition activities. The construction team consisted of the general contractor, the U.S. Army Corps of Engineers (under contract to the Kennedy Center for construction management), and WJE.

Construction began with the demolition of the existing paving system and acoustical isolation slab to the level of the waterproofing membrane adhered to the top of the structural slab. The waterproofing membrane was repaired and left in place as a temporary protection and an inexpensive second line of defense. Debris was removed from the roof terrace and roof levels by means of a hoist located at the southwest corner of the building, as no debris or new materials could be moved through the building. The new system was installed working from the north end of the building to the south in adjacent 3-bay sections, each approximately 100 feet (30.5 m) by 45 feet (13.7 m).

Proper installation of the pavers on the pedestals required significantly more handling of each paver than is typical when installing other systems. The combination of pavers from different quarries (the white and black granite) set on the same pedestal resulted in the need for significant care to be used in the selection of each paver to be used in combination with another paver. Failure to choose pavers of approximately the same thickness or with complementary variations of tolerances would result in inconsistent joint widths or the need for excessive shimming of the stone.

5. CONCLUSION

Within the past 8 years, considerable progress has been made toward remediation of many of the building deficiencies at the Kennedy Center. In addition to the roof terrace and main roof replacement, significant renovation work is scheduled for the next 10 years. This work includes significant interior work, restoration of the marble-clad main plaza, expansion of the parking facilities, and reworking of traffic circulation and site features.

6. REFERENCES

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[4] *Federal Register; Rules and Regulations, Vol. 56, No. 144, Section A4.5.1 General 1991, A5 p.*

[5] *Stone in Architecture; Properties Durability, Third Edition.* New York, New York: Springer-Verlag, 1997, 245 p.