


2017 Engineering Project of the Year
Ryan Biggs Clark Davis Engineering and Surveying P.C

Waterproof Grand Staircase between CEC and Plaza

The Grand Stair was constructed as part of the Governor Nelson A. Rockefeller Empire State Plaza complex, connecting the south end of the Main Platform to the Cultural Education Center (CEC). The structure has been in continuous service since the mid-1970s, providing pedestrian access over Madison Avenue and outdoor seating for concerts, cultural events, and 4th of July fireworks at the Plaza. The rehabilitation of the Grand Stair involved complete replacement of the subsurface waterproofing system and in-place repair of the structural components. This included removal and resetting over 2,300 existing stone units in a carefully sequenced manner to precisely re-align each stone while limiting the impact to adjacent masonry cladding and existing finishes and maintaining traffic along heavily traveled Madison Avenue below.

The New York State Office of General Services contracted with Lomonaco & Pitts, Architects P.C. (dba as Architecture +) along with Ryan Biggs | Clark Davis to complete the renovation design. Ryan Biggs | Clark Davis provided structural design services to develop work sequencing recommendations to prevent excessive rebound and movement during removal and replacement activities, repair exposed structural components, and develop details for the support and anchorage of the reconstructed stone cladding. The result was the successful in-place restoration of an architectural landmark using a thoughtful and orderly approach to reduce the impact to the public and surrounding structures.

Background

The Grand Stair is a large pedestrian bridge extending over Madison Avenue, connecting the iconic Main Platform of the Plaza to the terrace surrounding the fourth floor of the Cultural Education Center (CEC). Maintained by the New York State Office of General Services, the 150-foot wide and 160-foot long structure provides pedestrian access to the CEC terrace as well as bench seating for thousands of spectators that attend summertime cultural events on the Plaza.

Water leaking though the stair structure had resulted in water damage of the ceiling at the south end of the Main Platform concourse and adjacent maintenance offices and TV studio, as well as wintertime icicle accumulation over public sidewalks and pedestrian areas along Madison Avenue. Testing and investigations performed by the New York State Office of General Services identified deficiencies with the existing subsurface waterproofing system, deficient drainage details, and excessive weathering of the exposed masonry cladding. The $6.3M rehabilitation of the Grand Stair included the full replacement of the subsurface waterproofing system, restoration of the existing structural components, and removal and reinstallation of the granite stairs and benches. The exterior marble cladding and precast concrete soffits remained during the work to limit the impact of the restoration work on Madison Avenue below.

Structure Description

The existing Grand Stair structure was clad with large granite seats and treads over a mortar setting bed. The setting bed was constructed on a layer of reinforced concrete fill which established the stair profile. Directly below the concrete fill was a cement protection layer and a waterproofing membrane bonded to a thin concrete screed coat above a structural concrete deck. Moisture was trapped within the mortar bed and concrete fill above the waterproofing membrane and these elements had significant deterioration. The total overburden weight above the structural deck was as much as 250 pounds per square foot.

The structural concrete deck below the overburden is supported by a series of partially composite, built-up steel plate girders spaced approximately 6 feet on center. The depth of the girders varies along the approximately 115 feet span over Madison Avenue. The largest girder section along the span measures approximately 5 feet in depth. The existing paint coatings over the steel girders had failed and minor surface corrosion was prevalent.

The soffit below the Grand Stair is constructed with precast concrete drop panels attached to supplemental steel framing and supported from the main steel girders. The soffit encloses the girders and forms a large plenum space with access limited to a third-floor doorway at the CEC.

The replacement of the waterproofing system required the complete removal of the existing overburden down to the structural deck. The structural concrete deck was then sounded and repaired and a new waterproofing system was installed. New lightweight concrete topping was then placed over a series of shear pins and the existing granite benches and treads were restored and reset over adjustable stand offs to create a pedestal supported system, providing an open drainage plane under the stone. Drain details were improved and susceptible structural expansion joints were sealed with multiple waterproofing layers.

The project also involved the removal and reinstallation of the marble copings to allow for the waterproofing membrane to extend up and over each parapet. Inside cheek wall panels were removed and re-anchored and exterior cladding and soffit panels were repointed.

Design Challenges and Solutions

- Sequencing the construction was critical to the project success to limit the extent of structure rebound and movement to precisely align the reset stones and prevent damage to existing cladding and soffits on the staircase and adjacent structures. Limitations to the extent of overburden removals during any one phase of the work were established by analyzing the existing built up steel girders to determine the pre-loaded deflection and stiffness of the structure below the staircase and parapets. Restrictions were set by limiting the allowable joint closure between existing exterior marble cladding to less than 1/16 of an inch and total vertical rebound to 3 inches (l/450). Scenarios were than analyzed to determine the amount of overburden load that could be safely removed at various locations along the spans. Work phases extending up to 150-feet wide by 30 feet in length were established as a guideline, allowing the removals to take place over the full width of the staircase in a sequential pattern from top (south) to bottom (north). The removals were sequenced to extend approximately 15 feet ahead of the concrete topping placement and up to 30 feet ahead of the stone cladding installation, allowing for an efficient use of multiple work crews and a continuous work flow. Vertical and rotational displacement was monitored during construction and if movements exceeding trigger points the addition of dead load at specific locations along the span would be required.

- Predictable live load movement of the structure was also important during construction. Based on the deflection analysis of the existing steel girders, restrictions were established for construction live load, access points, gantry and equipment weights, and temporary stone panel placement layout and stone staging locations. The majority of the removal work was performed from the staircase surface to minimize the impact on traffic along Madison Avenue and the use of cranes was limited to a handful of nights during critical project activities. An understanding of the structures response under construction loading and clearly defined allowable construction loads allowed the Contractor to develop an efficient work plan early in the project.

- The range of movement at the structural expansion joints at the north and south ends of the staircase were estimated to ensure effective detailing at critical joint details immediately adjacent to the CEC terrace and Main Platform structures.

- The structural concrete deck was exposed during construction and the top surface was sounded. Deficiencies were identified, and localized shallow and deep concrete repairs were performed prior to placement of the waterproofing system.

- Downward sliding forces between the overburden and structural concrete slab were analyzed. A series of pins were utilized to provide predictable shear capacity across the waterproofing membrane layer.

- Granite treads and benches were reset over adjustable height stand-offs. The pedestal system required a flexural stress analysis of each stone size and type to determine the most effective support layout. The design also required each custom built stand-off to be anchored in such a way as to maintain consistent joint width and prevent lateral shifting of the stones.

- Existing traffic signals above the crosswalk at Madison Avenue were hung directly from the existing soffit panels, resulting in potentially overstressed conditions of the soffit panel. The lights were re-anchored to new supplemental steel frames directly hung from the steel girders above the soffit.