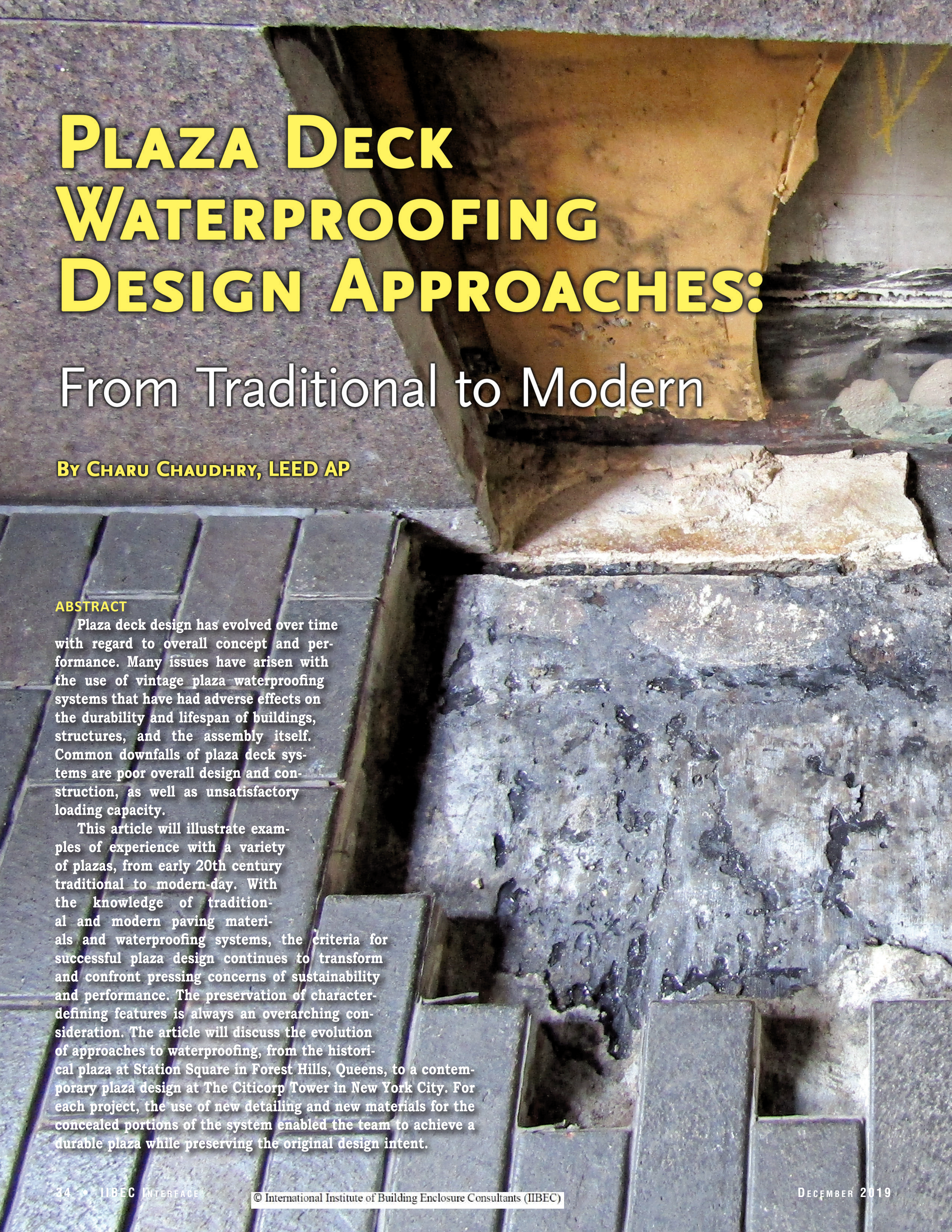

Plaza Deck Waterproofing Design Approaches:

From Traditional to Modern

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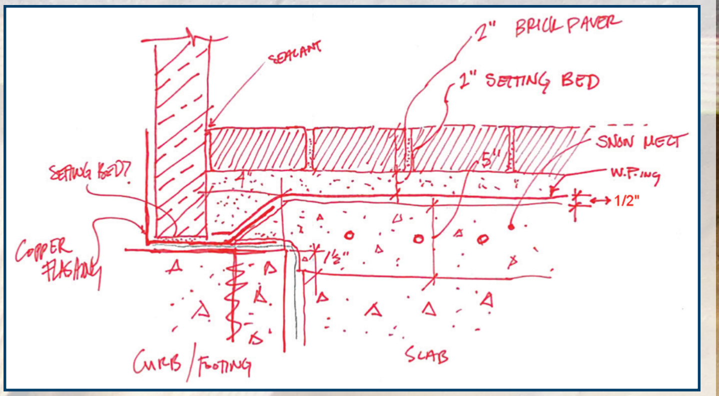
ABSTRACT

Plaza deck design has evolved over time with regard to overall concept and performance. Many issues have arisen with the use of vintage plaza waterproofing systems that have had adverse effects on the durability and lifespan of buildings, structures, and the assembly itself. Common downfalls of plaza deck systems are poor overall design and construction, as well as unsatisfactory loading capacity.

This article will illustrate examples of experience with a variety of plazas, from early 20th century traditional to modern-day. With the knowledge of traditional and modern paving materials and waterproofing systems, the criteria for successful plaza design continues to transform and confront pressing concerns of sustainability and performance. The preservation of character-defining features is always an overarching consideration. The article will discuss the evolution of approaches to waterproofing, from the historical plaza at Station Square in Forest Hills, Queens, to a contemporary plaza design at The Citicorp Tower in New York City. For each project, the use of new detailing and new materials for the concealed portions of the system enabled the team to achieve a durable plaza while preserving the original design intent.

INTRODUCTION

The architectural expression of the plaza continues to evolve through architectural history. Most traditional plazas in the 19th and early 20th centuries were built on grade level. These were surfaced with either stone or brick pavers set in mortar or sand beds of varying thicknesses set directly on compacted earth fill or a concrete deck. A waterproofing membrane was sometimes not installed with this system, as water was permitted to drain down through the slab into the soil. Modern plazas were usually post-war constructions, and were rectilinear forms with light, rigid plane surfaces that had no applied ornamentation and decoration to highlight the expression of the building. These plazas performed the dual function of a plaza and the roof covering for habitable spaces below. The design of the plaza hence evolved to contain thin paving systems with closed or open joints, protection courses, and a waterproofing membrane embedded within the assembly. All these requirements led to the development of more complex plaza assemblies that incorporate paving systems, drains and drainage mediums, and various kinds of waterproofing and protection courses.



Figures 1A – Sketch of a plaza paver system using coal tar pitch.

Waterproofing Types From Traditional to Modern

"Waterproofing" describes making an object waterproof or water-resistant, but in the construction industry, that term is defined as the treatment of a surface or structure to prevent the passage of water under hydrostatic pressure. The waterproofing industry grew tremendously throughout the 20th century. Early systems (prior to World War II) included a built-up membrane of hot coal tar pitch (a byproduct of the coal industry) reinforced with felts. Sometimes the reinforcement was not present. Most often, the membranes were placed just below the paved surface (*Figure 1*). The water resistance, the low viscosity of the coal tar, and the ability to remain tensile

Figure 1B– Coal tar pitch used as a waterproofing layer.

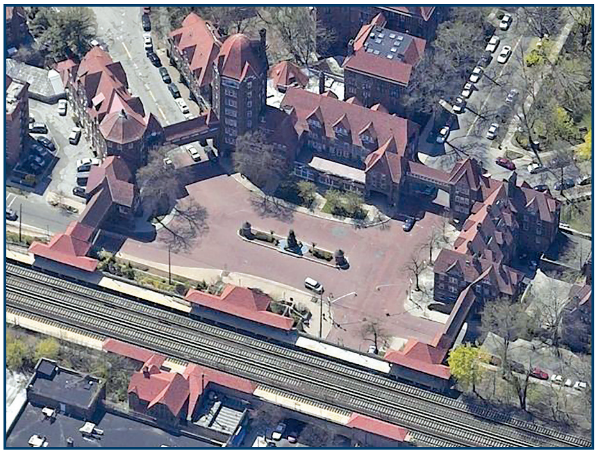


Figure 2 – Overview of Station Square.

and self-heal under all ambient temperatures made it suitable for use over plazas. Post-war decades witnessed a sharp decline in coal tar use, which was superseded by the introduction of asphalt to the industry. Unlike coal tar, asphalt is a highly viscous bituminous material and does not contain the ability to self-heal, leading to leaks in the membrane.

The 1940s and 1950s witnessed the use of unreinforced and reinforced modified-bitumen sheets for waterproofing with the advent of built-up membranes, such as atactic polypropylene (APP) and styrene-butadiene-styrene (SBS), used with varying degrees of success, since the sheets needed to be bonded at seams and to the substrate, making them prone to failures. Synthetic rubber sheets such as ethylene propylene diene monomer (EPDM) and polyvinyl chloride (PVC) were also used during this time. Unlike modified-bitumen sheets, which were used as multi-ply systems, these were single-ply systems, and both systems provided the assurance of factory-controlled thickness. Polymer-modified asphaltic materials like neoprene were introduced in the 1950s.

Subsequently, liquid-applied elastomers made their way into the field in the late 1960s. These included varying types of polyesters, synthetic rubbers, asphalt emulsions, polyurethanes, and poly methyl methacrylates. These were all synthetic materials (polymers) with a controlled factory formulation and needed precision in the field to install them to required thicknesses.

Today the waterproofing industry is dominated by cold fluid-applied liquid systems, which present a promising future. These are one- or two-component systems with various kinds of reinforcements that can be used to provide the desired thickness in the field. They offer the advantage of a seamless application of waterproofing membrane, and different kinds of penetrations can be flashed easily. They can be applied directly to concrete or with a vapor barrier for a multi-ply assembly.

Figure 3 – Historic Patton Clay Works brick.

INVESTIGATION, ANALYSIS, AND REHABILITATION

Traditional Early Plaza System

The deterioration mechanisms of various plaza assemblies are governed by the properties of the constituent materials and their composition in the assembly detail. An early plaza system such as at the Station Square (*Figure 2*), a historical plaza that is the centerpiece in Forest Hills, NY, employed 3⅞-in.-thick brick pavers in a 1-in. sand setting bed over a concrete base, which was situated over compacted earth

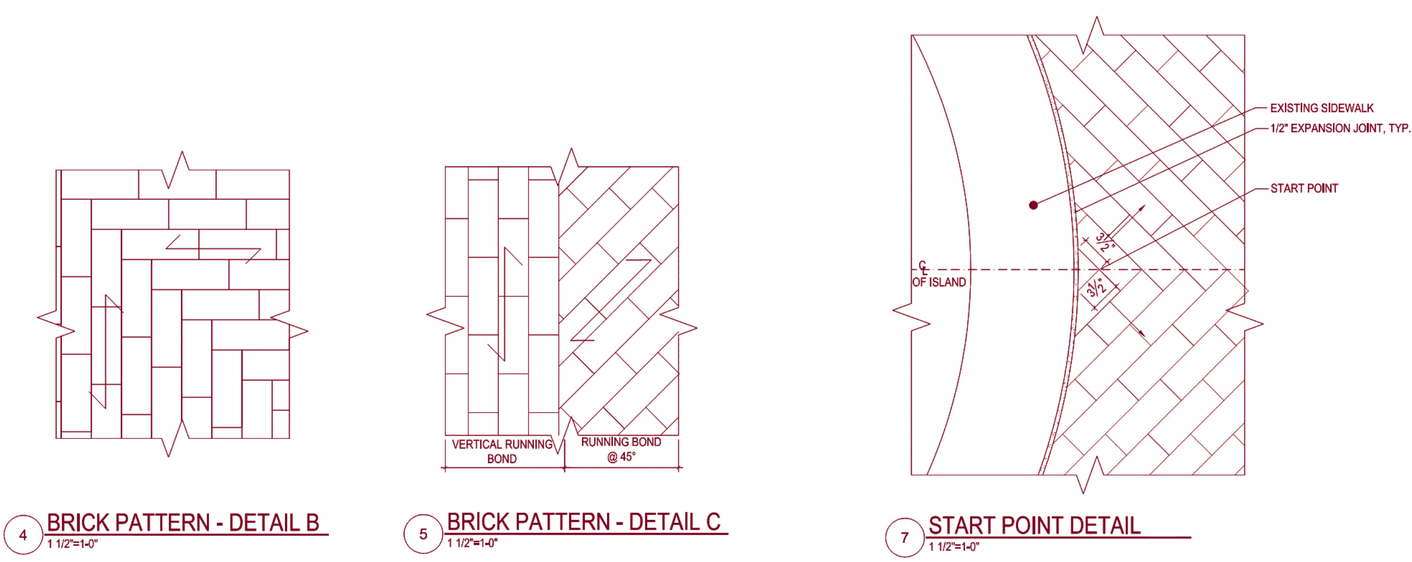


Figure 4 – Layout patterns.

fill. Designed by Atterbury and Olmsted in 1912, Station Square encompasses an area of 22,500 square feet and was envisioned as a large public square and the commercial center of the community. The relatively small size of clay pavers created a pavement surface with a proportion that signified its vintage. As many pavers could be observed simultaneously, the nuances of different colors, textures, and patterns like running and herringbone bonds were recognized.

Originally, the joints between the pavers were quite narrow to minimize water seepage into the assembly. Over the years of use, the sand-set paving became quite susceptible to differential movement of the paving due to settlement and improper drainage, and water ponding was common, which led to vegetative growth and further deterioration of the concrete surface below. Most of the brick pavers were observed to be free of cracks and any spalls.

In 1996, the State Historic Preservation Office determined that the station met the criteria for inclusion in the National Register of Historic Places. Preservation of the historical features of the plaza was an important factor in the rehabilitation of the plaza. The historical brick was a clay pressure-molded unit manufactured by Patton Clay Works of Patton, PA, which was closed in 1968 and hence is no longer available to create replacement units (see *Figure 3*).

Our goal was to take up and salvage the historical brick paving, replace the setting bed, and re-lay the original brick in its original pattern. During archival research, original drawings and photographs that showed the original brick pattern and limited subsurface conditions were located. Maintaining original assembly depths was important in order to match the finish lines with the other historical features on the square (see *Figure 4*).

The entire paving system was removed; the regrading of the concrete was performed with adequate expansion joints, edge restraints, joint fillers, and slopes. Adequate weep holes were integrated in the new concrete base to prevent impeded drainage. Transverse and longitudinal joints were treated with a reflective cracking membrane. The brick pavers were salvaged and reset in the original bonding pattern and joint sizing (see *Figure 5*). After completion, a maintenance plan was provided to the ownership.

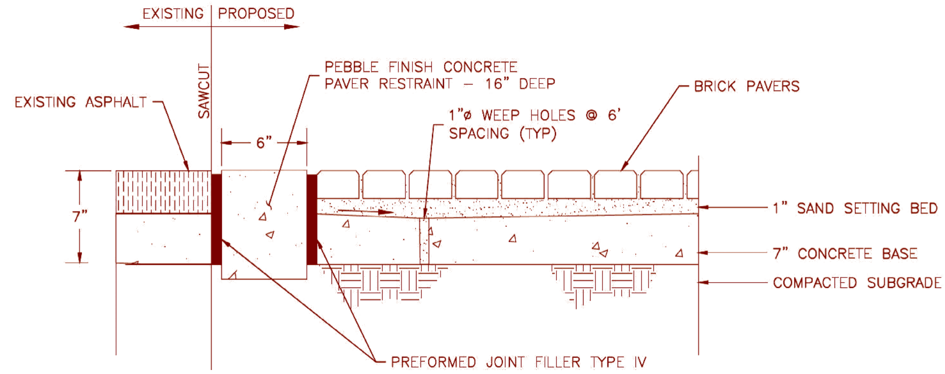
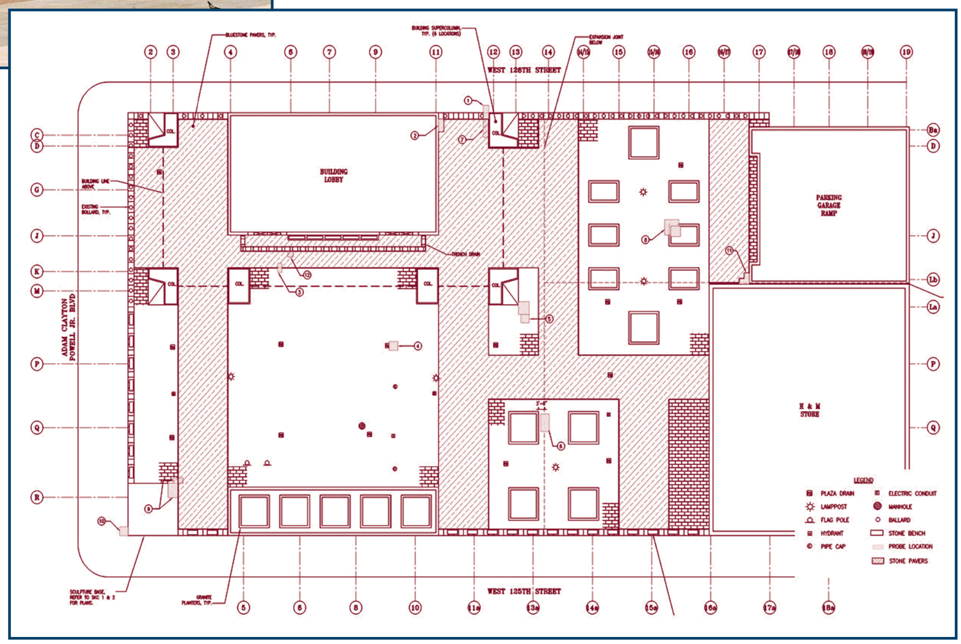


Figure 5 – Layout details.



Figures 6A and 6B – Overview of the Adam Clayton Powell Plaza.

Some early-period plaza constructions employed a coal tar pitch (on a concrete substrate) with a wearing surface just beneath the pavers. In the absence of a drainage layer (to laterally disperse the water), prolonged water ponding led to disintegration of the wearing surface and the waterproofing surface. Metal flashings were usually used in the assembly due to the inability of the coal tar pitch to be used in vertical applications.

Modern Plaza Systems

Modern plaza constructions consist of habitable spaces below, with many services such as drainage pipes and trench drains within the assembly and appurtenances like lighting poles and plantings integrated within the paving system.

Built in 1967, the Adam Clayton Powell Plaza in New York, NY, is paved with sections of brick and stone paving over a subgrade garage. Drains are located at the low points with the grates integrated with the plaza paving. A trench drain was situated along the south façade. The plaza is constructed of a concrete slab (which was flat); liquid asphaltic waterproofing membrane with an asphaltic protection board atop the concrete slab; tapered fill to drains; and a combination of bluestone flags, brick pavers, and granite planters. The bluestone pavers are 2½-ft. squares creating 5-ft. square grids. The red brick masonry was also laid in a pattern that is based on 5-ft. grids. There was setting bed material that ranged in thickness from ½ to 2 in. The brick pavers were set in a black bituminous setting bed. The bluestone flags were set in a mortar setting bed (see *Figures 6A* and *6B*).

The most significant issues of the plaza were failure of the waterproofing membrane, lack of positive pitch to the drains at membrane level, failure of the paving materials, inadequate moisture management within the plaza assembly, lack of a proper expansion joint seal, and inadequate flashing at penetrations and intersections leading to large-scale leakage into the spaces below (*Figures 7A* and *7B*).

Paving brick was tested in accordance with ASTM C902. Bluestone flagging was tested in accordance with ASTM C616. These standards are intended for the evaluation of new materials prior to construction, but they are relevant to this type of investigation for a comparative rather than absolute evaluation, particularly when evaluating the viability of retaining intact portions of materials that have failed locally.

Materials representative of the range of conditions were provided to the testing agency, but testing results reflected only the properties of those samples that were in good enough condition to test. For example, brick that had extensive cracks or frost fractures could not be tested. Some of the stone samples tested had cracks or fissures, but the stone with the greatest deterioration could not be properly prepared for testing. Therefore, interpretation of test results took into account that other portions of the material have failed.

Brick testing indicated that the existing brick failed to meet the requirements for saturation coefficient, which is an indicator of probable freeze-thaw performance. The brick also failed to meet the requirements for abrasion resistance, which is an indicator of durability. The standard has criteria for high, medium, and low abrasion resistance. The test results missed even the low-performance requirement by a wide margin. Bluestone testing indicated that the

Figures 7A and 7B – Existing conditions at Adam Clayton Powell Plaza.

existing stone was marginal with regard to absorption. In the wet condition tests, the stone failed to meet the test requirements for compressive strength, and it failed to meet the required values for modulus of rupture.

Because of these issues, the existing assembly materials were neither salvageable nor repairable. Repair approach included replacement of the existing waterproofing membrane with contemporary high-performance material such as cold fluid-applied liquid-reinforced polymethyl methacrylate (PMMA) membrane and an improved assembly to match the original depth available. The replacement design introduced pitch to the drains at membrane level, and allowed moisture to move through the system. A proper expansion joint seal was installed; properly designed base flashing and penetration flashing details were included throughout (*Figure 8*).

In some modern plaza systems, plaza rehabilitation needs to be completed in phases in localized areas due to various constraints. This was the case for the plaza of a high-rise midtown building located within the Plaza District in Manhattan. Phase one consisted of an early response to remediate a leak in the occupied spaces below. Built in 1985, the plaza construction included a single-ply EPDM type of membrane, which was crazed, detached, and could be easily lifted. The probes revealed that the assembly varied from the design drawings (see *Figure 9*).

The repair consisted of localized replacement of the waterproofing membrane with a new cold fluid-applied liquid-polyurethane-based membrane with a drainage panel that acted as a protection course and a drainage mat. All improvements were performed within the dimensional tolerances available, as the final finish needed to match the existing granite units.

CONCLUSIONS

Plazas experience traffic, extreme weather conditions, and chemicals, including deicing salts; hence, durability of the plaza is a function of the overall detailing and the choice of materials used. Secretary of Interior standards define the cumulative effect, and historical character explains that projects meet the standards when the overall effect of all work on the plaza is consistent with the property's historical character. The state historic preservation officer or local agencies usually review these, but preservation of original intent in a rehabilitation program should be considered carefully.

Waterproofing in a plaza deck application cannot be isolated from all other components of the plaza. Many factors influence the selection of the waterproofing

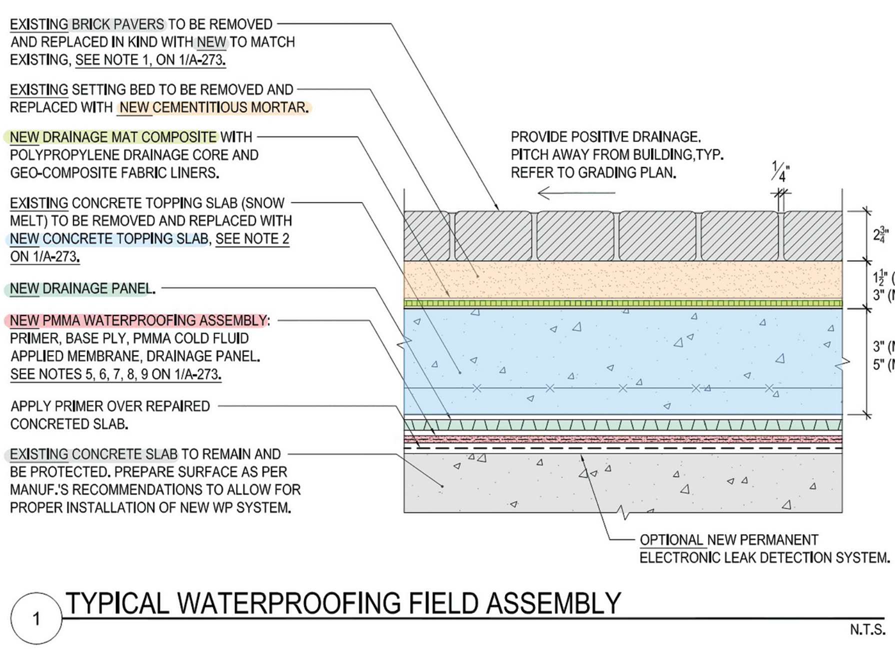


Figure 8 – Proposed waterproofing and plaza assembly.

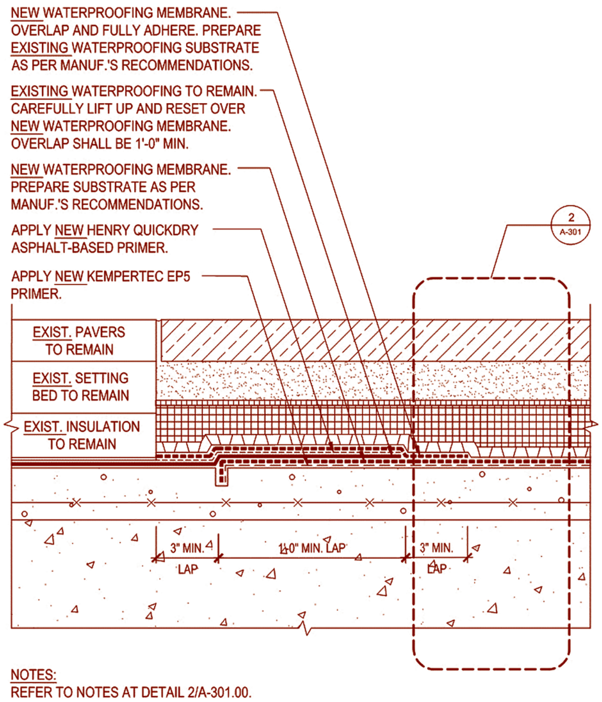


Figure 9 – "Tie-in" between the new and existing plaza waterproofing and assembly.

membrane. Exposure to temperature variations and other ambient conditions should be considered in addition to the placement concerns within the assembly, along with adequate flashings. Maintenance and re-treatability of the membrane is of great concern in the choice of the placement of the membrane. Understanding the waterproofing type, chemical nature, and physical properties are essential criteria for plaza deck applications. Whether complete or partial rehabilitation, criteria for a successful plaza deck waterproofing rehabilitation design include evaluation of the design loads over the structural slab, which may include a concrete tapering fill. Overall plaza slopes, drains, lighting, and trees need to be evaluated. Expansion joints are needed at strategic locations within the paving materials and at the building perimeter. Paver types and materials need to be assessed for condition and properties, such as their slip resistance and durability to be used in plazas, which can be tested in existing materials to evaluate suitability.

The function and design of the plaza has transformed through time. While the early plaza assemblies acted as a picturesque setting or base of the building, most modern plazas are highly functional spaces. Understanding of the history and the technology through archival research or a testing program should be considered as part of the evaluation of existing plazas.

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Charu Chaudhry has over 15 years of experience in historical preservation and building enclosure systems. She is an associate in the Renewal Group at Thornton Tomasetti, Inc. Her work includes investigating, designing repairs, and preservation treatments for historical landmarks and sites. She has written several peer-reviewed papers and lectured extensively on the subjects of masonry, terra cotta, concrete, grouting, climate change, and earth constructions. Chaudhry has a BA in architecture from the Institutional & Cultural Center in New Delhi, India, and an MS in historical preservation from the University of Pennsylvania.

Ycone Calls Itself Lyon Icon

Architectural firm Ateliers Jean Nouvel (AJN) has designed Ycone (French for "Icon"), a 174-ft.-high, 16-story residential tower near the confluence of the Saône and Rhône rivers in Lyon, France. The building houses 92 apartments ranging from its 27 "social-sector" dwellings (discouraging class/income ghettos) to a luxury condo with a rooftop solarium and pool.

The façade is wood clad with aluminum panels. Two balconies, wrapping around all four of the tower's elevations, are faced with white-lacquered aluminum frames. At the top is an 88-ton steel brise-soleil parapet that frames a rooftop garden.

Watch a time progression of its construction at: https://www.youtube.com/watch?v=87kGVGrMHhY.

Photo courtesy of AJN.