PRESERVATION
Tech Notes
U.S. Department of the Interior
National Park Service
Cultural Resources
Preservation Assistance Division

## THE LAND TITLE BUILDING
**Philadelphia, Pennsylvania**

The Land Title Building is a prominent turn of the twentieth century office building, located in the heart of downtown Philadelphia. Designed by the Chicago architect, Daniel Burnham in 1897, a second tower was added to the site in 1902 by Burnham and local architect Horace Trumbauer. The two interconnected towers are listed on the National Register of Historic Places. The property owner conveyed a facade easement to the Philadelphia Historic Preservation Corporation (PHPC) in 1981.

The twenty-three story 1902 tower is a steel framed structure, faced with gray Connecticut granite and organized in a classical tripartite composition typical of early skyscrapers. The tower's ''capital'' includes an enriched terra cotta cornice. The cornice is approximately 465′ long, projects nearly 7′ from the

# MASONRY

**NUMBER 2**

# Stabilization and Repair of a Historic Terra Cotta Cornice

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John Milner Associates

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Philadelphia Historic Preservation Corporation

***Terra cotta roof cornices should be repaired rather than replaced wherever possible.***

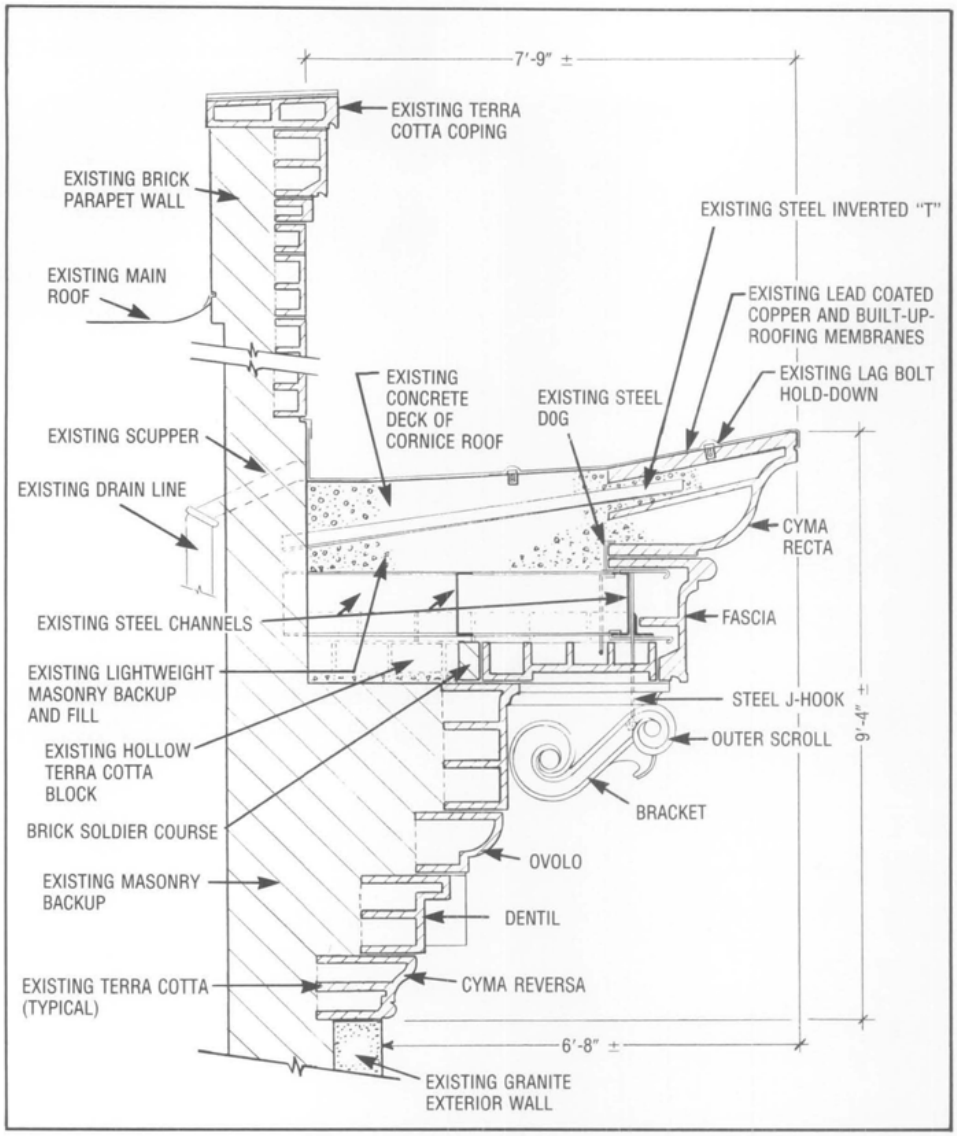


**Figure 1. Section through the cornice and the parapet showing the structure's construction and attachment to the building. The inverted T's are embedded in concrete and act in friction to help support the cyma recta unit from rotating outward. The test openings did not penetrate below the soffit level of the cornice. Drawing by Jeffrey S. Levine.**

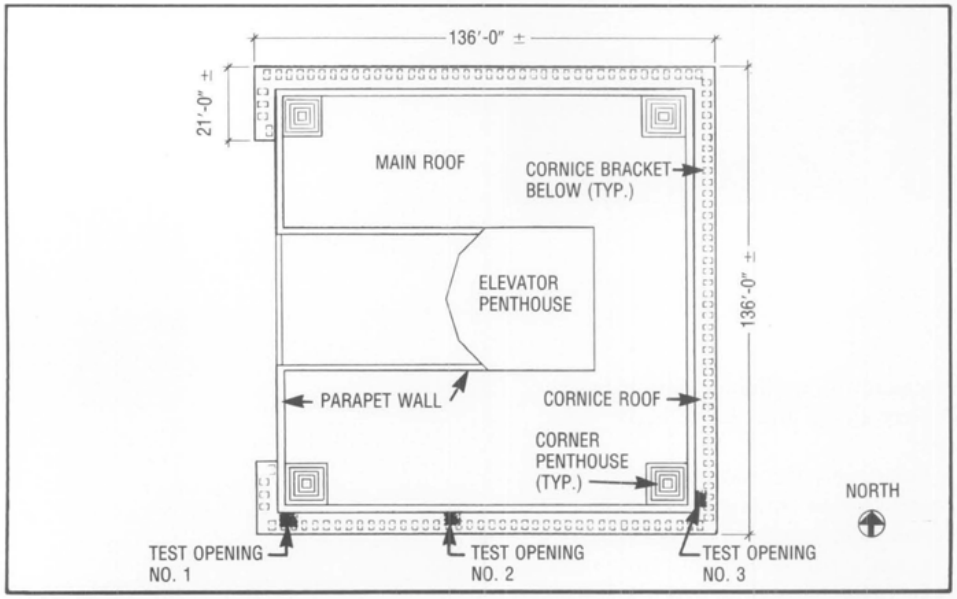


**Figure 2. Roof plan of the 1902 tower showing the location of test openings in the cornice roof. Each bracket was later numbered consecutively so that easy reference could be made to a particular area of the cornice. Drawing by Jeffrey S. Levine.**

granite face of the building, and measures over 9′ in height *(see figure 1)*.

The cornice is constructed of over 1,200 terra cotta face units and has a roof comprised of a concrete and terra cotta deck sheathed with heavy gauge copper *(see figure 2)*. Two concentric rings of structural steel channels which are tied to steel girt outlookers provide the main support for the cornice. The outlookers, in turn, are cantilevered from the structural steel columns of the building. The interior of the cornice is filled with lightweight masonry materials and lacks any ventilation. The backup materials consist of hollow terra cotta blocks and brick, supported from below by wood blocking and infilled with a cementitious mix containing coke and iron slag. The roof is surmounted by a brick parapet wall, the outside face of which is clad with terra cotta of similar appearance to that of the cornice.

## Problem

Due to recent terra cotta failures and evidence of earlier problems *(see figures 3 and 4)*, the architectural firm of John Milner Associates was hired by the building owners to inspect the terra cotta cornice of the 1902 tower. The purpose of the inspection was to determine whether the cornice could be successfully repaired and retained. The alternative would be to replace the cornice in a manner consistent with the historic preservation requirement of the facade easement placed on the building.

The cornice was examined utilizing aerial scaffolding that was cantilevered off the main roof and from upper story windows. Inspections were made in areas assumed to be most severely deteriorated to establish worst-case conditions. Due to the extreme depth and height of the cornice and the type of scaffolding used, inspection of the entire length of the cornice was not feasible.

Visual inspection of the terra cotta revealed four common types of deterioration: spalls, glaze crazing, cracking, and open mortar joints. In addition, sounding the terra cotta units with a wooden mallet indicated that roughly 10% of the terra cotta units had cracked internal webs. Deterioration resulting in loss of material appeared with less frequency and was found principally at the outer scroll of the brackets *(see figure 3)* and at the scalloped fascia *(see figure 4)*.

Water infiltration through holes in the cornice's roof membrane was determined to be the primary reason for much of the terra cotta deterioration. Water penetration had caused various steel anchors to corrode, resulting in ox-

ide jacking. [The corrosion product of the oxidation of steel takes up more volume than the steel itself. Oxide jacking refers to this expansion and the consequent displacement, cracking, and spalling caused to adjacent masonry materials.] Open mortar joints and inappropriate past repairs, including the extensive use of sealants which tended to trap moisture within the cornice, also contributed to the moisture infiltration and oxide jacking problems.

Test openings made in the cornice roof revealed much about the construction of the cornice and the condition and integrity of the structural steel members which supported the terra cotta facing units. Light rust was seen on all steel members, including channels, outlookers, J-hooks, and dogs. Flaking and scaling of the steel frame members appeared to be limited, except at the inverted "T" members where conditions were worse, but still not bad enough to warrant replacement.

Although based on a limited inspection, the structural steel framework appeared to be adequate for the continued support of the cornice. Problems with the terra cotta cladding of the cornice stemmed not so much from the quality of its materials and method of construction, which are good, but from inappropriate and irregular maintenance practices over its long history. The continued integrity of the cornice, however, depended upon limiting further oxidation of the steel structure and anchoring devices by removing all sources of water entry into the cornice.

## Solution

Since the underlying steel structure of the cornice appeared to be sound, the building owners, project architect, and PHPC agreed that the cornice should be retained and that a stabilization and repair program be undertaken to address the terra cotta deterioration and allay concerns over public safety.

Numerous options were explored by the architect for stabilizing terra cotta units with cracked internal webs and those units considered to be highly susceptible to oxide-jacking related failure in the future. The extremely porous nature and high moisture content of the light-weight concrete fill of the cornice made the use of an epoxy anchor system impractical. Pull-out tests of mechanical expansion anchors set in the light-weight fill revealed that the holding power of the fill was negligible at about 60 psi. Mechanical anchors were found

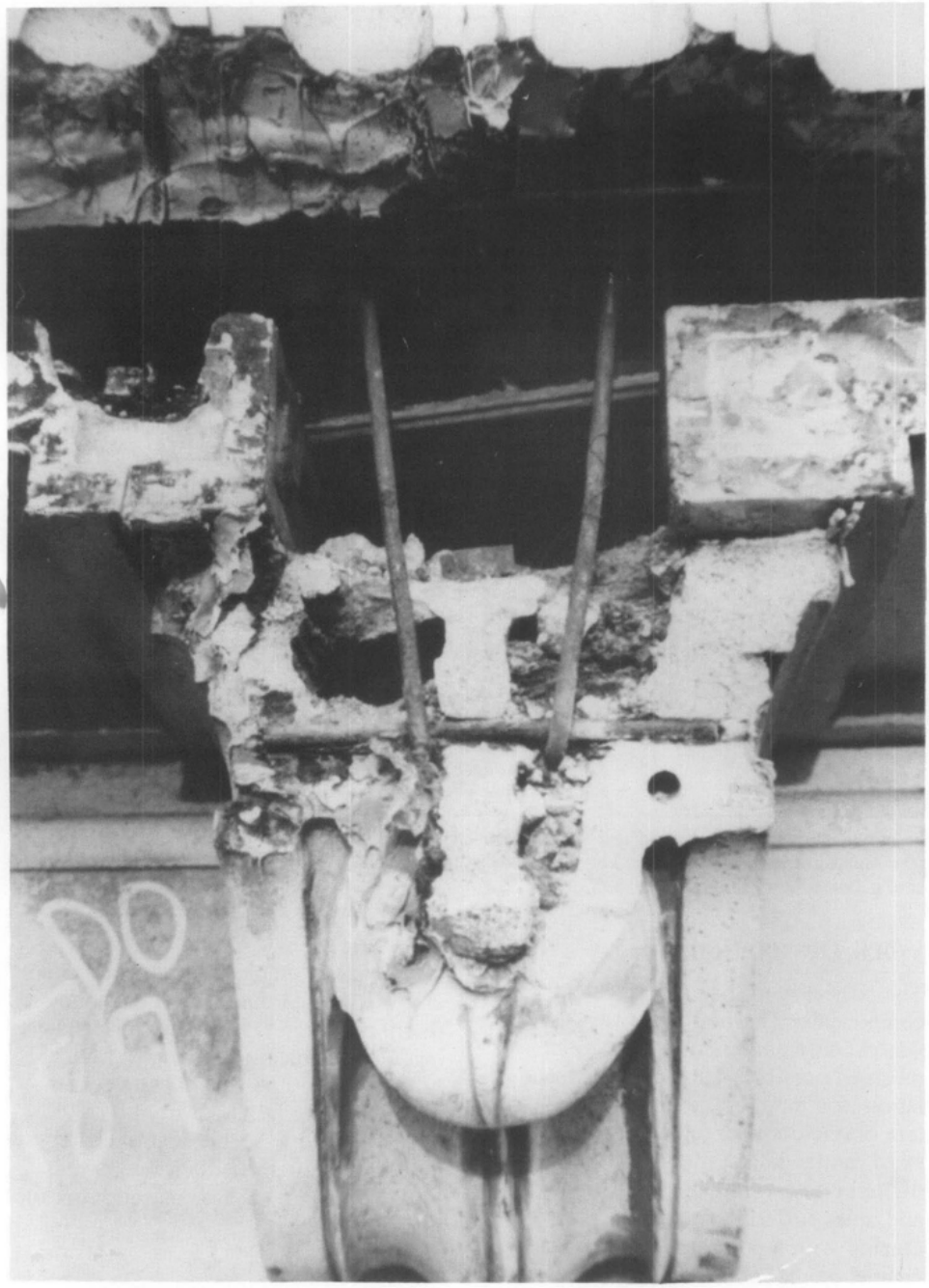

**Figure 3. Numerous brackets were found to be missing their outer scrolls due to oxide jacking of the steel J-hooks, steel pencil rods, and temporary support wires located within the units that were used for installation. Cracking in the brackets whose outer scrolls had not yet broken off indicated potential for further loss of material if stabilization measures were not undertaken.**

**During the original construction of the cornice, the brackets were hoisted into place and temporarily supported by the wires cast into the nose of the bracket units. J-hooks were then dropped down from the outermost steel channel above into the upper and outermost cells formed by the unit's internal webbing. A steel rod was then inserted horizontally through holes cast into the exterior sides and internal webs of the unit such that, with minor adjustment in the length of the J-hooks, the rod sat in the trough of the J-hooks; the weight of the bracket were thereby transferred to the J-hooks (see also figures 1 and 5). Photo by Jeffrey S. Levine.**

**Figure 4. Extreme loss of material was noted in the scalloped fascia above the brackets at the south end of the east elevation of the cornice. This deterioration and corresponding cracking in other fascia units was due to rusting of the structural steel angle iron which supports the fascia units at their center webs (see figure 1). A likely point of water entry was a large open joint located immediately above the fascia, at the bed joint of the cyma recta units. Photo by Jeffrey S. Levine.**

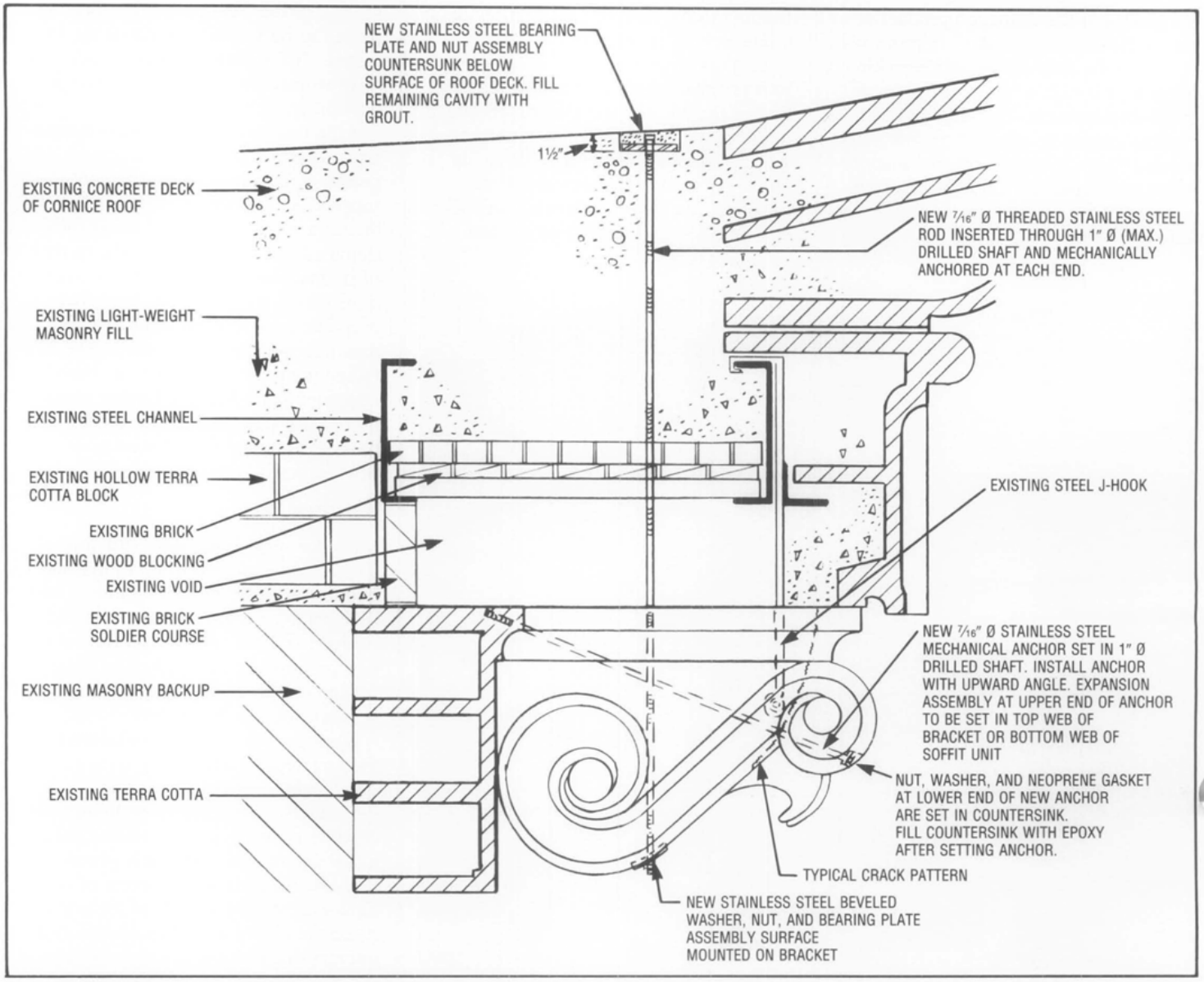


**Figure 5. Detail section through the cornice showing the manner in which the vertical and angled outer scroll anchors were installed in the bracket units. The vertical hash-marks represent a typical crack pattern found in brackets which had not yet lost their outer scrolls. All 128 brackets received angled outer scroll anchors and about 80 received vertical anchors. Drawing by Jeffrey S. Levine.**

to be suitable when set in brick backup or in structural steel. Pull-out values of from 500 to 1,800 psi were obtained in these materials, without any slippage or failure. These values were sufficiently high to provide a working safety factor of four times the weight of the terra cotta unit being supported. After making the decision to use mechanical anchors, drilling tests were conducted to determine anchor depths and backup materials at typical anchor locations on the cornice. Because the depth of penetration of the bracket units into the backup masonry could not be verified by non-invasive means, it was decided to anchor all brackets which had lost their outer scrolls or which had cracked internal webs. Given the condition of the light weight fill, this could only be achieved by extending vertical anchors through the roof *(see figure 5)*.

## Work Description

The project work had two different components. The first part was to prevent water from entering the cornice as much as possible. This involved installation of a new roof and drainage system on the cornice; repointing deteriorated mortar joints; injecting cracks in the terra cotta with epoxy; coating spalls and areas suffering from severe glaze crazing with a polyester polyurethane enamel paint; and installing patches at bracket and fascia locations where loss of material had occurred.

The second part of the project involved the stabilization of terra cotta units having cracked internal webs and, also, those units susceptible to such cracking or displacement due to the anticipated slow, yet continuing, oxidation of the steel structure and anchorages of the cornice. Four general categories of anchors were employed: vertical bracket anchors; angled outer scroll anchors; fascia clip-angles; and other miscellaneous mechanical anchors *(see figures 5-7)*. Over 750 new stainless steel anchors, ranging in length from 9″ to 6′, were installed to secure approximately 350 loose and cracked terra cotta units to the structural steel or masonry backup of the cornice.

## Scaffolding

The aerial scaffolding erected during the initial survey at the southeast and southwest corners of the building provided a stable platform from which to work on the cornice. Unfortunately, the expense and the disruption caused to the building tenants during installation of the scaffolding precluded the use of this type of scaffolding along the rest of the cornice.

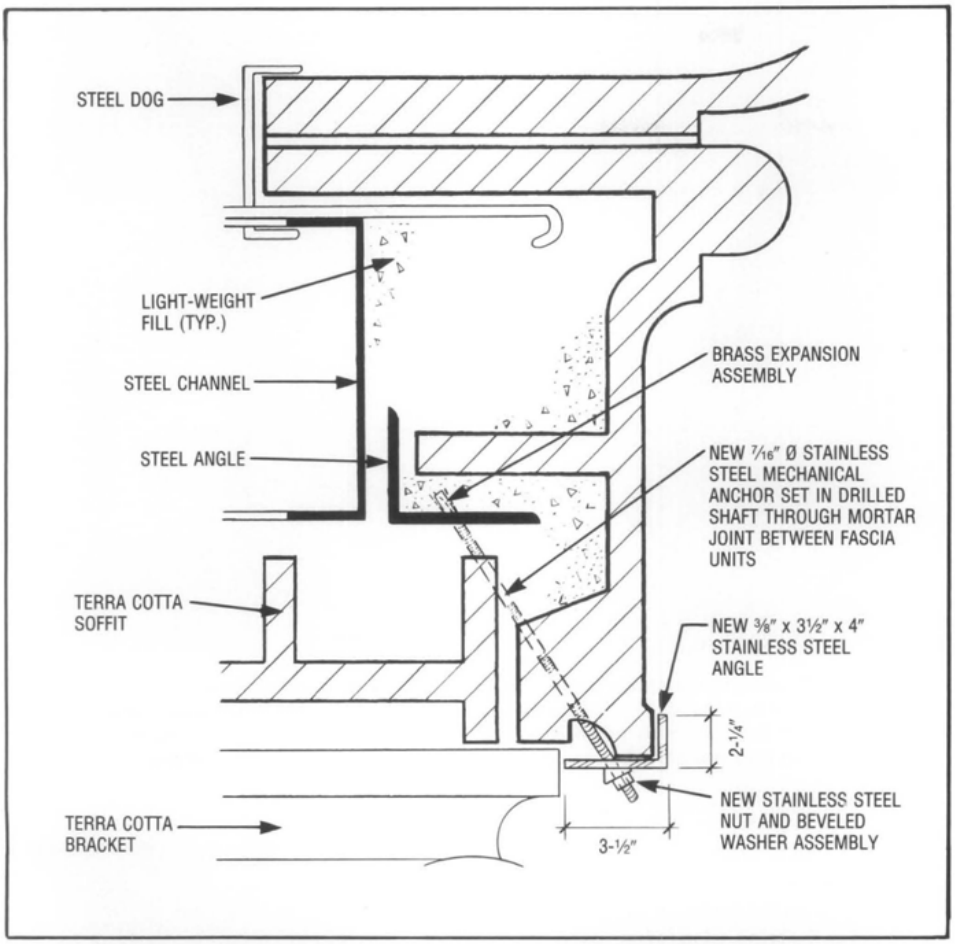


**Figure 6. Detail section through the fascia of the cornice showing the installation of a fascia clip-angle anchor. Clip-angles were placed in the joints between fascia units—128 total. Drawing by Jeffrey S. Levine.**

Frame-type scaffolding was also rejected as being too costly, given the height of the building.

The use of swing-stage scaffolds proved to be a practical solution. To accommodate the tall projecting cornice, custom-fabricated brackets were made which permitted two swing-stage scaffolds to be hung side by side, parallel to and at a distance of about 2′ out from the exterior wall. By tying the swing stages together and to the building, a stable work platform was provided for both the architect's detailed analysis of the cornice as well as the subsequent repair work *(see figure 8)*. A narrow section of scaffolding placed on the deck of the swings allowed for work on the upper reaches of the cornice. Using 32' long swings, roughly 10 drops were required, with 1½ days of breakdown and setup time between drops. Two sets of double swings were employed for the job.

## New Anchor Holes

To avoid introducing more water into the interior of the cornice, drilling of the anchor holes was accomplished using air-cooled, rather than water-cooled, 1″ diameter diamond core bits. These special bits have polycrystallized diamond (PCD) tips which are cultured onto carbide teeth. High heat-resistant steel tubing is used near the head of the bit to prevent the diamonds from over

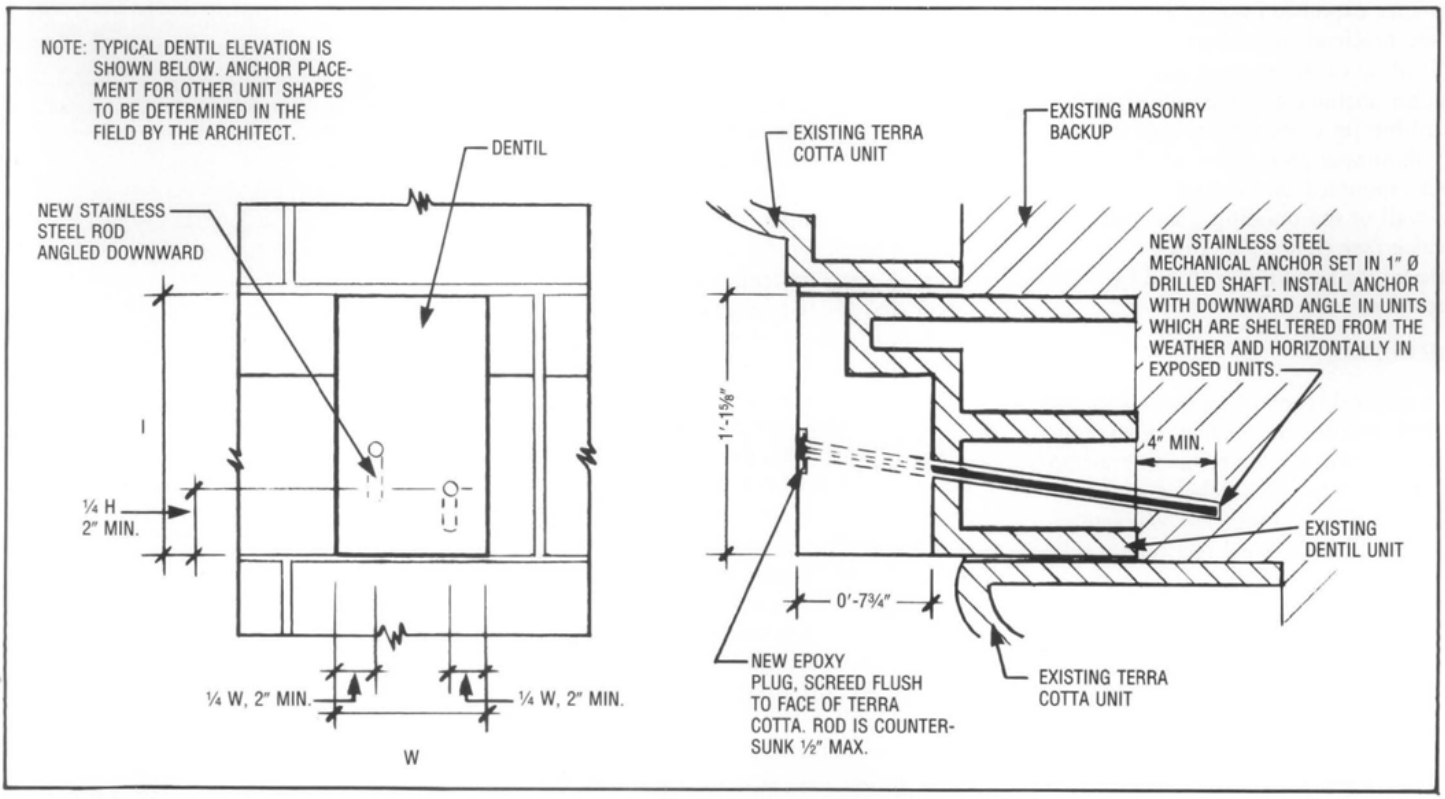


**Figure 7. The typical terra cotta anchor detail is shown here for a dentil unit. Other terra cotta units with cracked internal webs were anchored in a similar fashion. Roughly 30% of all terra cotta units, exclusive of the brackets, were anchored in this manner. Drawing by Jeffrey S. Levine.**

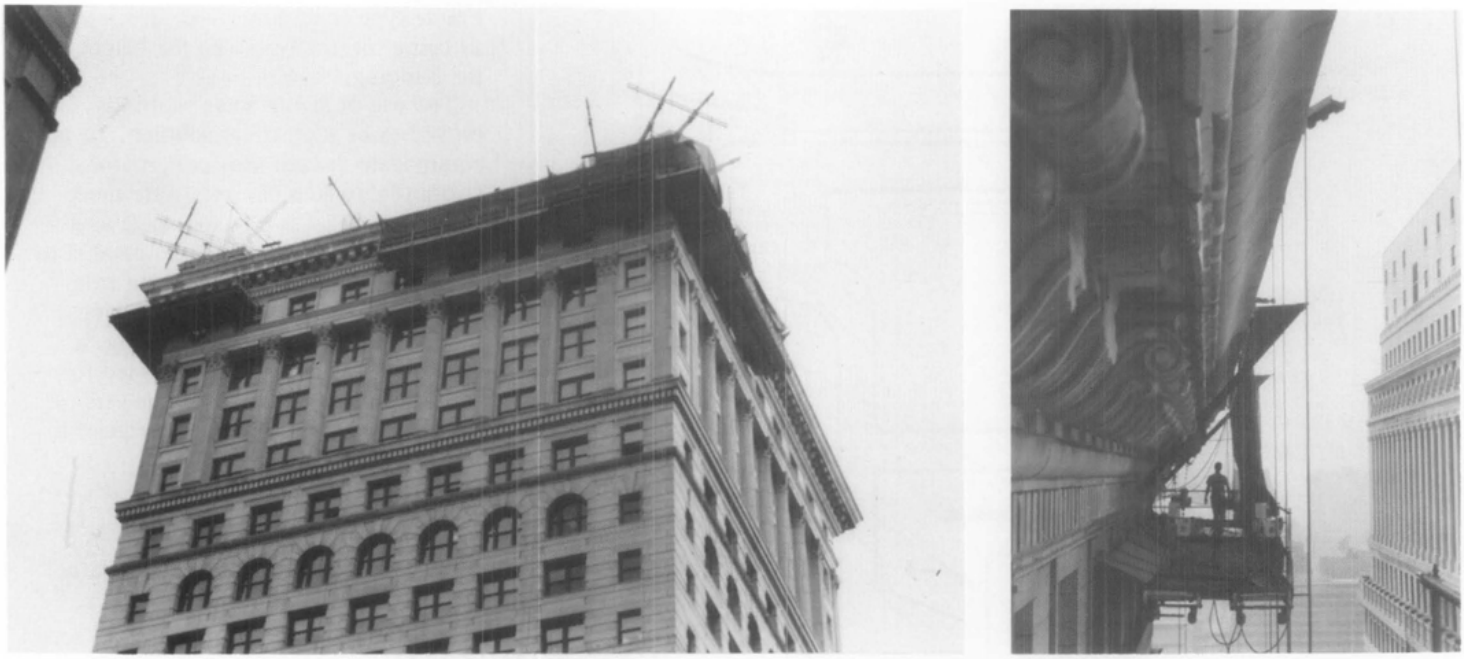

**Figure 8. Access to the cornice was provided by cantilevered aerial scaffolds at the southeast and southwest corners of the cornice. All other locations were accessed by hanging two swing stages, side by side. The inner swing was hung off of a V-shaped bracket (shown) while the outer swing was hung from a steel deadman which projected horizontally across the cornice roof. Both the V-shaped bracket and the deadman were designed to transfer the weight of the swings vertically down through the center of the cornice. No load was placed on the outer edge of the cornice. Photos by Jeffrey S. Levine.**

heating and breaking loose. A 7/8″ diameter drill bit extension was used to allow for holes to be drilled deeper than the 14″ length of the bit. Air-cooled diamond bits were also used to drill 2″ diameter countersink holes in the face of the terra cotta units. The last 3″ of each hole were drilled using ½″ diameter carbide bits to accommodate the 7/16″ diameter expansion assembly at the end of the mechanical anchors.

Drilling of the vertical and angled bracket anchors was accomplished using a drilling jig custom-fabricated out of ¼″ aluminum plate. The jig slid on tracks mounted on the roof deck and on the wall of the building, just below the cornice *(see figure 9)*. All other holes were aligned and hand drilled by skilled mechanics.

## Anchoring

Two general types of anchors were employed, one for the vertical bracket anchors and one for the remaining anchoring needs. Vertical bracket anchors consisted of a 6′ long, 7/16″ diameter threaded stainless steel rod with a ½″ thick, 4″ square stainless steel plate bearing on the roof deck and a ¼″ thick, 2″ x 8″ aluminum plate, bearing against the underside of the bracket *(see figure 5)*. Aluminum was chosen over other metals for the bottom plate because it could be more easily bent in two directions to fit the profile of the existing bracket. The rod and bearing plate assembly was secured in place with stainless steel nuts placed at each end of the rod. Ultraviolet-protected neoprene pads and a paint coating on the aluminum bearing plate were used to isolate the aluminum and stainless steel components of the anchor assembly, thereby preventing galvanic action between the two metals.

Stainless steel mechanical anchors, 7/16″ in diameter and with bronze expansion assemblies, were employed for most other anchoring needs *(see figure 10)*. Anchors of various lengths were special ordered from the manufacturer. The specified lengths were established in the planning phase by drilling test holes in the cornice at what were thought to be typical anchoring locations. A variable length anchor was also developed for use in unanticipated locations and in areas of the cornice where the original construction differed materially from the area in which test borings were conducted *(see figure 10)*.

As it turned out, the cornice construction was not very consistent and anchor placement varied according to the location of cracks. As soon as the initial order of fixed length anchors was used up, the drilling crew resorted to using all variable length anchors since these could easily be cut to the exact length required for any given situation *(see figure 11)*.

The mechanical anchors could be set either in the steel structure or the masonry backup of the cornice. Anchoring to steel was much preferred due to the

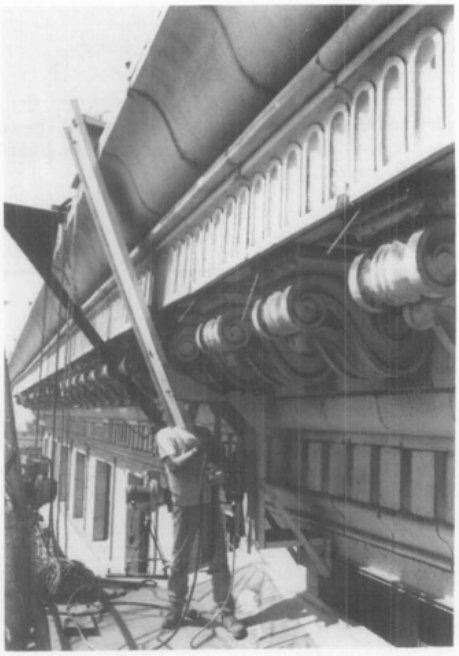

**Figure 9. Drilling 6′ long vertical holes through the cornice, in a variety of materials, was a delicate operation requiring great skill and specialized drilling equipment. The aluminum drilling jig provided the precise alignment needed to drill the holes for the vertical and angled bracket anchors. Drilling of a vertical anchor is shown. To create an angled outer scroll anchor hole, the drill was mounted on the angled portion of the jig, which passed directly in front of the bracket. Hand-drilled holes could be completed in 15-30 minutes, depending on the depth of the hole and the type of backup material encountered (e.g., brick, terra cotta, light-weight concrete, steel). Holes drilled with the jig required more time, 30-60 minutes, as alignment was more critical and it took time to set the jig in the proper position. Photo by Jeffrey S. Levine.**

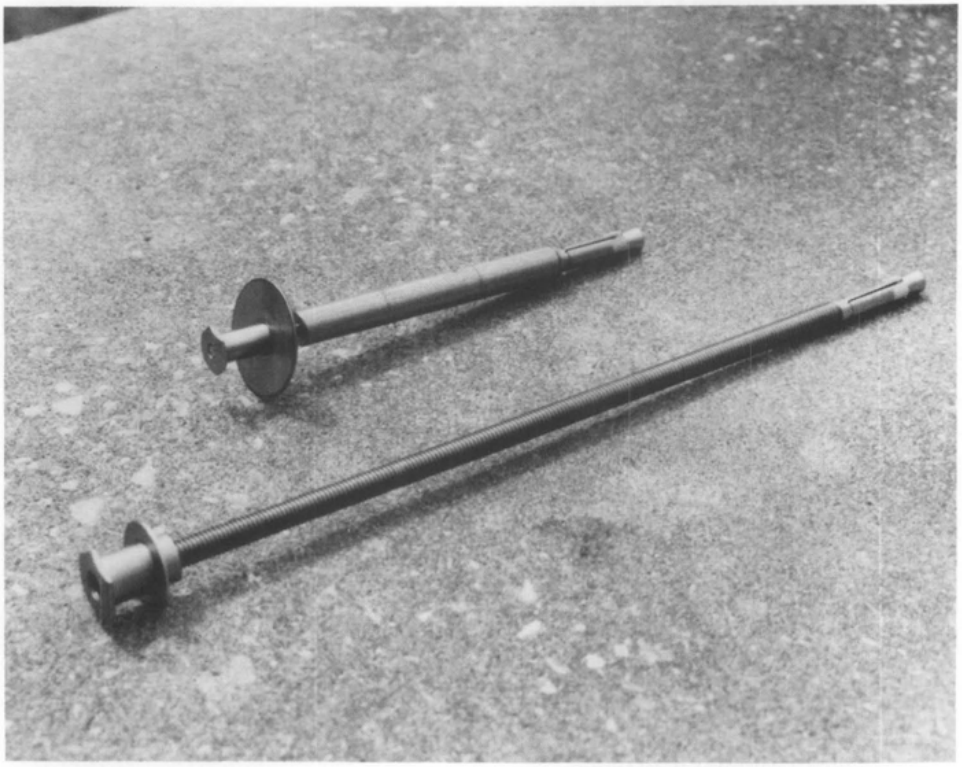

**Figure 10. A standard mechanical anchor (top) and a variable length mechanical anchor. The variable length anchors were fabricated from 6' long threaded stainless steel rods, which were tapped at both ends to receive expansion assemblies (two anchors could be cut from each rod).**

unknown condition of the masonry backup. Pull-out tests were conducted on a large random sample of installed anchors. Utilizing a safety factor of four, very few anchors failed. Those that did fail had been anchored into masonry backup and were easily replaced after drilling deeper into the backup material.

## Project Evaluation

The repair and stabilization of the terra cotta cornice of the Land Title Building was a large and lengthy project for the owners. The scope of the project could have been reduced, perhaps significantly, if timely maintenance activities, such as the replacement of the cornice's roof membrane, had been undertaken sooner by previous owners of the building. Working together, the owner, architect and PHPC achieved a repair approach that maintains the integrity of the cornice as an integral feature of a landmark building while simultaneously satisfying life-safety concerns and budgetary constraints. The drilling company's specialized equipment, skill, and close working relationship with the architect

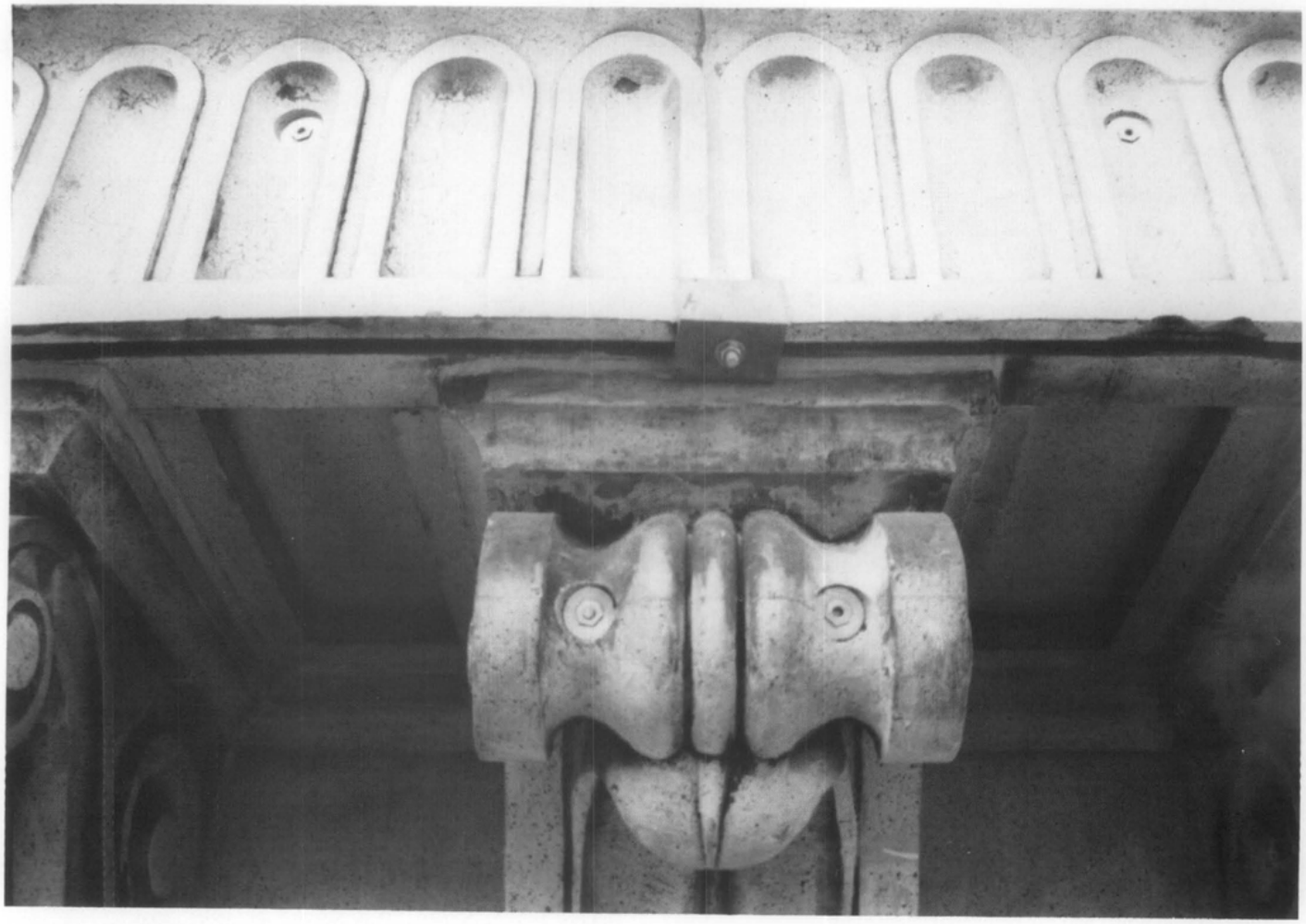

**Figure 11. Completed anchor installations at a fascia and bracket. The countersink holes penetrate no more than half the thickness of the outer wall of the terra cotta and were filled later with epoxy.**

likewise contributed to the success of the project.

No changes were made to the original design of the cornice. Anchor assemblies visible on the face of the cornice from up-close are imperceptible from street level. Further, none of the stabilization repairs precludes the future restoration of missing elements. Although the very nature of terra cotta makes it impossible to guarantee the absolute integrity of each masonry unit, the stabilization program significantly reduced the potential for future loss of material. Proper maintenance will help ensure this result.

## PROJECT DATA

### Building:
Land Title Building
100 South Broad Street
Philadelphia, Pennsylvania

### Owner:
LTB Limited Partnership
A Pennsylvania limited partnership

### Property Manager:
Seneca/Roach Commercial Property Services
Philadelphia, Pennsylvania

### Architect:
John Milner Associates
309 North Matlack Street
West Chester, Pennsylvania Project Director: Neale Quenzel
Project Conservator: Jeffrey Levine

### Easement Holding Organization:
Philadelphia Historic Preservation Corporation
1616 Walnut Street
Philadelphia, Pennsylvania

### Structural Engineer:
Joseph Cooke
Cooke-Chachkes, Consulting Engineers
Philadelphia, Pennsylvania

### Contractor:
Joseph Dugan, Inc.
Erdenheim, Pennsylvania

### Drilling Contractor:
Commercial Coring and Sawing
Vincentown, New Jersey

### Anchor Supplier:
Dur-O-Wal, Inc.
Baltimore, Maryland

### Drill Bit Supplier:
Golz Construction Tools
Virginia Beach, Virginia

### Project Date:
1989-1991

### Project Cost:
The costs per lineal foot of cornice for water infiltration mitigation and stabilization of the terra cotta were $539 and $719 respectively. These costs exclude architectural, engineering, and building management fees.

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Cover Photo: The Sansom Street tower from a 1905 post card. The earlier tower is shown in the background at right.

PRESERVATION TECH NOTES are designed to provide practical information on traditional and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures and standards. This Tech Note was prepared pursuant to the National Historic Preservation Act Amendments of 1980 which direct the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

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