

Westlake Reed Leskosky
925 Euclid Avenue
Suite 1900
Cleveland, Ohio 44115-1407
216.522.1350 FAX 216.522.1357
<http://www.vvrl.com>

Westlake
Reed
Leskosky



Perimeter Security for Historic Buildings: Technical Pilot

United States General Services Administration, Office of the Chief Architect, Center for Historic Buildings

Client

U.S. General Services Administration
Office of the Chief Architect
Center for Historic Buildings

Architect

van Dijk Westlake Reed Leskosky
925 Euclid Avenue, Suite 1900
Cleveland, Ohio 44115

Landscape Consultant

Sasaki Associates
64 Pleasant Street
Watertown, Massachusetts 02472

Blast Engineering Consultant

Hinman Consulting Engineers
290 Division Street, Suite 302
San Francisco, California 94103

Structural Consultant

Barber & Hoffman
1100 W. 9th Street
Cleveland, Ohio 44113

Cost Estimating Consultant

Project and Construction Services
3135 Euclid Avenue, Suite 200
Cleveland, Ohio 44115

Table of Contents

1. Project Overview
2. Design Parameters
3. Howard Metzenbaum U.S. Courthouse, Cleveland Ohio:
Technical Pilot Design Process
4. Howard Metzenbaum U.S. Courthouse, Cleveland Ohio:
Technical Pilot Implementation
5. Alternate Applications
 - A. U.S. Department of Housing and Urban Development Headquarters, Washington DC
 - B. Auditor’s Building, Washington DC
6. Appendix
 - A. Security Criteria for Perimeter Barrier, General Services Administration
 - B. Perimeter Security for Historic Buildings: Technical Pilot, Hinman Consulting Engineers
 - C. The Tao of Blast Design, Hinman Consulting Engineers
 - D. Howard Metzenbaum U.S. Courthouse 95% Working Drawings, VWRL and consultants

Project Overview

Historically, the intended image of Federal public buildings was to be inviting and accessible to visitors while portraying the aura of importance of the Government in the everyday lives of its citizens. These government buildings sometimes continue to serve the public in their original capacity and sometimes get adapted for a more current function, while maintaining their design integrity. The General Services Administration is committed to upholding the architectural excellence of these important structures while keeping them accessible, functional and safe.

Concerns for security at monumental Federal buildings have increased in the aftermath of the Oklahoma City bombing and the events of September 11, 2001. In many cases, grand historic government buildings, located in densely built urban districts, do not include setbacks from the streetline that would afford them adequate protection from blast damage. Where setbacks do exist, such as public plazas in front of monumental buildings, vehicles can easily approach without the presence of physical barriers.

This report focuses primarily on perimeter vehicular barriers for Federal historic buildings. The goal of this pilot study is to meet the needs of perimeter security criteria in a sensitive manner such that the architectural integrity of the historic building and its urban context are maintained and the pedestrian experience be enhanced rather than diminished.

In December 2000, KressCox Associates created a report entitled *Culture and Commerce: Bridging the Federal Triangle for the U.S. General Services Administration*. This report was to serve as the conceptual basis for the technical pilot study. In particular, the U.S. General Services Administration desired to test the “garden wall concept” presented in the KressCox report as a prototype through the development of construction document drawings, specifications and an estimate of associated construction costs. In addition, the U.S. General Services Administration sought concepts for alternate versions of the prototype elements for use at two other public buildings chosen to represent diverse historical styles and periods.

The Howard M. Metzenbaum U.S. Courthouse in Cleveland, Ohio was chosen by the U.S. General Services Administration as the prototype project for the technical pilot. Built in 1903 to 1910, the Metzenbaum Courthouse, adjacent to Cleveland’s Public Square, is listed on the National Register of Historic Places. The special challenges of this particular facility include the proximity to the street, the vaults under the sidewalks, its prominence on Public Square, and the various amenities on the existing site. The proposed resolution of these issues is illustrated later in this report.

Two other buildings chosen for alternate versions of the principal perimeter security elements are the Auditor’s Building and the U.S. Department of Housing and Urban Development Headquarters. Both are located in Washington DC, but vary greatly in materials and historical styles. The design process that evolved from the technical pilot study and the alternate versions has national application for providing perimeter vehicular barriers in a sensitive manner to historic Federal buildings, achieving GSA’s goals of preservation, performance, cost containment, public accessibility and design excellence.

Design Parameters

Design objectives and parameters developed by GSA and the design team include the following:

1. Disguise the protection.
2. Maintain accessibility to the public, i.e. permeability.
3. Security design is part of urban design.
4. Trees are not considered anti-ram.
5. Light standards and other typical streetscape elements are not considered anti-ram unless engineered to do so.
6. Elements can be combined.

Types of passive perimeter security elements include the following:

1. Bollards with foundations. Foundations to be tied together. Spacing allows 4 feet clear maximum.
2. Anti-Ram kneewalls with foundations. Three foot height minimum recommended. Can have openings, not greater than 4 feet clear.
3. Planters with foundations. Twelve inches below grade required for security protection. Deeper required to be below frostline. Planters 3 foot height above grade.
4. Surface-mounted planters. One-inch indent in slab minimum. Can be any shape or design.
5. Bodies of water.
6. Seating with foundations. Seat needs to be higher than axle of wheel.

The Metzenbaum Courthouse prototype incorporates specially designed and structured planters as part of the anti-ram perimeter security. The landscaping at buildings should respond to the conditions of the site including location (urban, suburban, rural), climate, site conditions (drainage, hardscape areas, wetlands, forested areas, etc.), and maintenance operations. Selected plant materials should be suitable for the particular site including hardiness, sun exposure, habit and disease resistance. As many federal buildings are located on urban sites, chosen plant materials should be hardy enough to thrive even in the harsh conditions of urban areas which include salt, soil compaction and pollution. Site design conditions including project limit lines, how the site circulates, drainage and utility locations must be understood and coordinated, especially on renovation projects such as the Metzenbaum Courthouse.

On large sites where the landscape is composed of extensive areas of lawn with trees, mowing may be a primary maintenance effort. In urban areas, typically the landscaping areas are smaller and more intensely planted. On a downtown urban block, such as the Metzenbaum Courthouse site, landscaping may be restricted to only planters and pots. Plantings may be rotated throughout the year for seasonal interest. Plant heights and shapes should be considered to ensure safety by maintaining views through the site.

The level of maintenance that will be provided should be considered when choosing which plant material to use and how to install it. Young plants will require more maintenance to ensure survival than established plants. Irrigation, if budget allows, should be approached like other utilities and coordinated with building systems and access through the site. Irrigation is an initial capital cost for a project, but may pay for itself over a couple years in savings for maintenance. For urban locations with small areas of planting, hand watering is an option. Pruning, weeding and fertilizing are other areas that will require ongoing maintenance.

Design cues for landscape design can be taken from the existing site. In addition to light conditions and orientation, existing plant materials may dictate a direction for the landscape design. At the Metzenbaum Courthouse, existing trees have shown a history of durability on this very exposed urban site. The landscape design solution for this application incorporates matching these existing trees.

Another design parameter for the aesthetic aspects of the perimeter security elements relates to the historical context of the existing building. Taking cues, but not necessarily replicating, historical features, details and materials for perimeter security elements is part of the balance that occurs with any historic preservation project.

General

The design of the technical pilot for perimeter security of historic buildings, using the Howard M. Metzenbaum U.S. Courthouse as the prototype, was a collaborative effort. The project was already in the working drawing phase for renovations to the Courthouse, so a design team familiar with the project and its site conditions was already in place. The technical pilot for perimeter security became an extension of that project.

The U.S. General Services Administration, including the Office of the Chief Architect and the regional office, has been involved with decision-making, design issues and discussions with local authorities throughout the design process. Along with van Dijk Westlake Reed Leskosky, providing project management and architectural design, the design team consists of Sasaki Associates for landscape design, Hinman Consulting Engineers for blast engineering, Barber & Hoffman for structural engineering and Project and Construction Services for cost estimating. The team also closely collaborated with the United States Bankruptcy Court, Northern District of Ohio, the City of Cleveland City Planning Commission, Division of Engineering and Construction, Traffic Engineering and the Greater Cleveland Regional Transit Authority.

Historical Context

The first step in the design process was acquainting the perimeter security team with the historical and physical context of the Metzenbaum Courthouse. In 1901, architect Arnold W. Brunner of New York City won the competition to design the Cleveland Federal Building, once called the Old Federal Building and now known as the Howard M. Metzenbaum U.S. Courthouse and Federal Building. The structure is located in the heart of Cleveland's central business district at the northeast corner of Public Square.

Brunner's commission places the project in the context of the emerging City Beautiful Movement and Cleveland's Group Plan at the turn of the century. Brunner's Federal Building was the first building of the Cleveland Group Plan to be built, and established the scale and style for the city's subsequent important landmarks. Its site and approach were significant to the city. The Public Library of 1925 directly across Third Street was intentionally patterned after the Federal Building and together the two form the inland terminus of the Group Plan Mall. Its prime site on the newly envisioned mall solidified the prominence and presence of the federal government, integrating public realm, urban design and architectural façade in one.

Today, the Howard M. Metzenbaum U.S. Courthouse remains one of the most significant landmarks within the downtown cityscape of Cleveland. The building is adjacent to Public Square and is a key element in anchoring the economic revival of the central core of Cleveland. It was listed in the National Register of Historic Places in 1974. The incorporation of perimeter security elements require design sensitivity to this important structure in its key urban setting.

Perimeter Security Zones

The Metzenbaum Courthouse site was analyzed for the application of anti-ram elements. Zones were created which dictated a variety of perimeter security elements. Clearly, a variety of types of elements is a more interesting design solution than using a single type of element, such as a bollard, around the entire site perimeter. All elements are designed to meet the anti-ram requirements previously established. The form and material of each element is designed to aesthetically compliment the style of the existing building and site conditions. The zones outlined below can and should be combined on various streetscapes.

Zone 1: Permeable. It allows physical pedestrian access to the site and is visually “lighter”. Bollards usually meet Zone 1 requirements. Several bollard styles were incorporated into the Metzenbaum project in a variety of locations where a more open feel was desired. Retractable bollards are also an option where vehicular access is required on a limited basis. Retractable bollards are incorporated into the Metzenbaum Courthouse on the north side at an access drive.

Zone 2: Partially Enclosed. This is a zone where site conditions allow planters or seating. These are more solid elements and they also add visual interest and public amenity to the site. These appear on the south and west sides of the Metzenbaum Courthouse.

Zone 3: Planting. This zone is located where there is a generous distance from the curb to the building. In the case of the Metzenbaum Courthouse, this occurs on the west side where there is already a deep zone accommodating existing locust trees.

Zone 4: Screen. This zone incorporates site amenities such as bus shelters, newspaper vending machines, post office boxes, and trash receptacles. All sites, especially urban ones, have site amenities that need to be addressed and coordinated with perimeter security elements. It is advisable to discuss the requirement of the site amenities at a particular site with the local authorities. Sometimes they can be relocated to a different location. At the Metzenbaum Courthouse, the majority of these site amenity elements were grouped on the west side.

Zone 5: Enclosed. This is an articulated wall. It can be a combination of bollards and rails, or a more solid wall treatment. This is used to add variety to the perimeter in locations where pedestrian access is not required or desired.

The shape, detail and materials used for the Metzenbaum Courthouse perimeter security elements are addressed in the next section of this report. Copies of the construction documents are also included in the Appendix.

City Review Process

As most historic Federal buildings are located in urban environments, local authorities are key team members to the design process. For this technical pilot, the design team and representatives from the General Services Administration met with various individuals and commissions that would be involved with the review of the installation. In the City of Cleveland, this meant meeting with the members of the Planning Commission, Division of Engineering and Construction, Traffic Engineering and the Greater Cleveland Regional Transit Authority.

Some site-specific conditions required close collaboration with City of Cleveland agencies. For example, two of the four streets require narrowing to meet the 20-foot standoff distance. At the Metzenbaum Courthouse, which has vaults under sidewalks on three sides, getting the foundations of the security elements into soil was a challenge. After extensive discussion, the City officials agreed to this approach for the design of the technical pilot. The design team had discussions with the Regional Transit Authority about the location of the bus shelters on the site and the possibilities for relocating them. In addition, the City of Cleveland has utility duct banks that were either worked around or created in the areas that were affected.



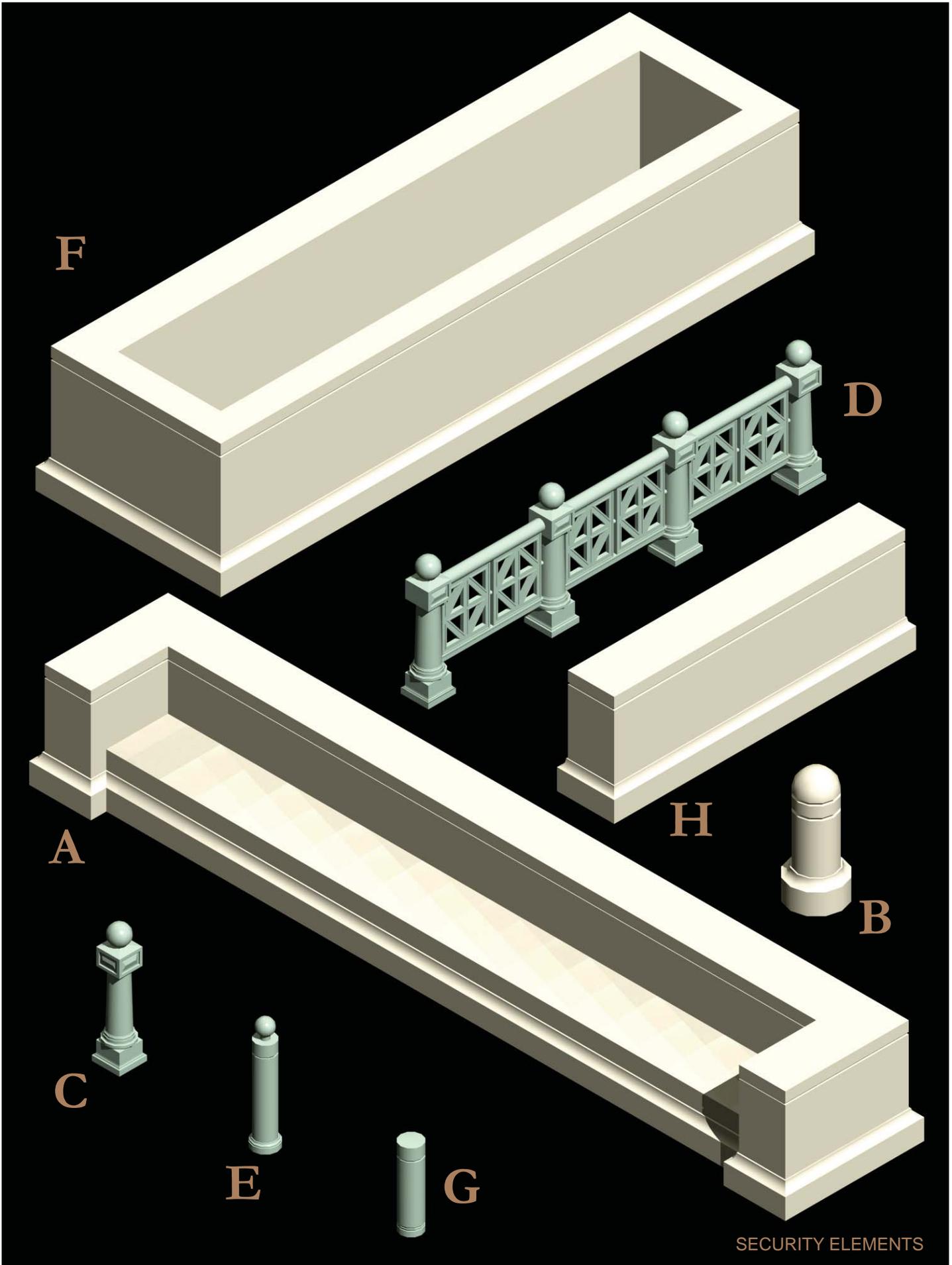
HOWARD M. METZENBAUM FEDERAL BUILDING UNITED STATES COURTHOUSE

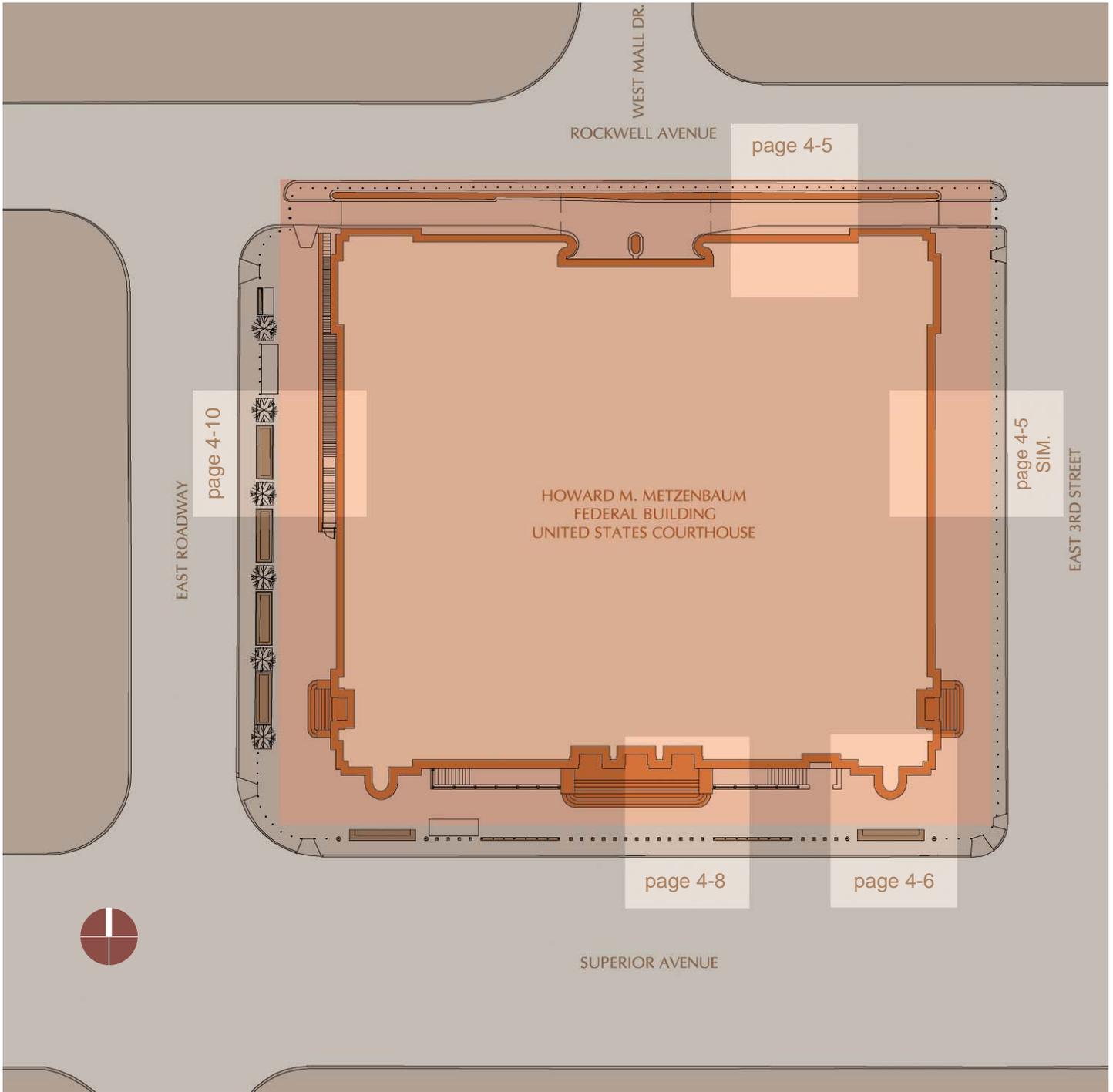
Cleveland, Ohio

1903-1910

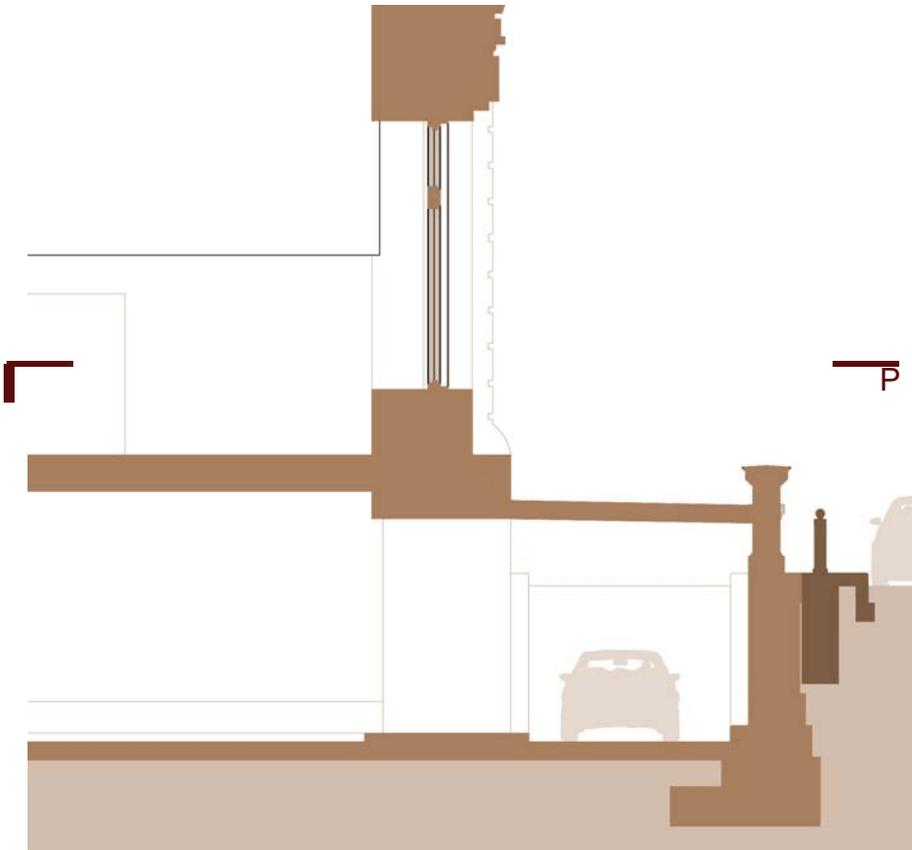
Arnold W. Brunner

- A. GRANITE BENCH
Two granite clad benches are located on the Superior Avenue sidewalk, across from the existing Daniel Chester French statues “Justice” and “Commerce”. The seat is intended to provide an opportunity to view the art adorning the building facade, while the reinforced concrete structure of the back serves as a security wall. (Zone 2)
- B. GRANITE BOLLARD
Pairs of granite clad bollards flank the benches and provide a material transition between the benches and the array of bronze bollards. (Zone 1)
- C. BRONZE BOLLARD
These are derived from existing oxidized bronze posts at the area ways on the south and east sides of the building. A filter-type security barrier against vehicles, this arrangement allows pedestrian access to the focal point of the main building facade. (Zone 1)
- D. BRONZE RAIL
An interpretation of the existing roman grilles, these elements are symmetrically located along Superior Avenue, on both sides of the main building entrance. (Zone 5)
- E. STEEL BOLLARD
The simplified geometry of these elements is a more economic solution for the secondary building facades on East Third Street, East Roadway, and Rockwell Avenue. The steel material is finished to match the oxidized bronze of the existing posts and grilles. (Zone 1)
- F. GRANITE PLANTER
Face granite on structural concrete and formal articulation complete the theme of blending in with the existing building granite base. (Zone 3)
- G. RETRACTABLE BOLLARD
Located at points of vehicular access to the building garage from Rockwell Avenue, these manufactured items compliment the design of the other security elements. (Zone 1)
- H. GRANITE SCREEN WALL
This element is a security barrier as well as a screen for street amenities. The geometry matches the bench and planter, while the granite material relates to the building. (Zone 4)

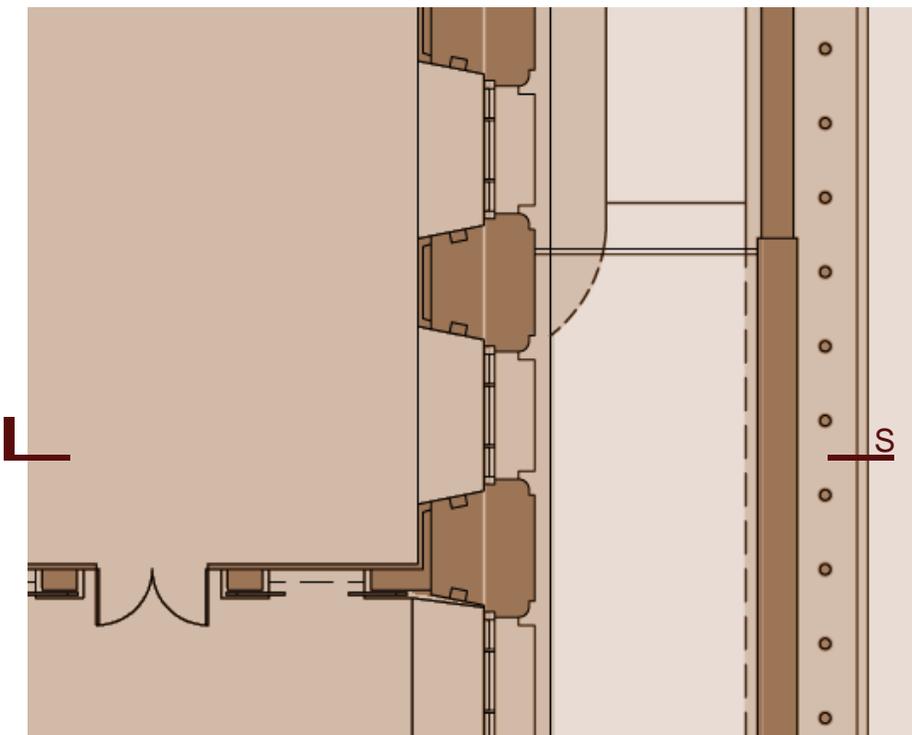




SITE PLAN



PARTIAL SECTION AT ROCKWELL AVENUE, LOOKING WEST



PARTIAL PLAN AT ROCKWELL AVENUE



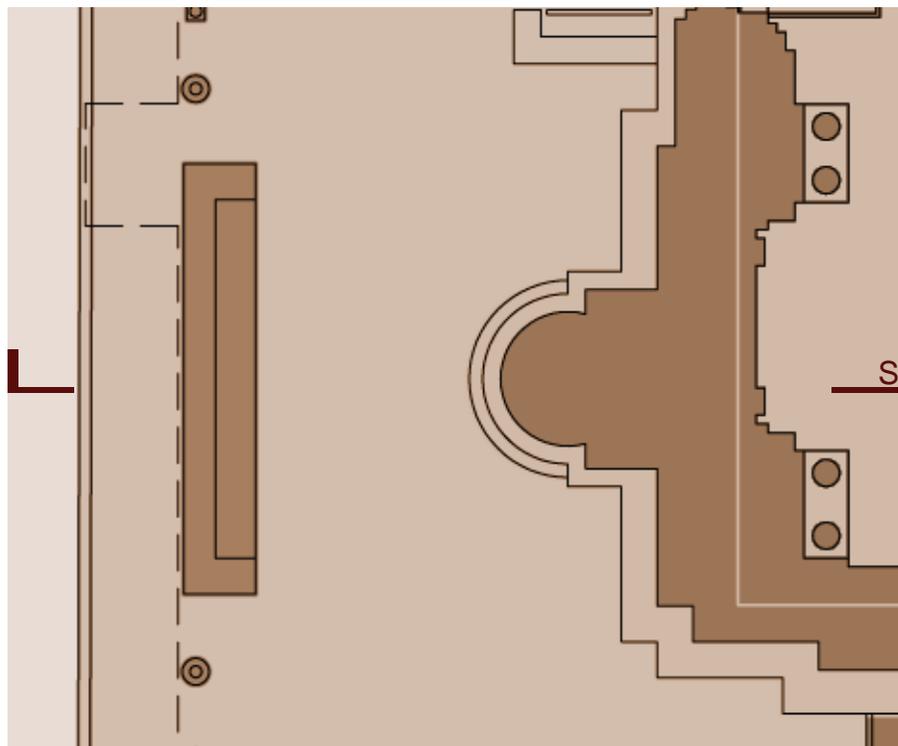
E



SECTION AT SUPERIOR AVENUE, LOOKING WEST



A



PARTIAL PLAN AT SUPERIOR AVENUE

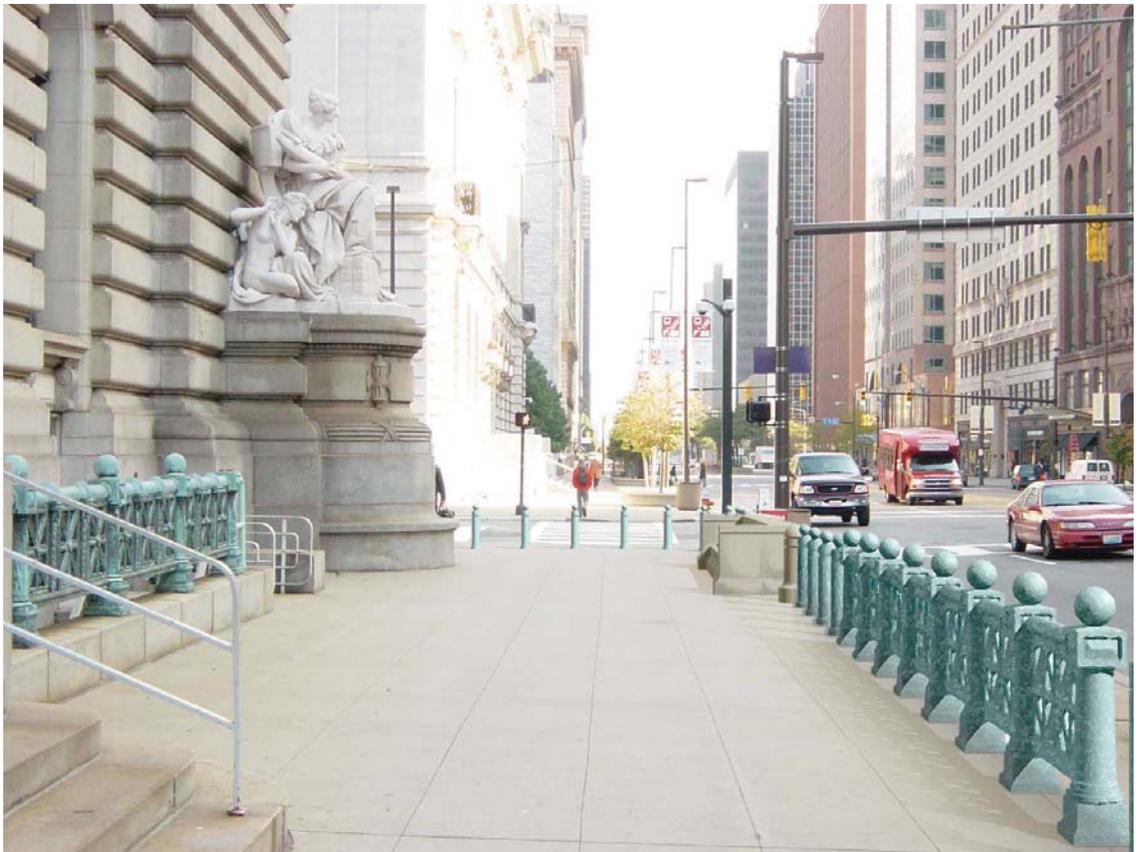


B



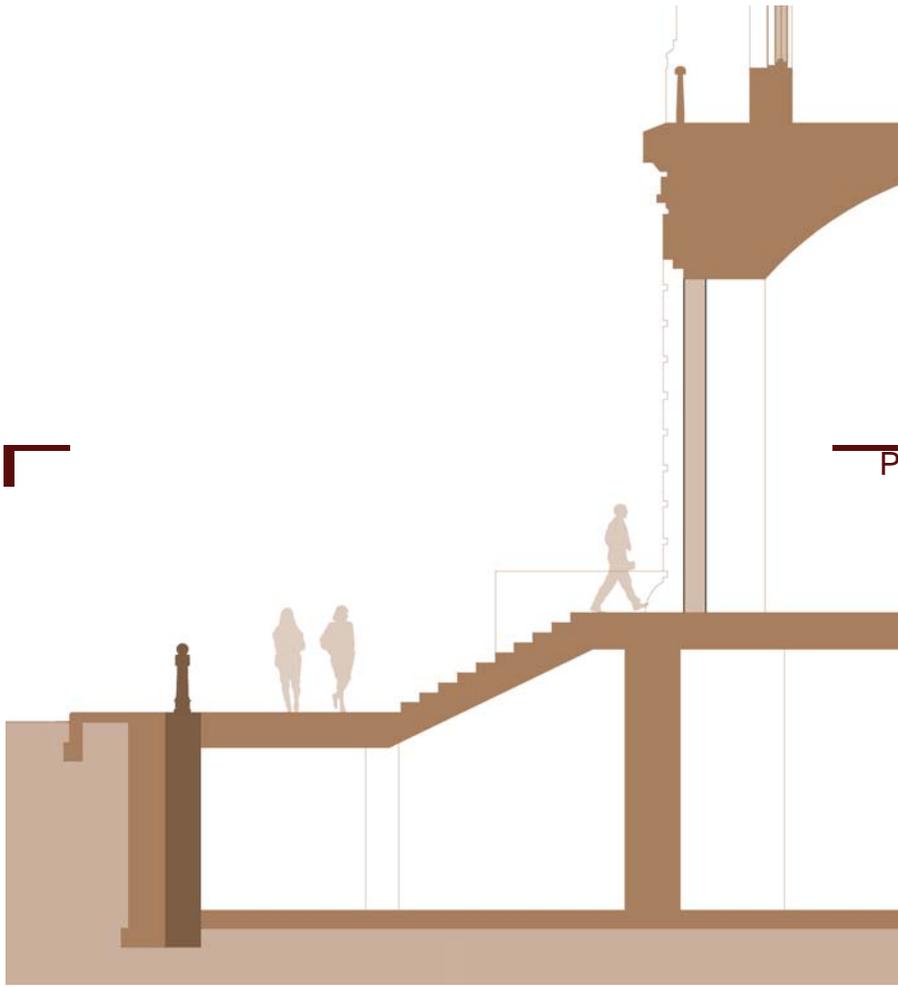
SUPERIOR AVENUE PERSPECTIVE VIEW, LOOKING EAST

BEFORE

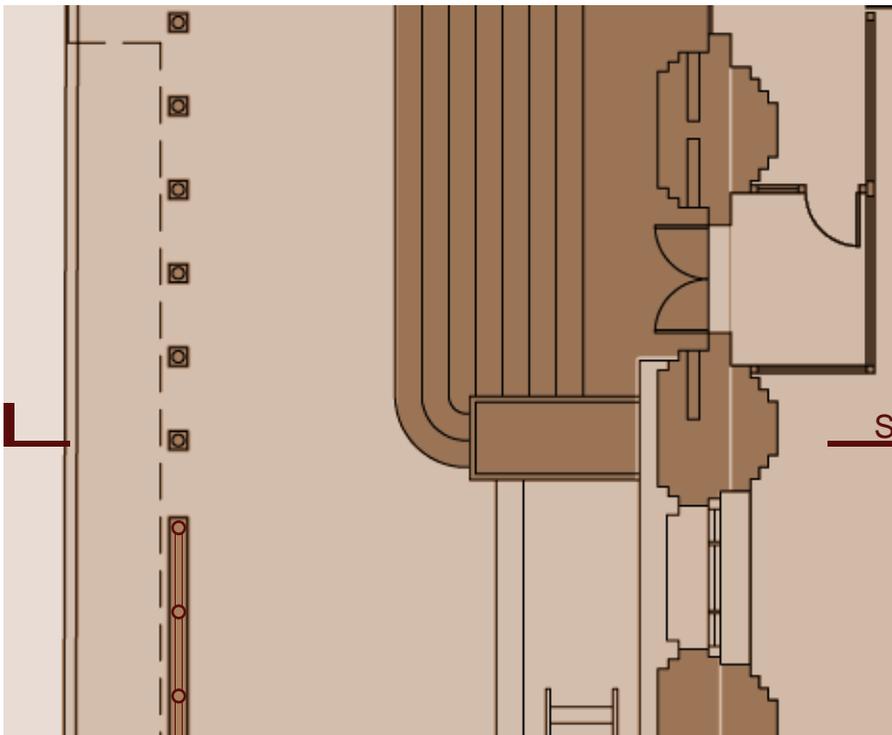
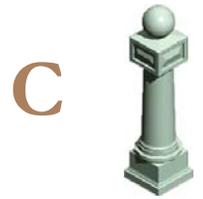


SUPERIOR AVENUE PERSPECTIVE VIEW, LOOKING EAST

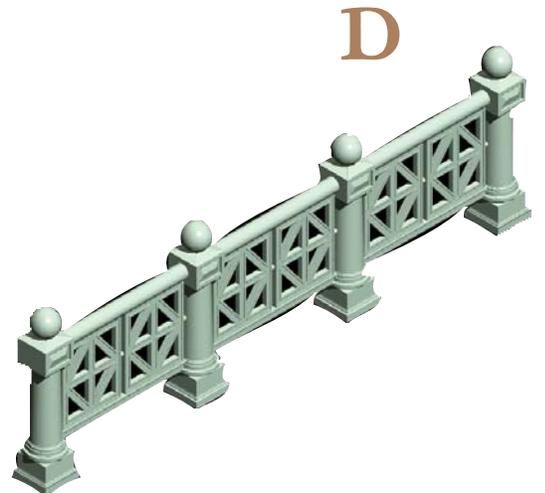
AFTER



BUILDING SECTION AT SUPERIOR AVENUE, LOOKING WEST



PARTIAL PLAN AT SUPERIOR AVENUE





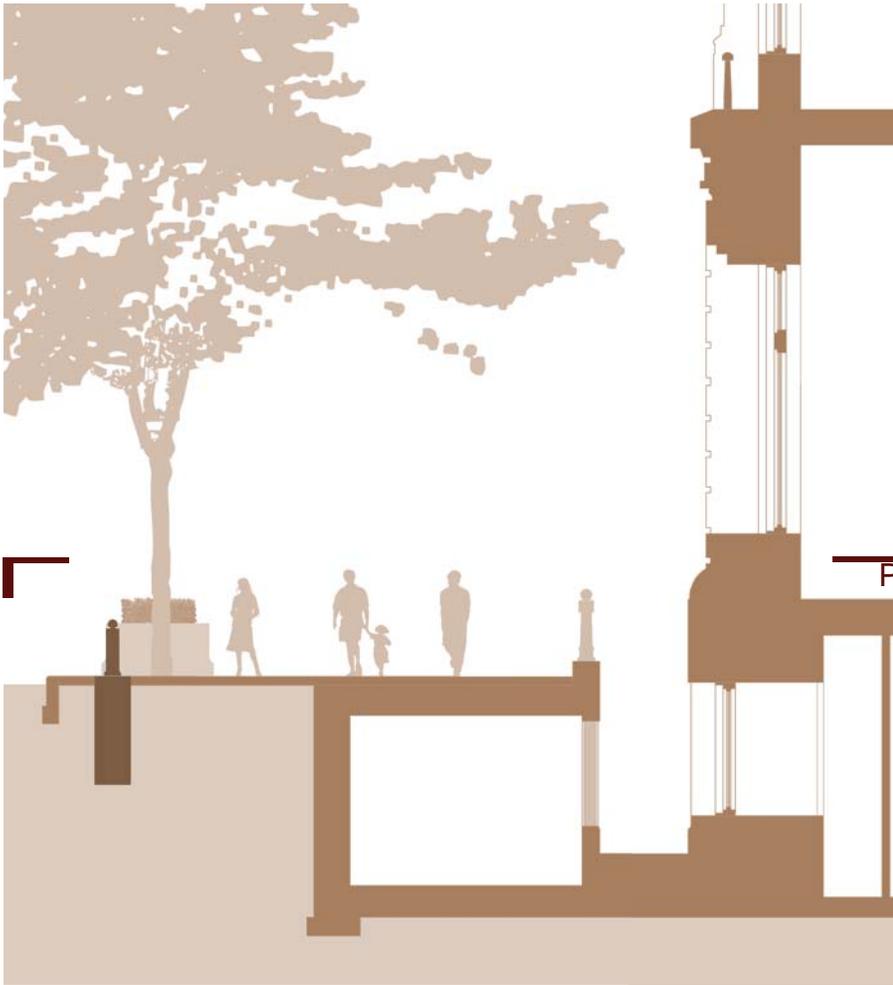
PERSPECTIVE VIEW AT SUPERIOR AVENUE, MAIN BUILDING ENTRANCE

BEFORE



PERSPECTIVE VIEW AT SUPERIOR AVENUE, MAIN BUILDING ENTRANCE

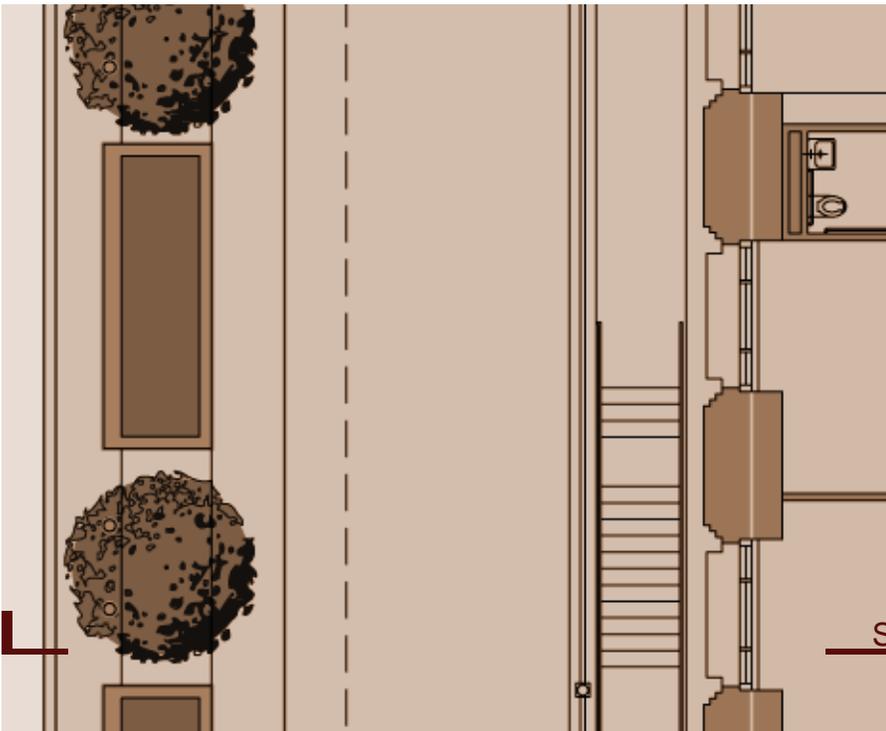
AFTER



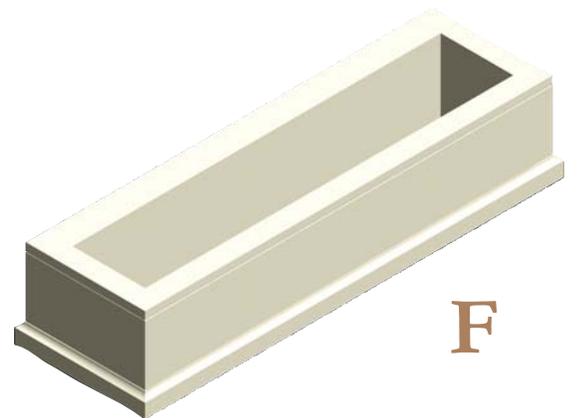
PARTIAL SECTION AT EAST ROADWAY, LOOKING NORTH



E



PARTIAL PLAN AT EAST ROADWAY

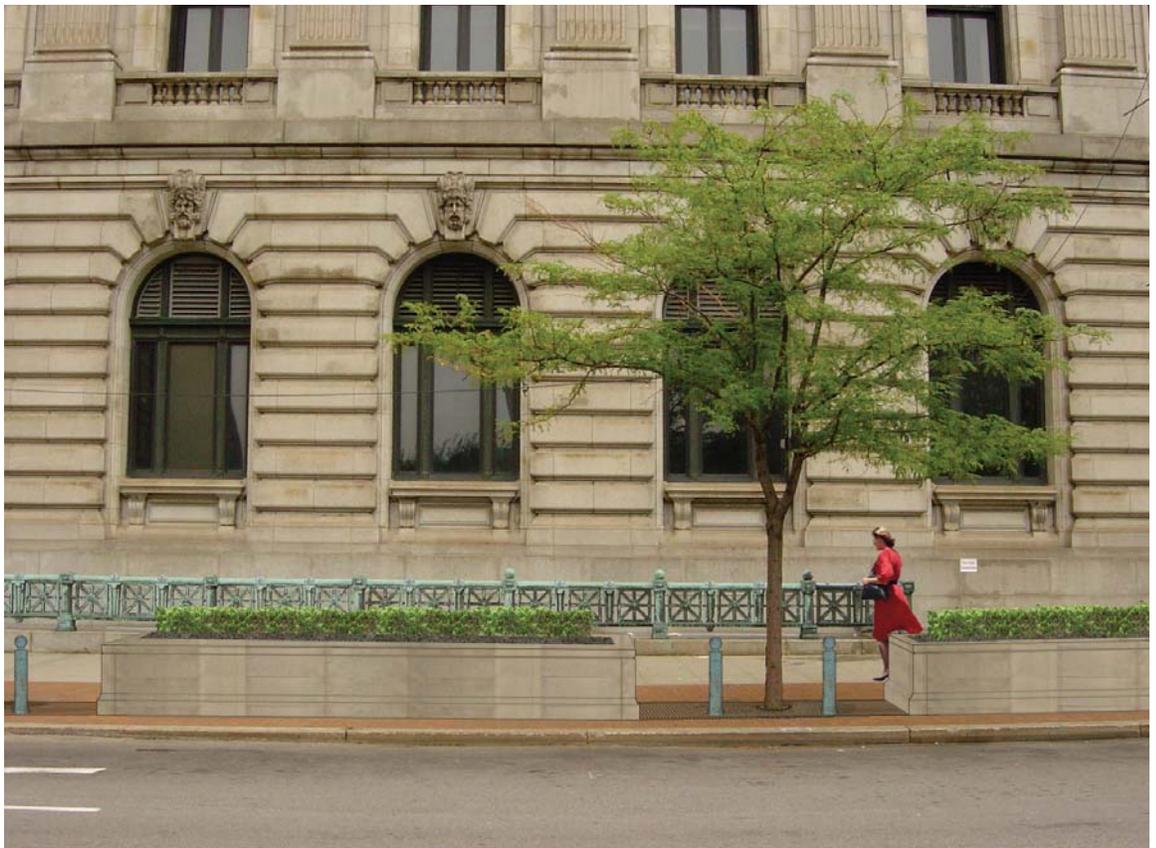


F



PERSPECTIVE VIEW AT EAST ROADWAY

BEFORE



PERSPECTIVE VIEW AT EAST ROADWAY

AFTER



U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT HEADQUARTERS

Washington, DC

1963-1968

Marcel Breuer

Designed by one of the world's leading modern architects, the HUD building was heralded as a major achievement that set high standards for public buildings. At completion, it was acclaimed for its imaginative plan, the boldness of its forms and the dynamic spatial engagement of its surroundings. It is the first federal office building to employ precast concrete and a radical departure from the architecture of its type. In search of a higher quality of design, it symbolically epitomized the devotion of a newly created department to upgrade the nation's cities and housing.

The building's monochromatic precast panel skin and the deeply recessed windows provide a setting for an intricate play of light and shadow. The end walls stone planes quietly add to the narrow range of materials. The cast-in-place frame of the building resembles a tree, growing out of a series of robust pairs of pilotis with slanted, angular walls.

The structure embraces the landscape with its curvilinear X shape. The sweeping convex curves of the 10 story high walls draw adjacent space inward to sculpt open plazas on each side of the building. Walking around the structure, which dramatically thrusts its body up and outwards, transcends viewing of an object. It is a dynamic experience of space and architectural movement.

SECURITY ELEMENTS: ARRAY 1

These elements establish a visual language for the design of security elements. All bollards and threat side walls require blast analysis and structural design.

A. BOLLARDS

These are platonic shapes cast in architectural concrete with stainless steel accents. The array of pyramids and prisms is a formal response to the clean geometry of the building. The slanted surfaces of the pyramids are a reference to the massive pilotis supporting the building. (Zone 1)

B. BOLLARDS

These minimal bollards clad in stainless steel are derived from existing site elements. (Zone 1)

C. RAIL

Stainless steel cables are spun between bollards to prevent passage without obstructing visual communication. (Zone 5)

D. SCREEN WALL

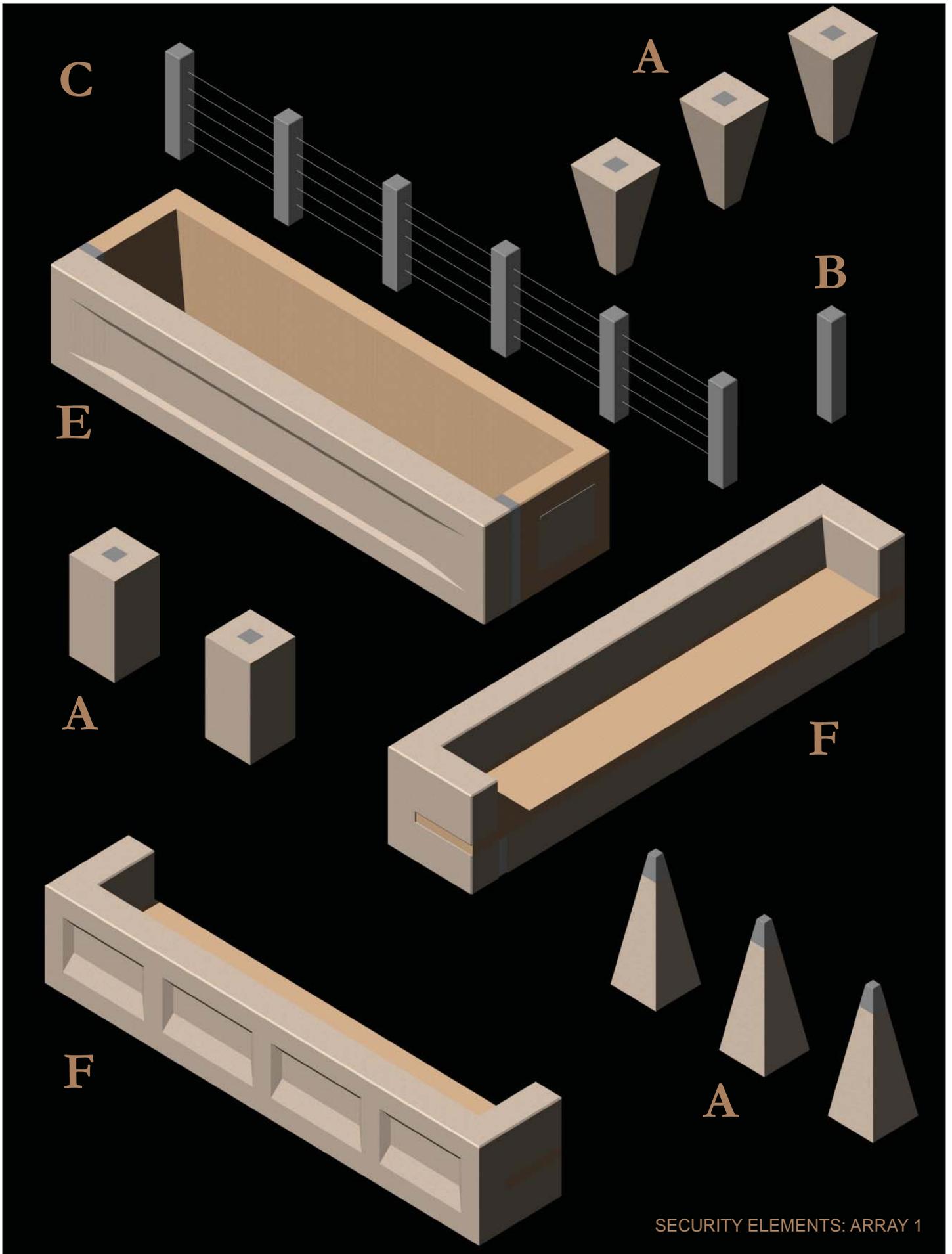
This element is not shown on its own. The idea is to repeat the motifs established in the backs of elements E and F. The screen wall is used as a barrier to deter passage. It may also be a screen for street vending, standardized trash receptacles and other amenities. (Zone 4)

E. PLANTER

The design explores the incorporation of two colors/textures of concrete/stone, with stainless steel accents at joints. The articulation of the back is derived from the building end wall. (Zone 3)

F. BENCH

This example shows a basic element with architectural concrete back and sides and a stone seat. The design of the back explores a connection with the building windows articulation. (Zone 2)



SECURITY ELEMENTS: ARRAY 2

These elements establish a visual language for the design of security elements. All bollards and threat side walls require blast analysis and structural design.

A. BOLLARDS

These are platonic shapes cast in architectural concrete with stainless steel accents. The array of cones, cylinders and spheres is a formal response to the clean geometry of the building. The curved shapes seek a softer look as opposed to the sharp edge elements in Array 1. (Zone 1)

B. BOLLARDS

These minimal round bollards clad in stainless steel are derived from existing site elements. (Zone 1)

C. RAIL

Stainless steel cables are spun between bollards to prevent passage without obstructing visual communication. (Zone 5)

D. SCREEN WALL

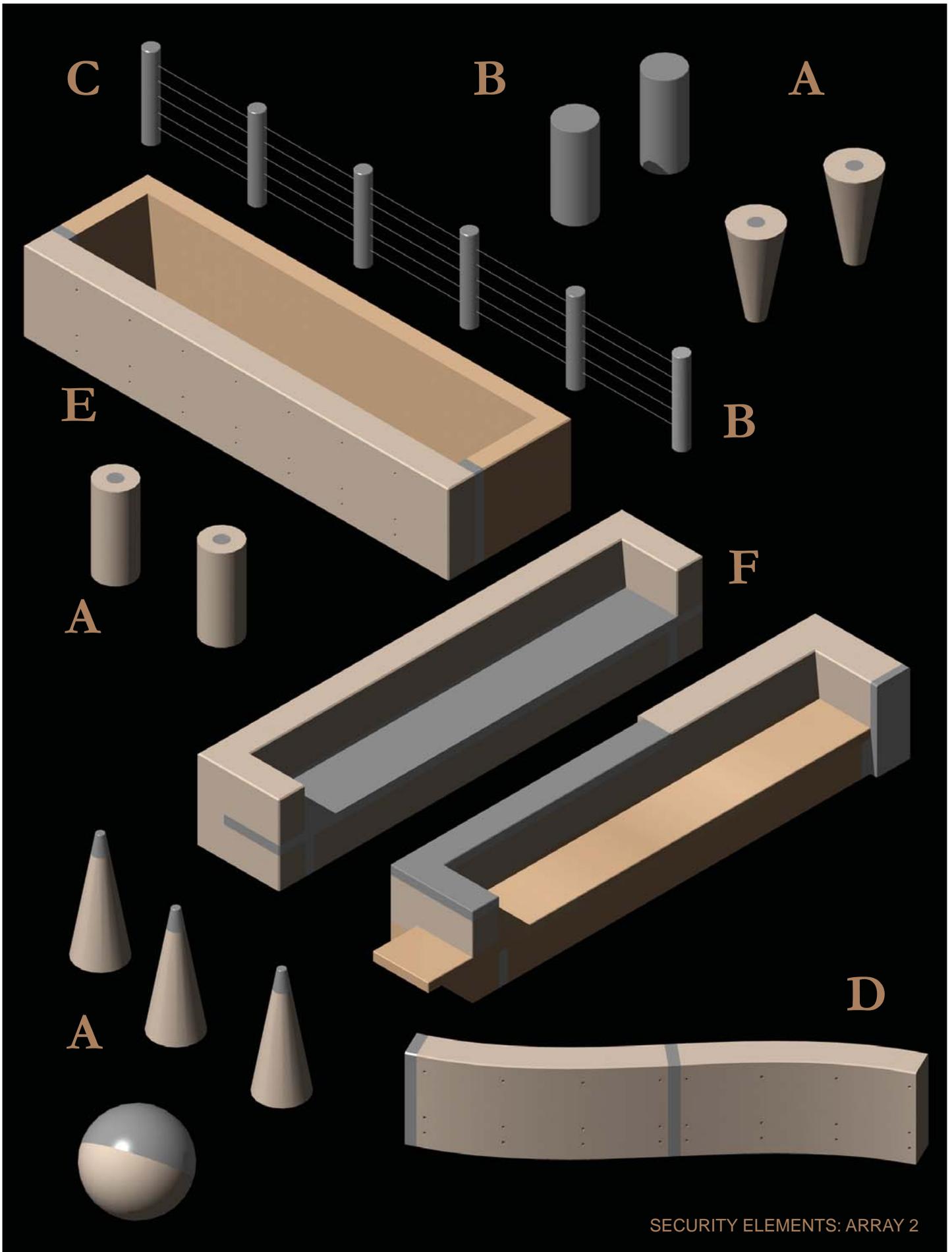
This element is used as a barrier to deter passage. It may also be a screen for street vending, standardized trash receptacles and other amenities. Architectural concrete is cast in sections with stainless steel treatment at joints. Tie form holes may be left open or plugged with stainless steel inserts. A curve compliments the existing building configuration. It also suggests the sculptural potential of cast-in-place concrete. (Zone 4)

E. PLANTER

The design explores the incorporation of two colors/textures of concrete/stone, with stainless steel accents at joints. The open or plugged form tie holes aim at establishing a rhythm similar to that found in element D. (Zone 3)

F. BENCH

This example shows a basic element with architectural concrete back and sides and a stainless steel seat. A second example explores a stone seat with fragmentation of the basic element with the introduction of offset planes, projections and joint articulation. (Zone 2)



SECURITY ELEMENTS: ARRAY 2



AUDITOR'S BUILDING

Washington, DC

1878-1880

James G. Hill

Originally built to house “The Bureau of Printing and Engraving”, the structure was designed by the office of the Supervising Architect of the Treasury. It was commissioned in the period in which Federal Buildings echoed the Romanesque massiveness of H.H. Richardson’s work. However, the use of Italianate and contemporary English elements is a stylistic departure from the exuberant Romanesque idiom.

Since the 1880 completion, three major additions have been constructed in 1891, 1896 and 1900. All wings of the building are four stories in height and the overall massing caters to the original function - an industrial facility housing an uninterrupted and uniform space for large equipment. The nine story tower adorning the east pavilion and the corbelled base bartizan at the southeast corner add visual interest to the restrained volume penetrated by a regular grid of fenestration. Dark red pressed brick laid in Flemish bond and molded black brick face the load bearing masonry walls culminating in a major corbelled cornice. Terra-cotta ornament, slate roofs and highly crafted ironwork complete the materials palette and bring together a stylistically harmonious building.

The Auditor’s building stands out in the nation’s capital amidst a collection of Federal, Greek revival and Beaux Arts examples. Through sophisticated detailing, it combines different stylistic impulses into a structure of historical, architectural and landmark significance. It was included in the National Register of Historic Places on April 27, 1978.

SECURITY ELEMENTS: ARRAY 1

These elements establish a visual language for the design of security elements. All bollards and threat side walls require blast analysis and structural design.

A. BOLLARDS

Ornamental iron shaft and spherical finial are abstracted from existing bollards in the building surroundings. (Zone 1)

B. RAIL

A combination of minimalist balusters and rails seeks to compliment the period architecture of the building. (Zone 5)

C. SCREEN WALL

The materials (brick and stone) are borrowed from the palette of the existing building. This element establishes a language for all solid security elements. (Zone 4)

D. PLANTER

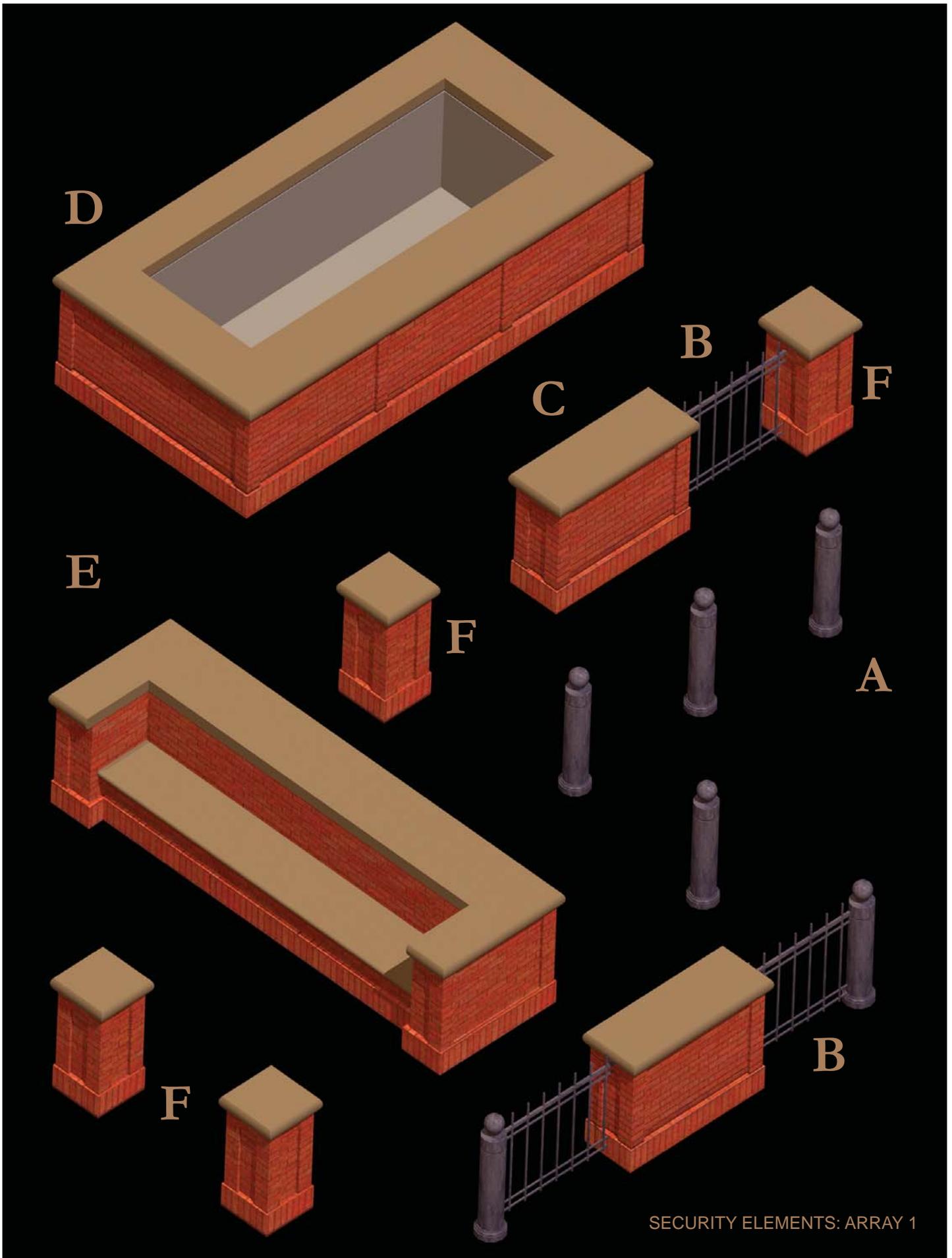
Soldier course base, panelization and stone caps are based on the screen wall example. (Zone 3)

E. BENCH

The solid wall motif is further articulated with the addition of a stone seat. (Zone 2)

F. BOLLARDS

These are based on the screen wall design. The emphasized corners are a minimal attempt to add design interest to the clean prism that forms the bollard's body. (Zone 1)



SECURITY ELEMENTS: ARRAY 2

These elements establish a visual language for the design of security elements. All bollards and threat side walls require blast analysis and structural design.

A. BOLLARDS

Ornamental iron body with fluted shaft and conical finial are reminiscent of existing bollards in the building surroundings. (Zone 1)

B. RAIL

A combination of spear heads and arches seeks to compliment the Romanesque detailing of the building. (Zone 5)

C. SCREEN WALL

The design is derived from the richly textured facade of the existing building. It establishes a language for all solid security elements. (Zone 4)

D. PLANTER

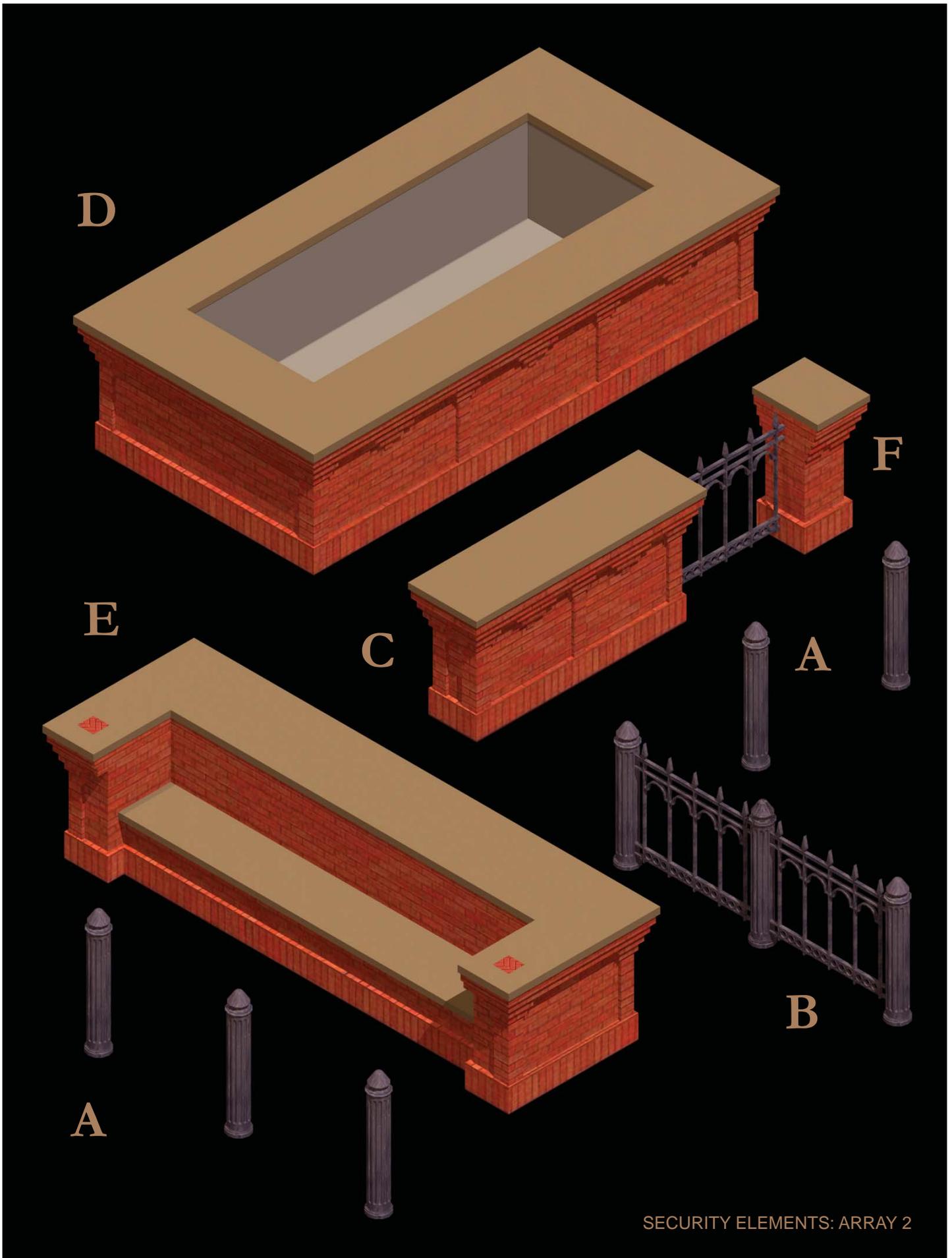
Corbelled brick, coursing, and stone caps are based on the screen wall example. (Zone 3)

E. BENCH

The solid wall motif is further articulated with the addition of decorative brick inserts in the stone cap. (Zone 2)

F. BOLLARDS

These are formed in brick with detailing similar to Elements C,D, and E. (Zone 1)



SECURITY ELEMENTS: ARRAY 2



The Tao of Blast Design

Lorraine Lin, Ph.D., P.E

Taoism

- ✓ Taoism seeks to create harmony and balance with one's environment. It is a metaphor for understanding blast design.

Blast versus Seismic Design

- ✓ Blast engineering is a specialized field of structural engineering. Blast engineers deal with enormous pressures applied for fractions of a second typically to the outer bays of a building. Seismic engineers deal with cyclical loads applied through the base of structure as shear forces.
- ✓ The small amount of overlap between blast and seismic engineering is in dealing with progressive collapse.

Rules of Thumb for Blast Design

- ✓ DO maximize the standoff distance between vehicles and your building.
- ✓ DON'T site your building so that there is a direct approach for fast-moving traffic.
- ✓ DO use passive perimeter barriers to increase the standoff distance.
 - Bollards
 - Anti-ram kneewalls
 - Concrete planters
 - Benches
 - Moats
- ✓ DO integrate perimeter security with the landscape architecture.
- ✓ DO use active perimeter barriers for vehicle access points.
 - Rotating wedge system
 - Surface-mounted plate system
 - Retractable bollards
 - Crash gate
 - Crash beam
- ✓ DO choose simple and convex building shapes.
- ✓ DO set back the upper floors.
- ✓ DO minimize the number of insets in the building façade.
- ✓ DON'T design overhangs with vehicular traffic below.
- ✓ DON'T use large transfer girders.
- ✓ DO use ductile materials for your structure, such as steel or reinforced concrete.

Hinman Consulting Engineers, Inc.

290 Division St., Suite 302 P 415-621-4423
San Francisco, CA 94103 F 415-621-4447

www.hce.com
llin@hce.com

- ✓ DO design your floor slabs for upward, as well as downward forces.
- ✓ DO design your building with sufficient structural redundancy for progressive collapse.
- ✓ DON'T locate loading docks and mail delivery areas within 50 feet of critical areas, such as occupied spaces.
- ✓ DO locate high-density areas and essential personnel away from the perimeter of a building and above the ground floor.
- ✓ DON'T allow unsecured parking in the basement or on the roof of your building.
- ✓ DO place stairways for emergency egress as far away from vulnerable locations as possible.
- ✓ DO allow these stairways to discharge away from lobbies, parking areas, or loading areas.
- ✓ DON'T cluster your emergency egress routes.
- ✓ DO provide areas of refuge in high-rise buildings.
- ✓ DO located refuge areas in the inner bays of a building.
- ✓ The best way to approach blast mitigation for new construction is *early* and with a multi-disciplinary blast mitigation team which includes the architect, structural engineer, blast engineer and landscape architect.
- ✓ Retrofits are more expensive, more complicated, less effective and have greater uncertainty.

Windows

- ✓ DO minimize the size of your windows.
- ✓ DO use strip windows.
- ✓ DO design hazard mitigating window systems.
- ✓ DO design cladding that is securely fixed to your structure.

Conclusions

- ✓ Architectural measures can be as, if not more, effective than structural measures at mitigating blasts. They allow the possibility of aiming for invisible protection.
- ✓ This requires that informed blast design decisions are made early in the design process.