REHABING HISTORIC STRUCTURES WITH ENERGY CONSERVATION: CONSTITUTION QUARTERS, CHARLESTOWN NAVY YARD.

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I. Introduction

Ten years ago last month, the U.S. Navy decommissioned the Boston Naval Shipyard at Charlestown. Seven years later, in 1981, Constitution Quarters opened its doors as the first recycled structure of a 1,200-unit, 58 acre redevelopment of the Charlestown Navy Yard.

Built originally from 1853-1858 Constitution Quarters, commonly known as Building 42, had been added to and modified numerous times, and thus represents over a century of wood and steel frame technology. Designated within a parcel listed on the National Register of Historic Places, the changes in use were made within the Standards of Rehabilitation set forth by the Tax Reform Act of 1976. This paper reviews the design process of converting a large masonry, wood, and steel frame structure into 367 apartments, parking garage, and retail space, and also the post-construction energy conservation measures intended to further comply with updated industry standards. As designer and project manager, this author found both the adaptive reuse of existing structures and the upgrading of buildings for energy conservation equally significant as new construction in the process of 'mechanical selection', the ongoing refinement of function to improve the built environment.

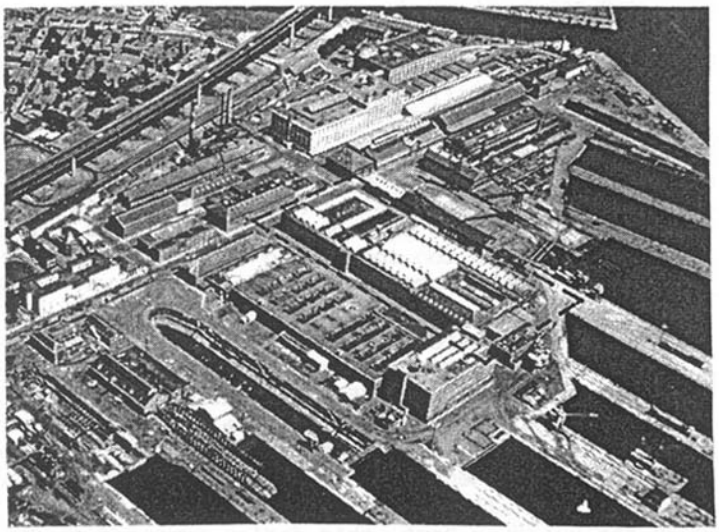

Fig. 1 Aerial view of Charlestown Navy Yard prior to redevelopment. Building 42 shown in dashed outline.

II. History

Since 1800, the Charlestown Shipyard had been devoted to the work of building and repairing ships. Wooden frigates and sloops-of-war of the early 1800's, the ironclad ship Merrimac of the Civil War, the massive square-rigged sailing ships of the late 1800's, the steel ships of the early 1900's, and the destroyers and frigates of World War II and the Korean War, all have made the Charlestown Shipyard a historic landmark in the city and in the Nation's naval history.

Fig. 2 Constitution Quarters (sub-buildings A & C)

To quote National Park Service historian Edwin C. Bearss:

> The yard was a living organism that grew and developed as missions changed. Facades were altered and floor plans shifted as the yard evolved from its beginnings in 1800 to its phaseout in 1974. The buildings tell long histories, and they cannot be restored to a particular historic period without destroying some part of their message or making the yard into something it never was. Its existence must be traced through to the end, as the living story it is.
>
> The navy yard was not pretty and should not be portrayed as such. It was an industrial site. The only notable landscaping was some trees planted in the 1820's and a landscaped walkway along the ropewalk called "flirtation walk"; these were gone by 1974. That sort of attraction disappeared with the buildup necessitated by World War II.

Perhaps only architects and historians can sense what is gained and what is lost in the transformation of this refined, brick quadrangle concept of 1853 through a century of bold, if sometimes raw edged, modifications for military industrialization, to its present reincarnation as a residential complex. Certainly the juxtaposition of so many uses, esthetics, and structural systems makes an invaluable laboratory for today's urban redevelopment strategy.

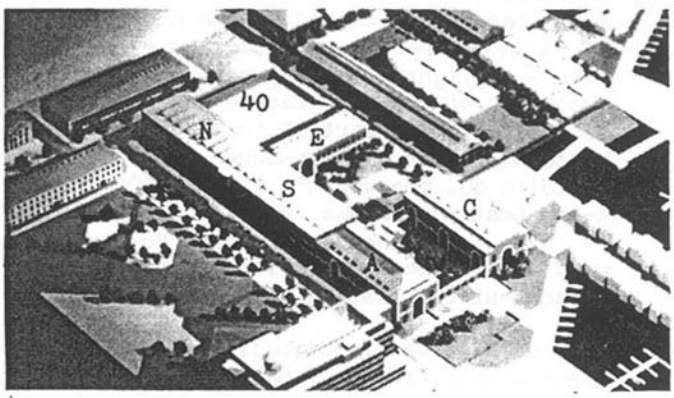

Fig. 3 Model of proposed development. Building 42 (Constitution Quarters) shown with center quadrangle section removed.

In 1827 a master plan for the Charlestown Navy Yard was designed by architect Alexander Parris on the grand scale of Europe's royal navy yards. Buildings in the classical style, designed by Parris and built of finely dressed granite, were constructed from 1830 to 1851. Joseph Billings (1821-1880) studied under Parris and executed some of his later designs. In 1842, Billings took over the position of chief architect vacated by Parris and served until 1865. Work of his own design was of brick in the Georgian Revival style, including what is now known as Constitution Quarters.

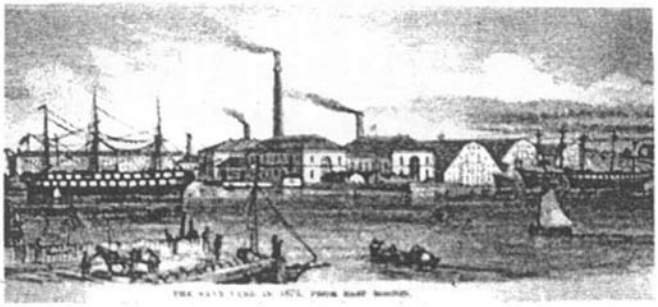

Fig. 4 Engraving of Building 42 - 1873.

The inventory nomination form for placing the Charlestown Navy Yard on the National Register of Historic Places includes the following description:

> Building 42 is significant in social history as the major working place or shop at the yard and in the history of technology and the navy for the major role it played in converting the U.S. Navy from wind to steam power and subsequent roles in developing a nuclear navy.
>
> It stands on the site of an 1820's blacksmith shop. It was used originally as a machine shop, foundry, and smithery. The Billings plan enclosed a quadrangle in which was located the "crystal palace," an artistic but leaky glass, frame, and brick structure built over a modern steam power plant. Adjacent was a handsome 239 foot tall brick smokestack.
>
> The shops, steam plant, and smoke tower are all of the same date. Engines for the U.S.S. Hartford, launched in 1859, were assembled here. Later during the Civil War, two wings of the quadrangle were connected with an additional shop, and cookery ovens were added on the east elevation. In 1901 the "crystal palace" was removed and the powerhouse rebuilt. The tower was removed between 1900 and 1910, and two small additions were attached to the powerhouse. During World War I, the quadrangle was filled with a skylighted factory building, and (later) a portion of the west facade was removed and reconstructed as part of the enlarged factory building, which also obscured a portion of building 40. The world's first 1,000,000-volt X-ray testing lab was installed in World War II to inspect castings and welds. Following the war, sonar domes were developed here for attachment to existing ship hulls.
>
> The building was functionally divided into a machine shop, foundry, boiler and blacksmith shop, tool shop, and copper and pipe shop. It also included a brass foundry and torpedo testing room.

Sub-building 42A originally had two separate floors spanned by heavy timber and steel rod roof trusses. A major improvement in use, and genesis of the present 700 ft. long mall space, came in 1902 with the restructuring of the building for a multi-story, steel framed gantry craneway with side galleries. This steel framework and craneway was later extended in the factory-like sawtooth roof additions of 1917 and 1939. Preservation of this space was one of the factors leading to a covered mall concept.

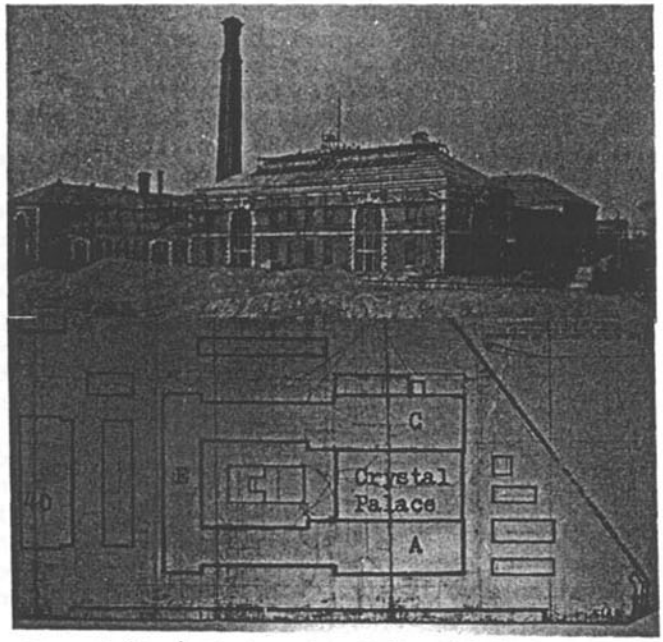

Fig. 5 (Top) Photo of Building 42 during roof and craneway restructuring of 1902. (Bottom) Plan of original quadrangle with crystal palace infill.

III. Covered Mall Concept

Initially, a design had been formulated for Bldg. 42 which filled in the lengthy craneway with spacious but deep and dark apartments, more closely associated with reuse of loft-type or industrial structures. This approach proved too costly and the covered mall concept surfaced from an economic viewpoint as a way to cut back and minimize the extent of new construction. In informal discussions with Mr. Tony Pepicelli of the Boston Building Dept. it was suggested that the covered mall section of the 1975 State Building Code could possibly apply to residential use. Use of the covered mall prior to this time was primarily for shopping centers. Residential use, being omitted from mention, was neither allowed nor prohibited. At the suggestion of the Building Dept. this design advanced on the basis that the forthcoming 1978 code would clarify this omission of residential use from the covered mall concept.

Bldg. 42 was assisted further by the newly introduced Article 22 of the Mass. Code, which defined public safety standards and design alternatives in the rehabilitation of existing buildings. To fit the new space program within the existing building shell it was also necessary to seek dimensional variances from the State Building Code. Dimensional constraints of secondary egress doors, for example, were among the nearly several dozen variances required. This quantity of variances was similar to another historic redevelopment in Boston, Quincy Market, by architect Alexander Parris mentioned earlier, rehabilitated just several years prior to Constitution Quarters.

Essentially, the covered mall concept is the simulation of exterior space between what are otherwise two separate structures, 30ft. apart, connected by a roof. This dimension is generally established as the limit beyond which non-bearing walls do not require fire-resistive construction. The mechanical ventilating system in the mall was furthermore required to have smoke exhaust capability in the mall space with pressurization in the tenant spaces, thus also simulating an exterior environment with regard to natural air dispersion. Dimensionally, the 90 ft. width of the existing building allowed exactly 30 ft. for the mall and 30 ft. on either side for apartment depths which, when repeated in the 24 ft. structural column bays, closely complied with FHA minimum apartment area requirements.

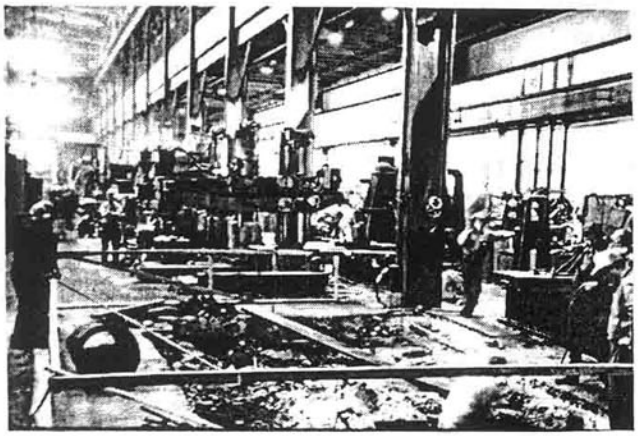

Fig. 6 Building 42N machine shop (looking north) showing milling machines and preparation of slab for new machine footing.

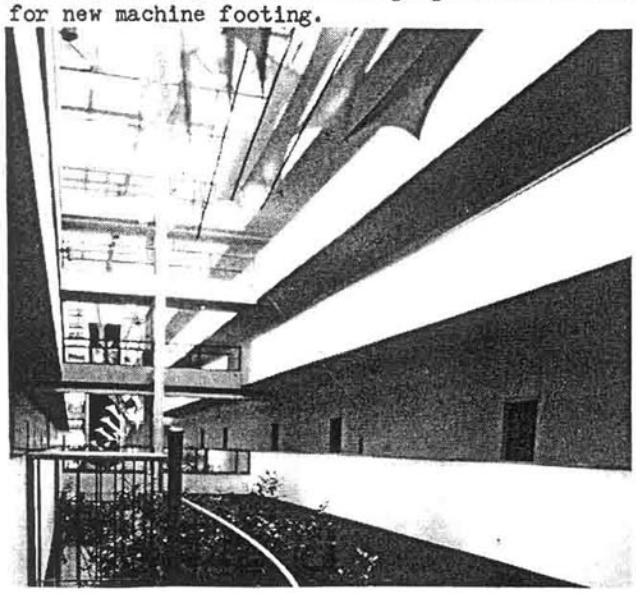

Fig. 7 Constitution Quarters (Bldg. 42) Mall. Skylit pedestrian mall used for elevator and stair access to apartments and also landscape and sculpture display. (View from Building 42S looking north) Covered mall requirement of 30 ft. from apartment wall to apartment wall.

Historic examples of the covered pedestrian mall are numerous, such as the Galleria in Milan, Italy, 1865-67, which serves as a skylit passageway connecting two squares, and the Crystal Palace, London, 1851, a large prefabricated metal framed exhibition hall, where the Victorian prediliction for greenery in architecture is evident.

While today this building type is most often applied to shopping centers where year round indoor weather protection provides both economic and social incentives, the covered mall concept within the past decade has gained wide acceptance in other uses, such as office, hotel and residential use. In some instances this is due to energy considerations, such as minimizing perimeter wall exposure, and also the availability of natural daylighting to otherwise unlit interior spaces. The covered mall concept at the Charlestown Navy Yard was advanced primarily for economic reasons to minimize the extent of new construction in an existing (though wider) mall type space. In addition, it seemed appropriate to this project architect that some of the character of the existing dramatic 6-story high, 700 ft. long space be maintained.

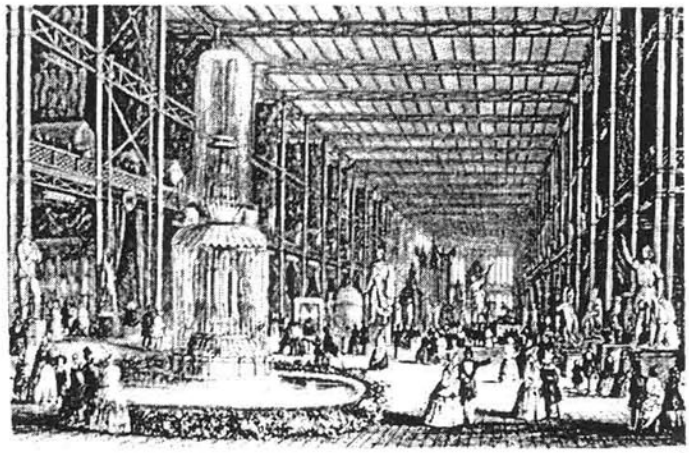

Fig. 8 Crystal Palace, London, by Sir Joseph Paxton, 1851. Example of skylit pedestrian mall used for product exhibition.

IV. Mechanical Selection

One may view the rehabilitation of existing buildings as part of what the French architect and theoretician LeCorbusier and Ozenfant, in their article Purism, published in Paris in 1920, called "mechanical selection". Similar to Darwin's concept of natural selection, or survival of the fittest, mechanical selection is a corresponding phenomenon occurring in the world of man-made objects; a process of purification whereby, through usage and refinement, maximum capacity, maximum strength, maximum economy of materials, maximum economy of effort is imbued into such commonplace objects such as vases, bottles, glasses. Similarly, objects of transport, boats, cars; objects of defense, arms, and objects of pleasure, musical instruments also have obeyed the law of selection: economy. The technological demands of the second half of the 20th century have led to the strictest respect for, and application of, the laws of economy.

The adaptive reuse of Bldg. 42 into Constitution Quarters offers an example of mechanical selection by:

1. adaptive reuse to new market demands - inner city housing,
2. extension of structural life of existing building shell, and,
3. transition from a tax-free government supported building to a privately developed residential complex.

V. Design Approach

The significance of this project to both owner and designer is its reliance on both appropriate technology and existing building features. The change in use, from machine shop to residential, provided a surplus of bearing capacity in the existing caisson footings and gallery spaces. The 700 ft. long, 6-story high craneway was converted into a landscaped pedestrian mall by setting new grade beams on the existing footings and framing intermediate light gauge metal floor mezzanines within the 175-300 lbs. per sq. ft. capacity galleries.

Fig. 9 Building 42 craneway 700 ft. long with side galleries (looking north from 42A to 42S & 42N).

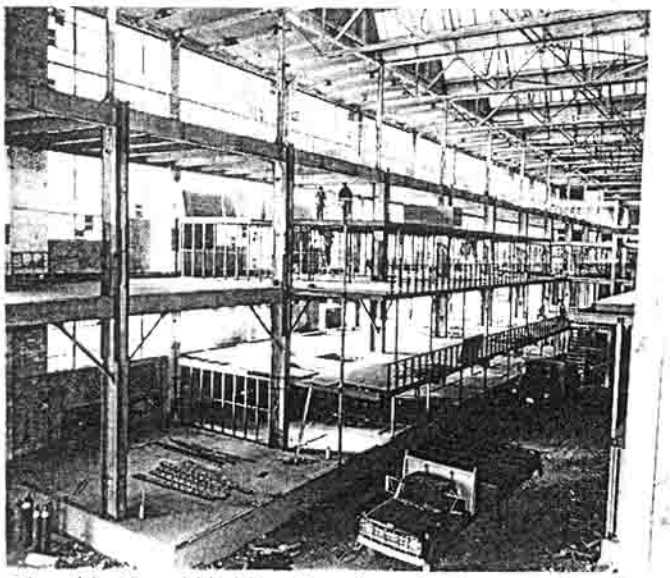

Fig. 10 Constitution Quarters during construction showing cantilevered grade beams and corridor trunks.

In addition to the Galleria, in Milan, another project that came to mind during the design of the interior space is the Solomon Guggenheim Museum, in New York, designed by Frank Lloyd Wright. In a succinct analysis, William Jordy in his book American Buildings and Their Architects, notes that the building, also facing a large park, has a molded space - forcefully conditioned by the path of movement through it, and relies heavily on a series of cantilevered trunks rising off a circular concrete ring wall. The resulting effect is both "space contained by space" and a "continuity of mass and space that rises vertically in bands of space to a central skylight."

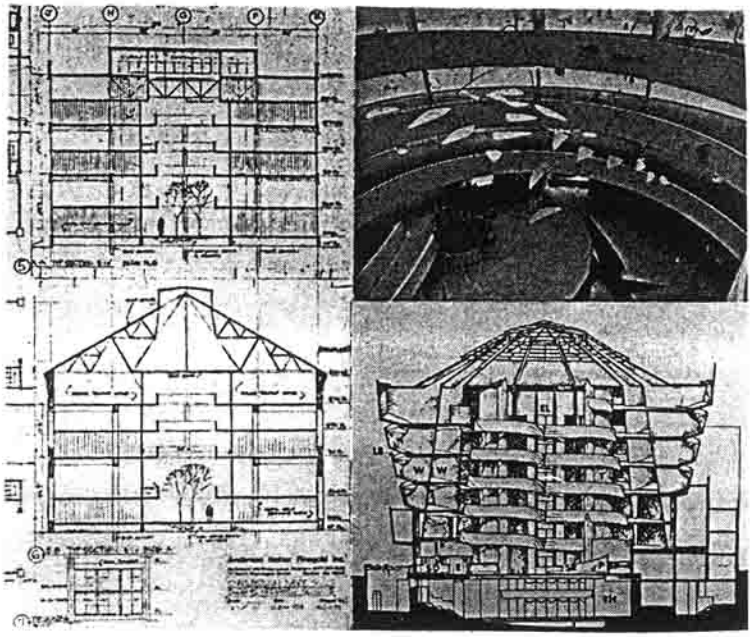

Fig. 11 (Left) Initial concept drawings of Constitution Quarters, Buildings N, S, & A, showing mall space and utilization of existing structure. (Right) Solomon Guggenheim Museum, New York, interior photo and section showing trunks with cantilevered corridors.

At Constitution Quarters, the framing module is that of a simple span platform with cantilevered corridor, the trunks themselves sitting on a cantilevered grade beam, that extend vertically to the angular sawtooth skylights and stretch horizontally toward the south facing marina park and Boston Harbor. This application of similar structural concept and formal balcony expression suggests an unwinding of the circular spiral of the museum building into an almost endless horizontal promenade in Constitution Quarters. Individual ground-floor apartment entrance stairs also cantilever from the concrete gradebeams. Pairs of open glass-walled elevators provide a moving vista within the six-story atrium space.

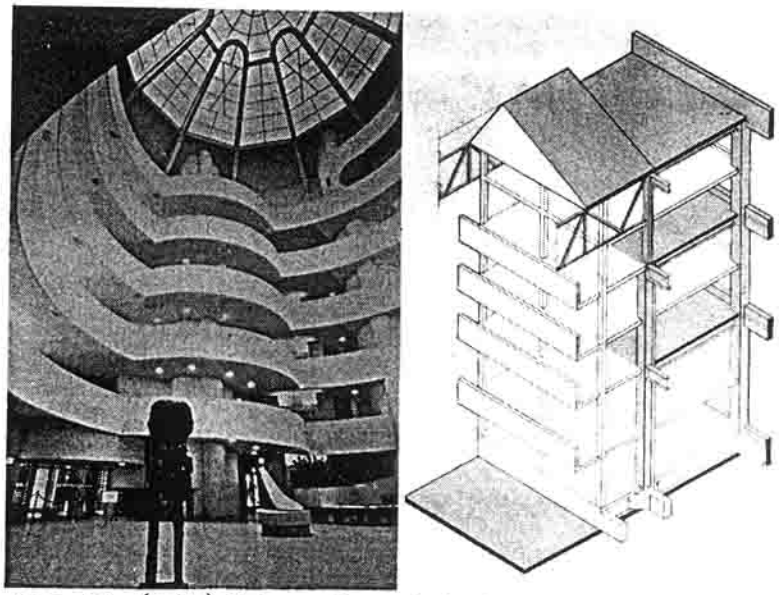

Fig. 12 (Left) Solomon Guggenheim Museum, New York, photo of interior showing layered cantilevered corridors. (Right Isometric of Constitution Quarters typical bay showing original structure shaded and new infill floors rising off cantilevered gradebeams and gallery slabs.

The variously shaped pits which surrounded several of the original milling machines were retained as planter beds in the mall. These and other construction economies using existing features, combined with the Tax Reform Act incentives, enabled the project to proceed within feasibility guidelines.

The major exterior design steps included removing portions of the steel infill structure within the quadrangle, added during World War I, in order to restore the original conceptual site plan as much as possible. A feature requirement of this site plan, developed by Anderson Notter Finegold, Inc. in conjunction with the Boston Redevelopment Authority, was to provide a visual easement from the new adjacent Shipyard Park across the Constitution Quarters' site to what is referred to as the Shipway area.

Fig. 13 Building 42C showing modifications to building, fragments of earlier structures, and easement.

Approximately half of the buildings are of masonry bearing wall construction on the exterior walls, and the existing wood sash at these locations were simply replaced with double-glazed aluminum windows. The 1917 and 1939 additions are steel frame with glass curtain wall infill. The 3 over 3 pattern of existing sash frames was continued in the new design, however, within this pattern, the window frames, HVAC grilles, and solid walls, covered with opaque glass, were painted dark bronze. The original horizontal mullion in what was previously one 16 ft. high gallery window now subdivides two floors. The new horizontal and vertical mullions are painted white to relate to the white painted sash found generally throughout the Navy Yard.

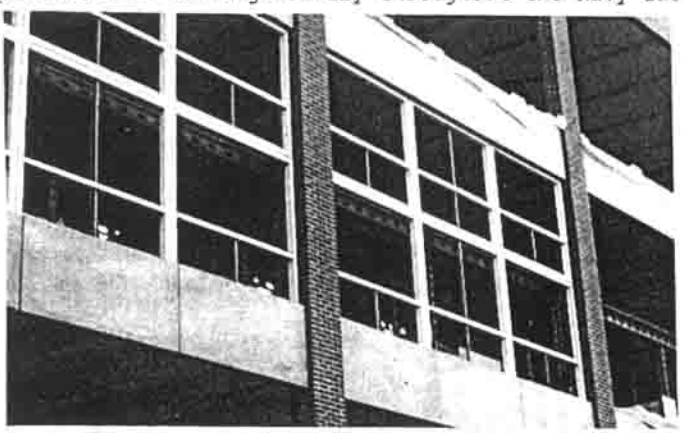

Fig. 14. Building 42S, east wall, showing new facade required after removal of 1917 quadrangle section.

At the mall-level, laminated oak entrance stairs were selected to signify a warmer, more residential use, and also to relate to the original wood patternmaking technology. Many of these patterns have been gathered into sculptural reliefs at the main entrance lobby.

Fig. 15 Constitution Quarters Mall. Photo of ground-floor apartment entrance stairs and planter pits.

VI. Energy Study

During design phase the project was reviewed by the State Energy Office. While the various components, such as insulated roof, walls, and double-glazed windows, were in compliance with state energy requirements, the overall performance of this project was less than ideal, Many existing conditions, such as the single glazed skylight over the mall - retained for economic reasons, allowed the historic preservation factor to mitigate some of the rigorous energy concerns at that time.

The pedestrian mall was designed to be heated to 55 degrees by two large 14,000 cfm gas-fired make-up air handling units at either end of the mall. Distribution ductwork in the mall was minimized, for cost reasons, and the existing single-glazed skylight above the mall lost heat quickly, causing the mall temperature to stratify. Subsequent to the project's completion, an energy study was performed to further reduce operating costs and increase comfort levels at the ground floor mall for pedestrians and indoor foliage. The solution to this problem was to take advantage of the vertical temperature differential, nearly 15 degrees in some areas, by installing a destratification system for the mall. An energy analysis of the space based on degree days, fuel costs, thermal envelope characteristics, and projected installation costs placed the simple payback for this system at less than two years.

This was proposed and implemented by the project architect, now in private practice, in a way that continued the industrial vocabulary of the original design. Vertically mounted cylindrical ducts were added to connect low-wattage destratification fans at the ceiling to mall level. Continuously circulating fans inject warmer ceiling air into the cooler floor level air, warm it slightly, and cause a rising current, or thermal. The vertical temperature differential is thus kept to within 5-8 degrees. In tandem, the fans can destratify approximately 1200-1800 sq. ft. of area, each, with a vertical capacity, if ducted. of up to 150 ft.

Energy conservation measures, in themselves, also define the process of mechanical selection, as the building adapts to changing design criteria.