Tweed Courthouse: New Approach to Life-Safety Management in a Landmark Public Building

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When restoring monumental public buildings for new uses, a performance-based approach to building-code compliance can allow the architectural integrity and historic features of a building to be preserved without compromising life safety.

The History and Architecture of Tweed Courthouse

The Old New York County Courthouse, better known today as Tweed Courthouse, is architecturally one of New York City's greatest civic monuments (Fig. 1). Built between 1861 and 1881, it is the product of two of the city's most prominent nineteenth-century architects, John Kellum and Leopold Eidlitz. The courthouse is also the legacy of Tammany Hall boss William M. Tweed, who controlled the initial construction. While notorious for his corrupt political machine, Tweed did in fact affect positive change in the city by reinstituting home rule, providing jobs for immigrants, and advancing many public construction projects.

Fig. 1. Tweed Courthouse, 52 Chambers Street, New York City, restored exterior. The exterior of the courthouse, constructed of Tuckahoe and Sheffield marbles, was completely restored. More than 1,500 pieces of stone were repaired across the entire building facade. The entire 1,220-foot-long cornice, including 335 modillions, was replaced. The monumental Chambers Street stairway, which was removed in the 1940s for street widening, was rebuilt as the main entrance to the building. Along with the re-establishment of the three double-doorway entrances on the main floor, the restored stairway provides code-complying egress for the new uses of the building. Previously, the building did not have adequate egress and exiting. Photograph by Michael Rogol.

Grandly scaled and richly decorated, Tweed Courthouse is among the most architecturally significant public buildings constructed in the United States during the third quarter of the nineteenth century. First intended to be the "New City Hall," it has actually served as county courthouse, city courthouse, and municipal office building. Through all these changes in use, the building retained its original spatial arrangement, encompassing 30 monumental courtrooms and a five-story central rotunda within its 177,500 square feet of space (Fig. 2). The immense cast-iron structural and decorative elements in the rotunda and courtrooms are unparalleled in any American public building.

Although the courthouse was threatened with demolition as late as the 1970s, its significance has been recognized by governmental agencies at the local, state, and national levels. In 1974 it was listed on the National Register of Historic Places and two years later designated a National Historic Landmark by the U. S. Department of the Interior. In 1984 the New York City Landmarks Preservation Commission honored the building with exterior and interior designations.

Restoration and Rehabilitation: An Overview

The restoration of the building began in 1989, when the city commissioned a feasibility study for the building's preservation and reuse. In 1999 Mayor Rudolph W. Giuliani directed the New York City Economic Development Corporation to proceed with a $90 million comprehensive restoration of the building. Under Mayor Michael

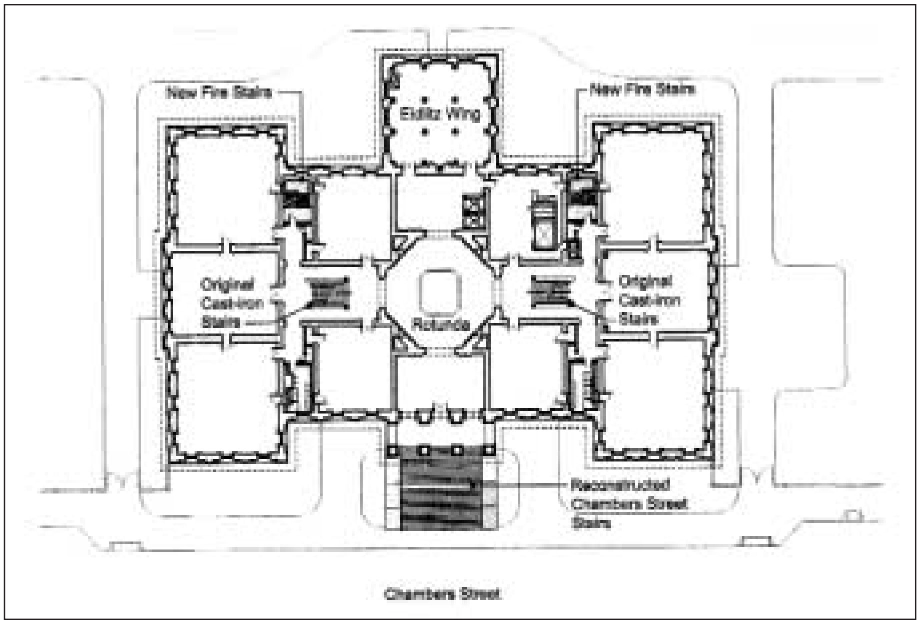

Fig. 2. Second-floor plan. The main floor of the building, at the second story, is reached by the restored Chambers Street staircase. The new code-compliant fire stairs are located within former service rooms. Drawing by John G. Waite Associates, Architects, PLLC.

Bloomberg the building was fitted out in 2002-03 as the headquarters for the City's new Department of Education.

The restoration of Tweed Courthouse was a complex and intricate process. A large team of architects, engineers, construction managers, architectural historians, archeologists, building conservators, and contractors was assembled to carry out the design and construction work. Because the work was so extensive and because there was a period of only two-and-one-half years for design and construction, the architects and construction manager established full-time offices at the site. At any one time portions of the work were under construction; the architects were preparing drawings for other areas of the building; and planning was underway for still more of the work. This integrated approach allowed the project to be completed on schedule and within budget. Ultimately, there were more than a hundred separate contracts and hundreds of construction workers employed on the project.

Prescriptive Analysis of Building-Code Compliance

Tweed Courthouse was constructed long before the City of New York established a comprehensive building code. Nevertheless, those responsible for its construction recognized the hazards of combustible building materials in a dense, rapidly growing urban setting. The courthouse is an early example of entirely fire-resistant construction, which utilized iron in place of traditional timber framing. The structure of the building consists entirely of wrought and cast iron with load-bearing masonry walls. Even the lath used in the plaster walls is made of iron, as are the concealed brackets supporting the plaster cornices. Cast iron was used for virtually all of the decorative elements in the public spaces.

Construction techniques have changed substantially since Tweed Courthouse was built, and building codes have reflected those changes. Building codes establish a minimum level of safety, particularly with respect to fire, that must be provided for a structure and its occupants. Today, the treatment of historic buildings is all too often adversely affected by a rigorous and inflexible interpretation of codes that were developed to regulate the construction of modern buildings, rather than the rehabilitation of existing buildings. In order to protect the historic integrity of a building while making it safe for its users, it is essential that codes be applied in a flexible manner that addresses the intent of the code rather than its prescriptive regulations.

When planning for the restoration and reuse of Tweed Courthouse began in 1989, the starting point was an analysis of its compliance with the current *Building Code of the City of New York*. While some deficiencies, such as the lack of fire-detection systems, emergency lighting, standpipes, sprinklers, and a fire-command station, could easily be addressed during a comprehensive restoration, other inherent code violations were not as easy to resolve. Many existing building features and elements could not be brought into compliance with modern building codes without a complete reconfiguration of the interior, which would have resulted in the loss of the building's historic integrity. For instance, the monumental cast-iron stairways were not enclosed; the central rotunda opened into the main corridors and stairways; the open-cage elevators were not located in enclosed shafts; the elevator lobbies opened into the central rotunda on all floors; and unprotected cast- and rolled-iron floor and roof framing members were exposed in most spaces. The building did not even have adequate code-compliant egress from each floor or exits to the exterior. Although following the prescriptive requirements of the code would, in many ways, have been the easiest course for the architects to follow, it would also have been very damaging to the building and would not have resulted in a safer facility.

As a result of this preliminary analysis, it became apparent that the key to an effective fire-management program for the building, regardless of its eventual use or occupancy, was a strategy focused on the central rotunda. The conventional fire-safety approach would have sectioned off the rotunda from the rest of the building by inserting rated fire separations in the openings that connected the rotunda to adjacent hallways and the monumental open staircases. However, this approach would have seriously altered the historic arrangement of the public spaces and compromised the basic character of the interior and many of the major architectural features.

Fig. 3. Restored rotunda. The key to the fire-management plan was the restoration of the rotunda for use as a smoke reservoir. In the event of fire, smoke and combustion gases are collected in the upper section of the rotunda, above and below the stained-glass laylight. The arched openings at the upper level were filled in with heat-resistant glass panels. Fans at the attic level extract smoke directly to the exterior, making the connecting corridors and staircases safe egress routes. Photograph by Michael Rogol.

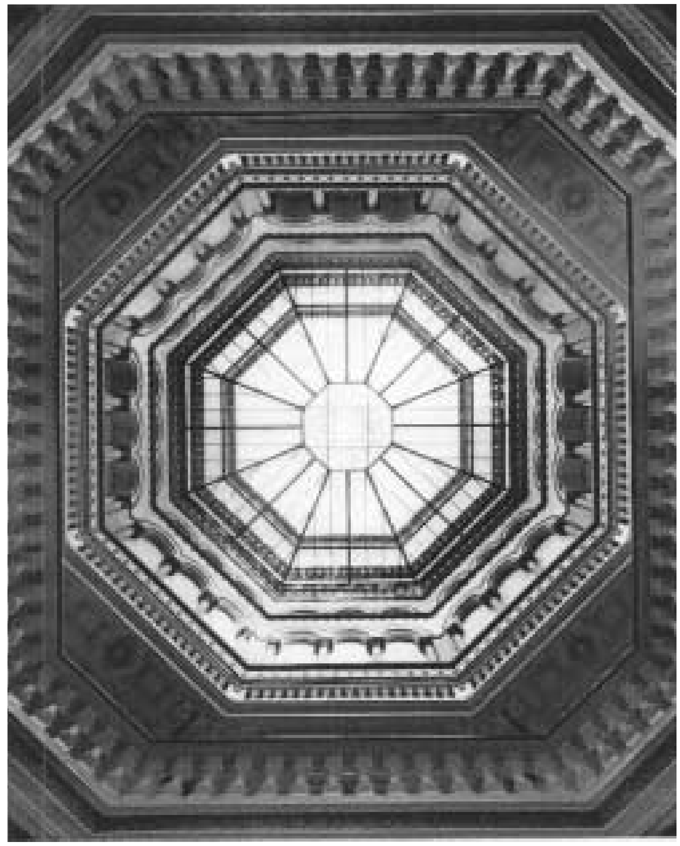

Fig. 4. Restored laylight. The stained- and etched-glass laylight, located beneath the main skylight, was reconstructed in its entirety based on dozens of fragments salvaged when the original laylight was demolished in the 1940s. The laylight forms the ceiling of the rotunda and is thus a critical element in establishing the rotunda as a smoke reservoir. The laylight is fabricated from heat-resistant, laminated glass so that it would not shatter in the event of fire. Photograph by Lily Wang.

An Alternative Approach to Code Compliance and Fire Management

Instead, the approach that was taken during the restoration of the building treated the large central space of the rotunda as an advantage, rather than a disadvantage, in managing the effects of a fire (Fig. 3). The volume of space above and below the decorative laylight in the upper portion of the rotunda, just under the skylight, would act as a smoke reservoir, collecting and exhausting smoke and combustion gases from the space. Central to the success of the rotunda as a smoke reservoir was the installation of four large fans at the attic level, which would extract smoke from the top of the rotunda. These fans are visible only from within the attic and not from any level of the rotunda or from the occupied floors. The fans are ducted to air plenums, and smoke would be ejected through dampered vents surrounding the base of two large skylights located above the monumental staircases. Connected with a new smoke-detection system and with emergency generators located in the basement, the fans are controlled by a computer that activates them automatically when a fire is detected. Manual control of the system by firefighters is possible, once they assess the smoke and building conditions upon arrival at the building. Also, one of the fans is redundant, functioning as a standby in case of equipment failure.

In order to make the upper section of the rotunda an effective collector of smoke, the arched masonry openings on the fourth floor were filled in with heat-resistant glass panels, and the stained-glass laylight was fabricated from heat-resistant, laminated glass (Fig. 4). By extracting smoke and dangerous gases into the upper levels of the rotunda, the connecting corridors and other major spaces were made safer in the event of a fire. These circulation spaces could then serve as additional, effective egress routes.

The basic concept of the fire-management program, centering on the rotunda, was developed early in the project by the architects and engineers and outlined in preliminary meetings with officials at the New York City Department of Buildings. Approval of the overall approach, which was granted by the Department of Buildings in 1990, was necessary because the lobbies of the historic 1911 open-cage passenger elevators, which were scheduled for restoration as the first phase of the larger, comprehensive project, did not meet modern code requirements. Approval of the basic concepts of the fire-management program, in particular the plans for a smoke-extract system for the rotunda and for interconnected spaces such as the elevator lobbies, meant that work on the open-cage elevators could proceed while planning for the other aspects of the restoration and reuse of the building was underway.

Evaluation of a Comprehensive Fire Strategy Using Performance-Based Engineering

In 1999 the fire strategy for the entire building was tested by ARUP, a fire-engineering consultant to the architect, with computer-simulation studies. The simulations of the performance of the existing building analyzed various fire scenarios with different building-user populations, combustion locations, fire intensities, and fuel loads. The development, size, and behavior of smoke plumes was modeled using computational fluid dynamics analysis, and human-behavior studies were incorporated into timed-egress studies, which graphically show the exiting patterns and times required for people to evacuate the building, given each hypothetical situation. The age, mobility, and number of occupants were adjusted in the computer program to provide the most comprehensive analysis possible. Carried out with the active participation of the New York City Department of Buildings and the Fire Department of New York, these timed-egress studies were among the first done for a historic building in New York City. These performance-based engineering studies, which can model, measure, and quantify the performance and effectiveness of alternate solutions to the prescriptive requirements of conventional codes, hold a great deal of promise in restoring and rehabilitating historic structures, so that they are made safe without destroying their distinctive character.

Detection and Notification Systems

The fire-management program included, and integrated into a coherent whole, all aspects of the building relating to fire and life safety. As part of this program, a sophisticated, interconnected smoke-detection and fire-alarm system was installed throughout the building. The installation of some of the detectors for this system required innovative techniques to allow them to be effective yet inconspicuous within the historic spaces. Monitored at the fire-command center within the building and remotely by the fire department, this system provides early detection of heat or smoke conditions related to a fire. In most of the spaces conventional smoke and ionization detectors were installed at the ceilings and energized through conduit buried in the new lightweight concrete topping slab poured above the vaulted floor construction. In the vast rotunda infrared beams are used for early smoke detection. This beam-detection system also minimizes the visual impact of the system in this space. In the large, interconnected spaces of the south wing, designed by Leopold Eidlitz, an air-sampling system was installed to continually monitor air within the rooms to detect products of combustion, as well as smoke (Fig. 5). Flexible plastic tube piping was laid underneath areas of new decorative floor tile and connected to monitoring tanks located in the basement and attic. The intakes for this system are incorporated into the historic gas-lighting fixtures within the spaces. Because of their location and small size, they are virtually unnoticeable.

Fig. 5. Restored courtroom in the south wing. This courtroom, designed by Leopold Eidlitz, has tile floors and polychromed-brick jack-vault ceilings. The bottom flanges of the rolled-iron beams supporting the jack vaults are exposed. The reproduction chandeliers provide the principal illumination for the room, using frosted tungsten halogen lamps. The historic fixtures also serve as emergency lighting throughout most of the building; they are wired to emergency circuits that are activated by the fire- and smoke-detection system. This arrangement alleviates the need for modern emergency-lighting fixtures, which would be visually intrusive in the historic spaces. Because the detector heads for the air-sampling smoke-detection system are incorporated into the lighting fixtures, they are not visible in the room. Photograph by Lily Wang.

Prior to detailed presentations to and conversations with the fire department, a series of acoustical tests was conducted within the rotunda, major corridors, and large rooms. These tests measured the acoustic performance of the various spatial configurations, as well as of the plaster, marble, and cast-iron surfaces and their respective audibility and intelligibility levels. These tests were critical in determining the type, quantity, and placement of horn and strobe-alarm notification devices within the historic interiors. The acoustic demonstrations, especially within the five-story rotunda space (Fig. 6), also supported the fire department's decision to approve a fire-alarm system that notifies all occupants of the courthouse simultaneously, instead of only in zones as the building code stipulates for large, modern, high-rise buildings.

Fire-Protection Systems

Following an analysis of the performance of various structural members when exposed to fire, it was determined that sprinklers were not required in any of the historic courtrooms, corridors, or other public spaces. Sprinklers were installed, however, throughout spaces that are not connected with the rotunda smoke reservoir. They were located in the basement, first and fourth floors, and in confined areas of the attic (Fig. 7). These areas, most of which have low

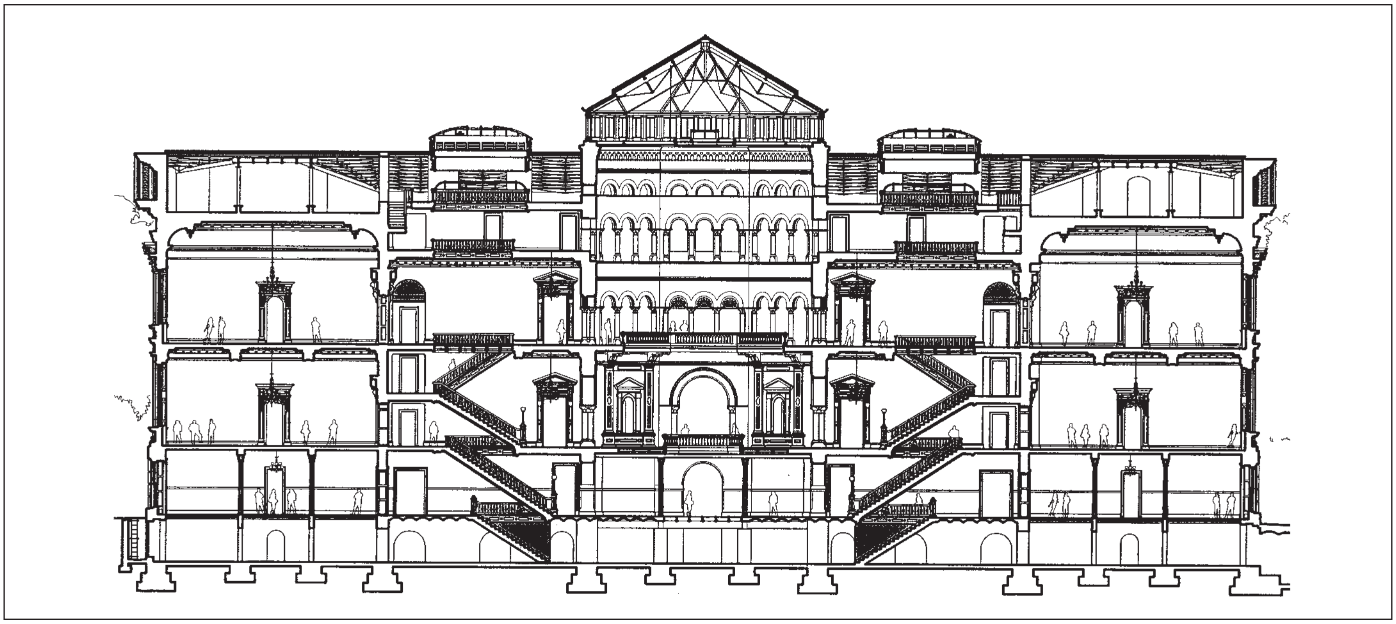

Fig. 6. Cross section looking south. This section shows how the central rotunda is open to the main corridors and monumental staircases. By using the rotunda as a smoke reservoir, the historic, open character of the space was preserved. The four large fans, which extract smoke and gases from the rotunda, are located in the attic and are not visible from the rotunda or connecting public spaces. The fans, one of which is redundant and on standby in case of equipment failure, are controlled by the building-management system and are activated by the new fire-detection and alarm systems. Drawing by John G. Waite Associates, Architects, PLLC.

ceilings, were more likely to contain combustible materials because of their projected occupancies. Standpipe risers were located within the new fire-stair enclosures, as well as in the passenger-elevator lobby off the rotunda. Fire-department siamese connections to supply the standpipes were installed in three locations around the exterior of the building and stand free from the granite base of the marble facade. The fire department considered it a benefit that the building is located within a public park, thus permitting access to the entire perimeter of the building by fire apparatus. Increased access to the building means more options for fire suppression and management and, therefore, a safer building.

The standpipe and sprinkler systems were planned to accommodate future expansion and distribution capabilities within the building, and a fire pump was installed in anticipation of extending the system to provide protection within the wood-framed attic of City Hall, which is less than 100 feet away. In order to provide adequate water pressure for both of these systems, an eighteenth-century water main, which had ruptured long ago and had been abandoned by the city, was repaired and reconnected in front of Tweed Courthouse at Chambers Street. This repair, which required careful monitoring because of the archeological sensitivity of downtown Manhattan, restored the integrity of this segment of the city's underground water-supply grid while providing two independent sources of water for the fire-suppression system within the building. Additionally, a new fire hydrant was installed at the relocated curb edge of the street.

The original unprotected metal framing of the building, which consists of cast-iron columns, the bottom flanges of the rolled-iron floor beams, and rolled-iron trusses, was also analyzed. Rather than encasing the members in conventional concrete or plaster fireproofing, it was decided to protect critical structural members by using intumescent paint, which expands to form a protective layer when subjected to high temperatures. On most of the floors, however, the wrought-iron beam flanges were already effectively protected by the original ceilings, which consist of plaster on corrugated iron lath.

Much study was given to the structural performance of the roof framing members, many of which had been fabricated from both wrought- and cast-iron components. Analytical efforts were focused on the major support elements that would trigger larger structural failures if locally compromised by fire; these columns and trusses were protected with intumescent paint. The new roof assembly incorporated a fire-retardant underlayment installed over metal decking, which further protects critical structural members of the roof system.

Emergency Systems

To provide illumination in the event of emergency, a new emergency-lighting system was installed throughout the building. Instead of visually intrusive battery-pack lights, many of the historic chandeliers and wall sconces were wired to emergency panels. The emergency panels are energized by two diesel generators located in an exterior, below-grade vault connected to the basement; these generators power all the life-safety systems located within the courthouse and all the power requirements within City Hall. A fuel-storage room, located in the basement, adjacent to the generators, is protected with three-hour-rated construction. Even though construction

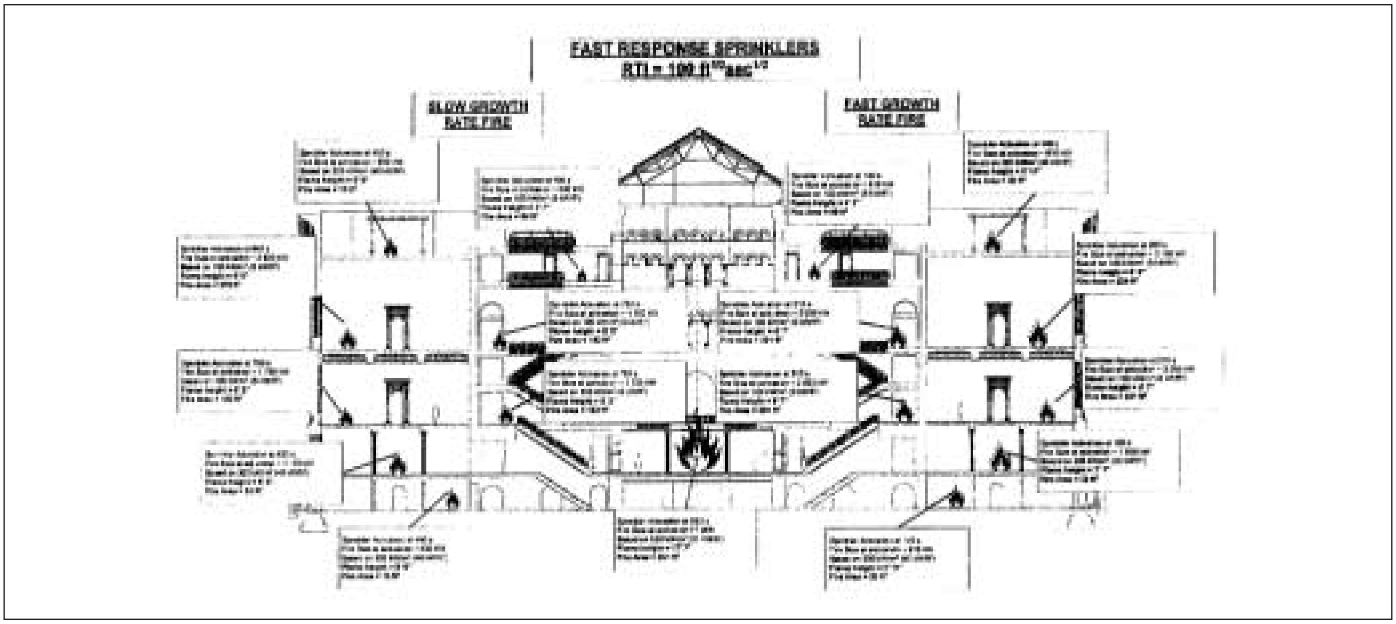

Fig. 7. Sprinkler studies. As part of the computer-simulation studies undertaken by ARUP, the fire-engineering consultant to John G. Waite Associates, Architects, the need for sprinklers was evaluated. Based on these studies, it was determined that only the basement, first and fourth floors, and attic spaces needed to have sprinklers in order to be safe for the building's new uses. These areas are not directly connected with the central rotunda. Drawing by ARUP for John G. Waite Associates, Architects, PLLC.

work at the courthouse was still underway on September 11, 2001, the two emergency generators were already in service. Because of these generators, Tweed Courthouse and City Hall were among the few buildings below Canal Street that had electrical power and therefore could be used by emergency workers and government officials in the aftermath of the attack.

Tweed Courthouse was used by the fire department as an emergency facility for firefighters working at the World Trade Center site. It is worth noting that on September 11, Tweed Courthouse was protected not only by modern, state-of-the art fire detection and protection systems but also with mid-nineteenth-century fire-protection measures. Just before vacating the building on the morning of September 11, the architects and contractors closed the original iron window shutters, which had just been restored to operable condition, to protect the interior from damage, should the exterior windows break. The windows did not break but the stone facades suffered smoke damage which required exterior cleaning again.

Timed-Egress Simulations and Exiting Capacities

Another critical component of the fire-safety strategy was providing sufficient fire exits from the building to the exterior. Because a smoke-management system was to be installed, the two original, freestanding cast-iron stairways, located adjacent to the rotunda, did not require fire-rated enclosures. Instead, they were restored and left open to the corridors and rotunda (Fig. 8). Two new steel-and-concrete fire stairs were constructed, one at each end of the building, in spaces previously occupied by service rooms. Fully enclosed, these 5-foot-wide stairs exceed the code-mandated width of 3 feet 8 inches; they serve all floors including the attic and basement and exit directly to the exterior. The new stairways are suspended from the roof framing by steel rods and do not touch the 2-foot-thick masonry bearing walls, thus preserving the original plaster wall finishes and cast-iron architectural trim of the service rooms. In the future the rooms could be restored to their original conditions if the stairs were removed and new floors were inserted.

The keys to providing additional exiting for the restored building were the rebuilding of the original monumental staircase at the Chambers Street entrance and the restoration of the three original double doorways at the main-floor level. In the 1940s, as a result of increased vehicular traffic and the reduced use of the courthouse, the exterior masonry staircase at the Chamber Street entrance was truncated, and the remaining portion of the staircase was covered over with concrete slab construction. In 2000 the city approved plans to narrow Chambers Street, remove a lane of traffic, and reorganize the flow of traffic. This scheme allowed the courthouse's primary entrance to be reconstructed.

The rebuilding of this monumental staircase, the restoration of the front entrance lobby space within the building, and the restoration of the three original double doorways at the main floor level provided additional exiting for the building that exceeded the code requirements. The restored exterior staircase was essential in providing the required egress for the building and also critical in reestablishing the original character of the building.

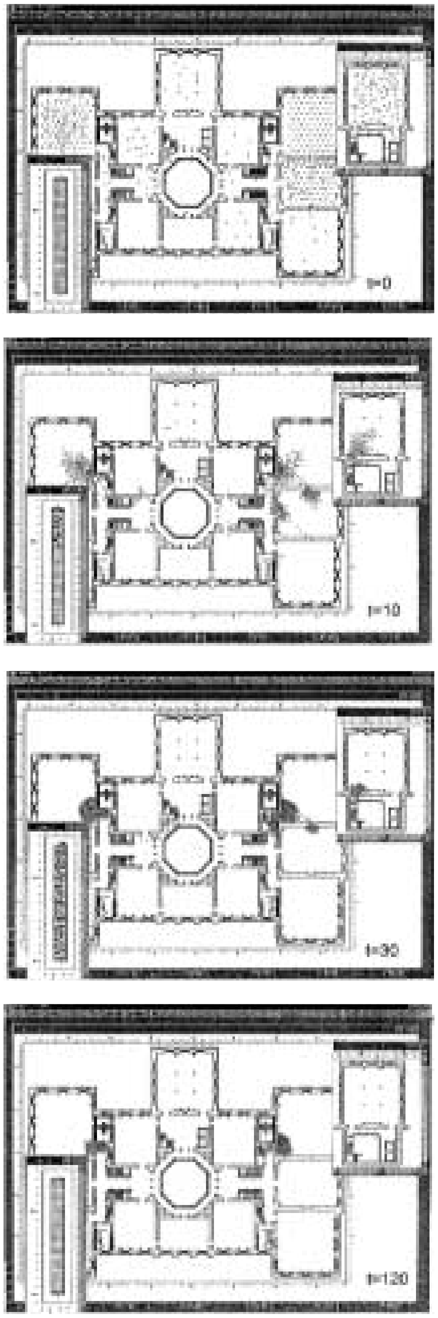

Fig. 8. Fire-simulation studies. Computer-simulation studies analyzed different scenarios with varying building-user populations, combustion locations, fire intensities, and fuel loads. The studies graphically depicted the development, size, and behavior of smoke plumes and heat, as well as the exiting patterns and time required for people of different ages and levels of mobility to vacate the building. These plans show how people dispersed throughout the building proceed to exits within 10, 30, and 120 seconds. The plans also show the performance of one of the new fire stairs as part of the exiting process. These studies helped to confirm the concept of using the rotunda as a smoke reservoir. Drawing by ARUP for John G. Waite Associates, Architects, PLLC.

Compartmentation and Smoke-Development Studies

Most building materials within Tweed Courthouse — stone, brick, and cast iron — have an intrinsic fire resistance that greatly aids the containment of smoke or fire within a given space. As part of the fire-safety strategy, especially with regard to the smoke-management system, the historic courtrooms needed to be separated with fire-rated construction from the circulation spaces and central rotunda. This compartmentalization was inherent in the bearing-wall construction but could be compromised by the heavy wood and decorative etched-glass entrance doors to each room. Computer-modeling simulations demonstrating smoke and heat development examined the behavior of various fire scenarios within in a typical room. The results indicated that in an intense fire situation, the heat produced would most likely cause the glass of the large exterior windows to break, allowing the buildup of smoke to vent first to the exterior, rather than throughout the interior of the building. To add an extra level of safety, the wood doors were restored; magnetic hold-open door catches connected to the fire alarm system were installed; and the original etched-glass panels were removed at the request of the Department of Buildings and replaced with a technically advanced ceramic. The original etched-glass panels were used by the door restoration contractor to duplicate the appearance and exact pattern onto each individual replacement piece of glazing. This ¼-inch-thick material, which can withstand temperatures of 1200° F, is laminated, providing an extra measure of safety. This material was developed for use in the space exploration program and has only recently been made available for architectural installations. In the event of a fire in one of these spaces, the door assemblies would have a performance fire rating equivalent to one hour, as required by prescriptive codes.

Conclusion

The custom fire management program for the Tweed Courthouse demonstrates that a historic building can be made safe without compromising its historic integrity if the fire risks, and resulting building performance, are carefully analyzed and if a comprehensive strategy is developed to address those risks as part of the restoration program. This approach requires the utilization of state-of-the art technologies and procedures, creative architectural and engineering solutions that are individually tailored to the specific building or condition, and the participation and cooperation of building-code and fire-service officials throughout the process.

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