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Consulting-Specifying Engineer

Original Intent

By Geoff Weisenberger, Associate Editor -- 10/1/2006

Let's face it, we live in a throwaway culture, and buildings are no exception. Too often, historically and architecturally significant edifices are bulldozed to make way for brand new buildings with modern bells and whistles. And for many owners and developers, "historic building" means "leaky plumbing," "too drafty" or "structurally unsound." And in some cases, they're right.

But some buildings are simply too precious not to keep around, and when it comes time to renovate, building teams are challenged not only with maintaining historical significance, but also with addressing the issues of occupant comfort, energy efficiency, modern communications and increased electrical needs. This is indeed a difficult balance to achieve, but one that has been attained time and time again.

Digging in

In the case of Trinity Church in Boston, there were several reasons for renovating. Situated at Copley Square in the heart of the city's Back Bay area, the church's interior artwork, stained glass windows and stone façade were in need of restoration after inspiring parishioners for more than 125 years in bustling environs. The church also wanted to renovate its adjacent Parish House and expand its "unfinished" basement, an area known as the Undercroft. This previous storage area would be converted into 15,000 sq. ft. of usable assembly space for the church's growing congregation. The project would involve excavating approximately 5 ft. of earth to expand the floor-to-ceiling span to an acceptable height.

From a mechanical perspective, the most significant challenge was determining how to supply heating and cooling and where to place the necessary equipment. The main sanctuary uses radiators for heating and is not air-conditioned, and the mechanical systems for this space were not modified to include air conditioning, due to the precious artwork that Trinity Church houses. As such, the new heating and cooling equipment would service the Undercroft and Parish House only.

Due to the constricted nature of the site, on a parcel bound by busy streets, there was no room to place mechanical equipment adjacent to the structure. And because the structure is a National Historic Landmark, and for obvious aesthetic reasons, placing a cooling tower on the roof wasn't an option either. Furthermore, locating mechanical equipment in the attic would increase the likelihood of leaks that might potentially damage the artwork in the sanctuary. Another method would have to be found.

The Cambridge office of Cosentini Assocs., Inc., the engineering firm for the project, came up with one. They had previous experience designing geothermal heating and

cooling systems. While this technology is still not in wide use, the designers were able to convince Trinity Church that it was the right solution for this project. “They realized that we had previous success with the technology, recognized it as a viable system, saw that this approach made the most sense for this project, and they became comfortable with it,” says project manager Michael Williamson, P.E., LEED AP, senior HVAC engineer, Cosentini.

“It became the obvious option, as Michael says, but there was careful analysis of its impact, both in the short and long term,” says Stefan Knust, the project's architect, from Goody Clancy. “Cost analyses were performed, evaluating first costs and operating costs, as well as reviewing other potential heating and cooling schemes.”

The system involved digging six 1,500-ft.-deep wells around the building and placing 13 water-to-water heat pumps into an underground vault connected to the church. Heating and cooling is distributed to fan coils throughout the Undercroft and Parish House. According to Williamson, the heat pumps are roughly the size of filing cabinets, and he notes that smaller, more modular equipment is a trend to watch for with renovation projects. “For renovations, this system makes sense in terms of getting the equipment in and out easily as opposed to putting a huge chiller down there,” he says.

Knust cites coordination of the digging of the thermal wells as a significant architectural challenge for this portion of the project. “As an architect, the only drawing I issued was a plan with six holes in the ground dimensioned off the building; that's what we expected to see at the end: little manhole covers that are 18 in. across, so it's nothing at the end of the day,” he says. “But the effort it took—the mobilization and the logistics involved, getting the neighbors involved with this because of the noise involved and all of the other events that happen in the public square to deal with—it was a big effort on the contractor's part to make all of this happen.”

As Copley Square is a major public gathering space, the drilling of the wells was performed in winter in an effort not to disturb the area during its “high season.”

Being able to perform work on the fly was crucial, according to Knust. “The biggest challenge was to integrate all of these systems to add this floor below the building—15,000 sq. ft. for assembly,” he says, noting that because of the stone structure, the architects and engineers spent many hours working with the contractors in the field to determine the best locations to penetrate the stone with ductwork and piping. As such, a great deal of coordination work had to be done up front to determine how deep the Undercroft floor needed to be.

Complicating matters was the fact that nothing was straight or level, and some critical decisions had to be made on how much to excavate, all of which, Knust says, had to do with mechanical systems integration.

“When you are creating a new space for the basement for a large gathering space, bringing in fresh air posed a significant obstacle,” says Williamson. “Fortunately, the

architect had a good understanding of what was required in terms of space for ductwork and all that needed to be accomplished in the way of M/E/P systems, and that helped tremendously.”

The Undercroft opened in January 2005 and the Parish House opened in January 2006. The sanctuary was kept open for the duration of the project.

Rising from the ashes

Trinity Church's motivations for renovating its historic structure were fairly practical, but when it came to Eastern Illinois University's historic Blair Hall in Charleston, Ill., it was all about rebuilding, as the 34,000-sq.-ft., three-story structure had suffered a devastating fire in 2004 that essentially destroyed everything except for the stone exterior and some wooden flooring. Of course, there were no sprinklers at the time of the fire.

As such, this unanticipated \$6 million retrofit called for a fast-track schedule and also allowed for some improvements that would have been needed regardless of the fire. “This was one of the original buildings on campus, and it needed to be updated as it was, and it just happened to be that the fire forced those updates to occur very quickly,” says Steve Rhoades, P.E., LEED AP, associate with the St. Louis office of KJWW Engineering Consultants, the project's engineer. Unfortunate as it was, the fire enabled the project to become integrated into a new campus-wide electrical distribution upgrade, a separate, ongoing project, and also make provisions for a future extension of the campus chilled-water system into the building. And, the project offered the chance to improve energy efficiency and occupant comfort and usability.

As with the Trinity Church project, a major question was where to locate mechanical equipment so as not to alter the historic nature of the building, and a similar solution arose. The building, which runs north-south, had included an extension that jutted out to the west. The university made the decision to demolish this section completely and rebuild it, deepening the basement in the process to create room for mechanical equipment. As a result, the building team called for the floor to be lowered more than 11 ft. so that the bottom of the utility space, which used to be above the existing steam tunnel, is now more than 3 ft. below the bottom of this tunnel. The expanded basement now includes utility space for new electrical service and houses the AHU as well as the steam, water and fire protection systems. Until the building is connected to the chilled-water system—financial reasons have kept this from occurring to date—the building is currently using the campus steam distribution system for heating. Chilled water is provided by an air-cooled chiller with a buffer tank to provide adequate system volume.

In the end, KJWW and the rest of the building team were able to restore Blair Hall to its original condition while also providing much-needed upgrades. “Maintaining the architectural and historical flavor really drove some space constraints that we had on the M/E/P systems side that led to extensive coordination throughout the design process for routing of utilities and shafts,” Rhoades says. “Doing a good job on the

engineering meant nobody knew it [building systems] was there.” The building reopened this past spring.

Taking it to the top

While the Blair Hall and Trinity Church projects involved “digging deep” to accommodate mechanical systems, the design team for a recent renovation to Rockefeller Center in New York went the opposite direction. The Top of the Rock project, which reopened the outdoor public observation deck at the top of the building (also known as the GE Building and “the Rock”)—closed since 1986—involved three levels at the base of the building and three at the top, including the outdoor deck. As part of the project, the existing mechanical space near the top of the building actually had to be moved up one floor.

Much of the mechanical equipment that serviced the top of the building was located on the 67th floor, some of it in a very inconvenient spot. In order to provide public access to the observation deck, the elevators needed to be extended from the 66th to the 67th floor, but the main elevator machine room that serviced the bank of 12 high-rise elevators was located in the spot on the 67th floor where the shafts would need to be extended, meaning the machine room would have to be relocated. But there was a rather large problem with this strategy, which came in the form of a 13,000-gal. water storage tank that was located directly above the machine room. This tank couldn't be completely removed because it serviced the fire protection/sprinkler and domestic water systems at the top of the building.

The solution was to install a temporary wooden tank on the roof deck outside. It was initially only supposed to reside there for a few months, but ended up staying in this location for more than a year. As a result, heat tracing had to be added to the piping during the colder months. But relocating the water supply opened up new mechanical space for the elevators in the tank's original spot, which in turn, allowed the elevators to be raised a floor—one at a time, so as to create minimal disruption to the building's tenants.

Besides juggling elevator equipment and vast amounts of sprinkler water, much of the mechanical equipment servicing the renovated area had to be upgraded or expanded as well. “Some of the power risers had been overtapped throughout 70 years of changing tenants, and there just was not enough water at the top of the building for this project,” says Bradley Williams, P.E., principal, Edwards & Zuck, engineer for the project. The design team extended the power riser to a new substation and put in a new chilled-water riser from the central plant to provide the appropriate AC capacity. The power riser was dedicated to the observation deck and its support spaces for current requirements, and also any other special events that might occur. The new elevators, HVAC equipment and observation deck systems required a minimum of 3,000 amps at 460 volts; the design team tapped into a 4,160-volt vault at the concourse level, and a new 4,160-480-volt, 2,500-kVa substation was installed at the observation deck level.

In fact, Williams said, the loads kept increasing during the design process as

sponsors for different areas came on board. For example, the Target Room (named for and sponsored by the retail chain) is an interior breezeway on the 69th floor that features thousands of LEDs behind frosted glass in the walls and ceiling. When a visitor enters the room, motion sensors find, track and assign him a color, which follows him wherever he walks throughout the space. “That required additional power that, up until two years into the project, wasn't even planned on,” says Williams.

In addition, in order to meet new code requirements, a generator had to be installed. It was located on the roof of an adjacent building and provides backup power to the observation deck loads as well as other life safety loads in the GE Building. Life safety systems were also upgraded, including emergency lighting and strobe and speaker systems. ADA requirements also needed to be met. Installing ADA-compliant restrooms in an already tight space proved challenging, but the design team found a way to kill two birds with one stone. The famous Rainbow Room restaurant, on the 64th and 65th floors, was being served by older, oversized AC equipment. In its place the designers specified smaller units and were able to use the extra space for the restrooms.

Transporting all of this equipment and material to the top of Rockefeller Center was no easy feat. No hoists were allowed, per the owner's instruction, and cranes weren't an option either—the Rock stands at 850 ft. So, everything, including steel and the components for two escalators, was transported to the top inside elevator cars or under-slung. And this work needed to be accomplished in a designated time frame so as not to disturb tenants. “Thirty-thousand people in the building all expected it to work from 6 a.m. to midnight every day,” says Williams.

Meanwhile, at the ground-level portion of the project, Edwards & Zuck was able to take advantage of the building's grading to incorporate a solution that has become common in new construction, but not in structures built in the 1930s, like Rockefeller Center: underfloor distribution. Williams explains that the ground is sloped from Fifth Ave. to Sixth Ave. so that it drops several feet as you walk from one end of the building to the other, and Edwards & Zuck used that space to install power, AV and ducted air distribution in the exhibition and queuing areas on the mezzanine level (one of three levels at the bottom of the building that were included in the project). This solution was especially beneficial, as the owner wanted the ceiling of the exhibit space to be free of exposed ductwork.

Old, yet new

Aesthetic restoration, expansion, re-opening an unused portion of a building and even rebuilding from a fire have certainly spurred some innovative system renovation projects. Whatever the reason for upgrading, the flexibility to make design changes on the fly, making systems fit the building and the ability to bring buildings that were around before electricity into the 21st century—all while committing minimal disturbance to the occupants and often irreplaceable elements—are all key components for engineers hoping to tackle historical renovations.

Seeing Things in a New Light

Two years ago, a fire all but completely destroyed Blair Hall, one of the oldest and most beloved buildings on the Eastern Illinois University campus. Luckily, the university decided to preserve what was left of the building, and reconstruction was completed earlier this year.

While certainly an unfortunate event, the fire did allow for system upgrades, including lighting. According to Steve Rhoades, P.E., LEED AP, associate with the St. Louis office of KJWW Engineering Consultants, at about the same time the fire occurred and project design started, the state of Illinois changed its requirements to have all construction follow the International Energy Conservation Code. The code limits total watts per sq. ft. for lighting. And, there were several 10-ft. ceilings with tall exterior windows, allowing for an abundance of daylight in some areas. Meeting the code limitations and maintaining the historical appearance required extensive lighting calculations throughout the building to determine where more lighting was needed and where not quite as much was required, in order to provide the right amount artificial lighting. Rhoades also notes that KJWW employed a combination of newer T5 and T5HO fixtures for Blair Hall, one of the first projects for which they've specified these lamp types. The design team was able to achieve an average of 1.2 watts per sq. ft. for lighting usage in a building with predominantly 9- and 10-ft ceilings.

“The lighting system really is the highest-technology item associated with the project, other than putting 21st-century technology into an early-1900s building,” says Rhoades.

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