Special structural solutions for adaptive use in grand hotel in Norwich, CT USA

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ABSTRACT: The Wauregan Hotel (c. 1855) in Norwich, CT, USA was restored in 2005–6 and adaptively reused for new affordable housing and retail. The structure was unique with sloping timber joists to accommodate early indoor baths with full mortar setting beds. Floors were leveled and strengthened by inserting engineered wood members (Laminated Veneer Lumber). The exterior walls contained narrow fireboxes and stove flues where central boilers could not go at that time. These flues needed to be grouted solid as they represented weakened areas in these bearing and shear walls. Special construction shoring was designed to allow environmental abatement while providing safe working floors for the selective demolition and abatement crews. Modern Codes (IBC 2003) required a full seismic upgrade and an interactive structural analysis was performed using 1850’s brick bearing walls in conjunction with interspersed reinforced concrete block walls. Special diaphragm to shear wall ties were devised and over 1500 installed.

1 INTRODUCTION

The Wauregan Hotel was constructed in downtown Norwich, Connecticut, from 1853 to 1855. Local businessmen, manufacturers, and railroad and steamboat interests formed a corporation for the purpose of creating a first-class hotel, designed to accommodate travelers between New York and Boston, and those visiting Norwich on business or pleasure. The upper two floors of the five story building were rented to permanent, year round residents.

The president of the corporation was William Buckingham, later Republican governor of Connecticut during the U.S. Civil War. Local architect Evan Burdick designed the building in the Italianate style. The hotel contained rooms for public meetings. Planning meetings for commemorative events, such as the 200th anniversary of the founding of Norwich, political meeting, and public receptions were held at the hotel. The most famous guest was Abraham Lincoln, on March 9, 1860. Lincoln spoke at the Norwich city hall that evening, and later held forth in the hotel parlor. Other distinguished visitors included President Ulysses S. Grant and Booker T. Washington, in whose honor receptions were given. Gypsy Rose Lee stayed at the Wauregan while giving performances at the summer stock theater in town.

The Clarendon Annex, with a second floor dining room/ballroom, was added as a north, integral wing, in 1906. The hotel lobby, entrance, and storefronts were remodeled about the same time. About 1950, the ornate Victorian window trim was removed to “modernize” the building during the post WWII modern image era in the USA. Construction of the interstate highway system, and motels and hotels by the highway exits, was a factor in the decline of the Wauregan as a hotel in the second half of the 20th century. By the 1980’s, the building was deteriorating. A fire in 1989 destroyed the boiler room, in a rear addition, and the Wauregan was condemned. In 1999, the City of Norwich announced its intention to demolish the hotel. The Connecticut Historical Commission, in a decision on December 1, 2001, voted to oppose the demolition, as the Wauregan was a contributing structure to the Downtown Norwich National Register Historic District. The entire complex became a major restoration and development project by Becker & Becker Associates and has transformed the building into 70 apartment units with retail space on the first floor (Plummer, D. 2007).

Significant structural challenges had to be met due to the devastating water and environmental damage sustained during the vacancy period. Modern Code requirements came into play adding complexity to the safe structural design required for these upgrades. This paper will highlight some of these unique challenges; their solution allowing this historic structure to be saved and progressively transformed to a downtown focal piece and impetus for future urban development in Norwich.
2 GENERAL DESIGN REQUIREMENTS

Generally, the building was going from a commercial hotel use to a new multi-family residential use. This change in consort with the major level of renovation triggered the requirement for a structural upgrade to current code standards. Structurally, this meant complying with Chapter 16 “Structural Design” of the 2003 International Building Code (IBC). Both gravity floor and roof loads needed to meet the current code requirements as well as an analysis and upgrade for lateral loads caused by either wind or earthquake.

The building’s structural systems were comprised of sawn timber joists of local pine species for both the low sloping roofs and interior floors. These were bearing on the exterior, multi-wyeth brick walls and interior stud corridor or room demising wall partitions. Original wood lath and lime plaster was the predominant wall finish material even on the exterior walls which were wood furred and then plastered.

Gravity live loads for hotel use and modern apartment use were almost equivalent, and most of the existing floor joists which were not water damaged were found to be capable of sustaining the necessary superimposed loads required for structural upgrade. Where members had minimal damage, new “sister” timbers could be added and fastened to the existing timber to provide the necessary reinforcing. In the case of major damage of floor timbers and joists, new members were inserted to replace these excessively damaged ones. Stronger, modern laminated veneer lumber (LVL) members or engineered I joists were chosen as their depth could replicate the original timbers and provide added strength and serviceability.

The building’s lateral loads were originally taken by the mass brick exterior walls as a “box system” with some interior masonry walls being used to act as bearing and shearwalls. These augmented the exterior walls and added strength due to the building’s ell shape. The design basic wind speed of 120 mph for Norwich produced the greater building design lateral loading as opposed to the seismic lateral requirement. Connecticut is in a moderate seismic zone, with the State’s ground accelerations per Code analysis producing less forces in the building’s lateral resisting structural elements. Two factors contributed to this result. First, the building’s height (5 stories for the Wauregan and 6 stories for the Clarendon Annex) presented a substantial area for wind loads, and second, the light weight wood floor did not contribute substantial mass in the earthquake’s lateral load formulas. The wind’s total base shear was thus in excess of that produced by seismic analysis. It is worth noting here that due to the re-use of the building’s numerous original unreinforced masonry brick walls (URM’s), the most conservative seismic design factors were used in the analysis. The seismic response modification coefficient, R, for URM walls is 1.5 as opposed to a higher value of $R = 5.5$ for special reinforced masonry shear walls which we used in numerous locations as replacement walls. As can be seen in the base seismic shear ($V$) equation.

$$V = 1.25 D_S W/R,$$

where $D_S$ is the wind load, $W$ is the floor mass, and $R$ is the seismic response modification coefficient. A smaller $R$ value produces a larger, more conservative seismic design base shear. Even so, the high wind loads offset by the lower floor mass ($W$) produced a higher wind base shear for design purposes.

3 STRUCTURAL CHALLENGES

Due to water damage and severe winter climate of New England, the building’s unoccupied years and lack of any maintenance caused areas of major deterioration. In particular, one area was in extremely bad condition and collapse in 2004 was imminent. The Wauregan’s rear, reentrant corner five store rear walls were in danger of collapsing. The roof’s valley terminated at the corner and water cascaded down these corner walls causing excessive damage. In order to save the floor framing in these walls, special two-way heavy timber shoring was designed and erected in a tiered fashion. This was completed in September of 2004 and over the upcoming winter the walls did collapse, exposing the building’s interior to the weather. The floors were saved, however, due to the prior shoring being timely installed (See Fig. 1).

This shoring remained in place until the floor could be adequately reinforced and the new exterior wall...
reconstructed. Where possible, new reinforced concrete or hollow, grouted reinforced concrete masonry units (CMU) were installed for the necessary shear-wall strengthening at the building’s lower levels (See Fig. 2). The rear of the building was being covered with an Exterior Insulated and Finish System (EIFS) and stuccoed a brick color to match the existing finished brick. This was a cost savings effort applied to a building’s rarely viewed exterior walls.

Again, excessive water had damaged much of the building’s original wood deck floor including supporting joists. As this original timber deck would not provide the necessary floor diaphragm to resist loads due to wind forces, it required replacement or reinforcing. A new, lightweight flowable gypsum floor fill was specified to be used in floor areas where the old sags or deflection exceeded a value of 1 in. (2.5 cm). In order to achieve the required diaphragm design values and provide a sufficient substrate to receive the gypsum floor fill, a new layer of 3/4 in. (1.9 cm) plywood was applied over the original decking. Where the original decking was rotted and removed, new in-kind decking was placed prior to the new plywood installation (See Fig. 3).

As necessitated per Code, prescriptive for seismic requirements, all floor diaphragms must be attached to transfer their in plane loads to the building’s shear-walls. Generally, 1850’s construction was very weak on this requirement and no original connections were found. With all new plywood, this diaphragm was then attached to the brick or CMU shear walls with clip angles, screws and epoxy inserts to the masonry. Some 1500 such clips were required to provide this vital positive attachment (See Fig. 4).

The project developer chose not to have the plaster finishes removed prior to bidding the project due to initial lack of project funding at that point. This left the finish removal as part of the General Contractor’s job during construction, Phase I – Selective Demolition. This of course uncovered numerous structural issues including faults in the major shearwalls due to old fireplaces and, more notably, old unlined flues. These flues were voids in the building shearwalls that were unanticipated during the earlier design phase. These voids had to be grouted from above, but the old soot/tar inhibited the bond of grout to brick. To bond these two together to act as a single shear-wall unit, new 9 mm Helifix stainless steel self drilling rod anchors were inserted through the brick and void to provide a “shear-lug” anchor system. These were
drilled at a 22.5° angle to insure solid brick would be penetrated as opposed to being in a more weakened lime mortar joint. Over 2000 of these re-anchors were employed successfully and economically to solve this complex problem (See Fig. 5).

An unusual find during plaster removal were the long span joists of the second floor ballroom in the c. 1906 Clarendon ballroom. These timber joists were 2 in (5 cm) × 14 in (36 cm) spaced at 18 in. (46 cm) on center. They were spanning approximately 22 ft. (6.70 m) to a central steel carrying beam. The original builders or designers knew the heavy live load of the ballroom floor. The current code calls for 100 psf (490 kg/m²) for this assembly use. As the original plain wood joists could not safely carry this loading the original design incorporated two 7/8 in. (2.22 cm) diameter steel rods in an end-trussed condition as added strengthening pieces. These “queen posts” rods would come into play when live load was added above, go into tension and then deliver this force to the joist ends at the bend-up points near the ends of each joist (See Fig. 6).

This trussed rod apparatus was generally confined to large, long span industrial timber girders. It was quite unusual to find these in a repetitive floor joist application.

4 LATERAL LOAD CHALLENGE

The Wauregan Hotel and Clarendon Annex each had grade level glass store fronts supported on original, ornate wrought iron columns. Between the columns were low rise brick arches used to span this unsupported distance and carry the multi-story brick bearing wall above. Again, no consideration to lateral stability was apparent in both the 1855 Wauregan and 1906 Clarendon building structures. This façade construction was present along the entire east and south elevations facing Main and Broad streets. The architect wished to keep this façade and show the original wrought iron decorative columns as well.

These columns at the lowest level below the long brick shearwall/bearing walls above represented a lateral seismic “soft-story”. The soft-story concept in lateral load design is one in which the more rigid, upper shearwalls attempt to deliver their shear loads to the column tops which are unbraced and only fixed at the top and bottom to the building’s structure. This large lateral load deforms these columns into an “S” shape whereupon these columns go into an incipient buckling mode and fail. In order to prevent this failure mode and still allow the architectural store front mode, a new deep beam-wide column moment frame was introduced just behind the cast iron store front. New steel columns were placed to the rear sides of the cast iron columns and new steel headers were erected between them to support the overloaded low
Figure 8. Restored façade of the Wauregan Hotel. (Camardella, P.2006)

rise arches. Poured concrete was added between the low rise arch void and the steel beams to ensure complete vertical load transfer (See Fig. 7). Note each of the described elements in Figure 7 including the new concrete girder behind the top of the store front windows.

5 CONCLUSIONS

The Wauregan Hotel restoration and adaptive use project is successful proof that innovative structural engineering solutions can be employed to save buildings that might otherwise be considered hopeless and ready for demolition. With a thorough inspection and understanding of each of the structure’s important components, solutions can be obtained to save and even improve the functional capabilities. In the case of the Wauregan project, this was especially acute as numerous problems arose during the construction phase which had to be dealt with in a timely fashion to keep the project on schedule. On site presence during this phase was practically on a daily basis by the structural engineer, and complete cooperation of both the architect and contractor(s) was tantamount to each successful solution.

In the final analysis each of the challenging and often unique solutions when put together went into making the Wauregan adaptive use project a great success. Today it stands as a “poster child” for the preservation community stating that patience and teamwork can turn the one time wrecking ball project into a new and vibrant facility restored to its original grandeur ready and for new life (See Fig. 8).