150 Tremont Street

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CBI Consulting Inc. was engaged by KBA Architects to evaluate the cause of masonry displacement at the eighth story of an exterior corner of an office building recently converted to a university dormitory. This article reflects an engineer's perspective during the repairs.

The structure at 150 Tremont Street, Boston, is a twelve-story building, approximately 100 years old. The exterior wall construction is mass masonry encasing a structural steel frame. The floor construction is a terra cotta flat arch system with supporting steel wide flange beams. Exterior evaluation, using destructive probes, uncovered extreme corrosion of the embedded steel column and the corresponding floor beams that frame into the corner column.

Due to the severity of corrosion, CBI proposed full masonry stripping of the building corner, as well as replacement/reinforcement of the remaining steel frame sections.

Repairs of the structure, which is used as a dormitory, would directly affect the corner suites throughout the full height of the building. The owner allowed a 3½ month repair schedule, which included preparation of construction documents, bidding, and completion of repairs. Schedule, rather than cost, was the driving force for the repairs. Design documents with bidding were completed in 3½ weeks. A contractor pledging to meet the schedule was selected, and work began by the fourth week. Weekly project meetings involving the design team, owner, and contractors were scheduled to keep the project on track.

As soon as students vacated for summer break, corner suites were captured and exterior staging was erected. The corner room of the suite was stripped of its finishes: walls, ceilings, flooring, etc., to expose the interior face of the structure.

The amount of corrosion revealed, and questionable beam to corner column connections observed, required shoring of the entire corner. Design proceeded to allow for installation of shoring prior to mass masonry removal. Shoring needed to support all stories (assuming column removal), and was to be positioned within the confines of the dorm space. No exterior shoring was used due to site constraints. Transfer of the floor loads from the existing floor beams to the vertical shoring was achieved by shoring towers and dunnage beams. Due to corrosion of the exterior beam and tie rod connections, which tie the arch together, the floor arch system required the installation of tension members with vertical shoring to all floors. The shoring was designed to accommodate gravity load and provide floor arch stiffness to minimize potential demolition vibration, which could cause the floor arch to unravel.

Prior to the completion of the shoring, the abutting property owner agreed to allow removal of the abutting south wall face earlier than scheduled. The removal of the abutting wall revealed that the column corrosion was so extreme that column failure was imminent, if the column was to be subjected to design loads. This condition ultimately required the replacement of three consecutive column stories. To reduce the chance of column buckling, the masonry removal was halted until all shoring was in place, and temporary column cable banding was installed.

With the shoring and column stabilization in place, the demolition continued on the east face of the corner. As masonry removal descended down the east face of the corner, the original steel floor beams, connection, and column became exposed. The masonry removal continued down the building face as the program for steel repair commenced above. At this juncture, the steel repair and masonry removal was proceeding hand in hand.

The process of steel repair began with an evaluation of the steel section losses and the subsequent determination of any necessary reinforcement. Due to severe corrosion, various sized reinforcing plates, angles, and channels were added to salvageable steel floor beams. Unsalvageable beams were replaced.

Due to corrosion, the eight story column and corresponding floor beams required a variety of repairs. Five column stories received steel channels welded to the column web to supplement the remaining steel section. Three column stories required full column replacement. Before providing steel replacement engineering details, the process began with providing the steel contractor various scenarios for repairs. Steel repair concepts were engineered to minimize down time for steel fabrication, delivery, and installation. CBI worked in the field, with the steel fabricator detailer, to detail on site repairs.

The three-story column replacement required a special procedure prior to removal. Even though the shoring was in place, loads were still being transmitted through the remaining column section. Simply cutting the column free in one operation was not advisable. The shoring was not jacked to receive the induced 100% load, and slack between floor to floor shoring distribution needed to be accounted for.

To cut the column free, systematic torch cutting was performed in increments, slowly reducing the column cross section. As more steel was removed, column vertical distortion was measured, and compared with elastic shoring deformation calculations. The torch cutting, column distortion, and measurements continued for two hours until the column distortion halted, which demonstrated that the shoring had fully supported the load and that the column was free. The total vertical deflection recorded was ⅜ inches, which compared well with a ⅝-inch deformation calculation.

View of flat masonry arch and parapet

By Week 7, the steel repairs were well underway. The steel contractor utilized ten-hour work days to stay within the construction schedule. At this point in the schedule, the general contractor (GC) opted to change the proposed replacement of the mass masonry infill construction to a brick veneer system with cold form studs. The GC felt it would be quicker to construct versus mass masonry. The owner authorized this new design midstream during the repair.

Re-engineering began immediately, with the design of a curtain wall system that included a brick veneer, air space, and vertical cold form construction with slip connections to accommodate thermodynamic volume changes. The curtain wall system, which incorporated appropriate waterproofing and flashing details, contained a brick veneer to replicate the original building appearance. Supporting the masonry veneer, which was approximately 16 inches off the column face, required the design and fabrication of steel support brackets which cantilevered off the face of the column at every floor line. The curtain wall system became very complex at the 11th and 12th story. The original construction of the 11th and 12th stories consisted of mass masonry window arch headers supporting a large corbelled masonry parapet.

It was decided that reconstruction of the top two floor spandrels would be mass masonry, with review and resolution of both gravity and thrust arch loads affecting the existing steel corner column.

By Week 10, installation began with the curtain wall back-up stud wall system. Cold form steel stud construction required the retrofit of the original structure floors and exterior beams to accommodate the new wall design.

Steel repairs were ongoing during this period, requiring the general contractor to adjust crew size and extend work hours for the steel welding operation and exterior wall work.

The steel work was completed by Week 11, and interior shoring removal began. The interior finish installation was underway by this time.

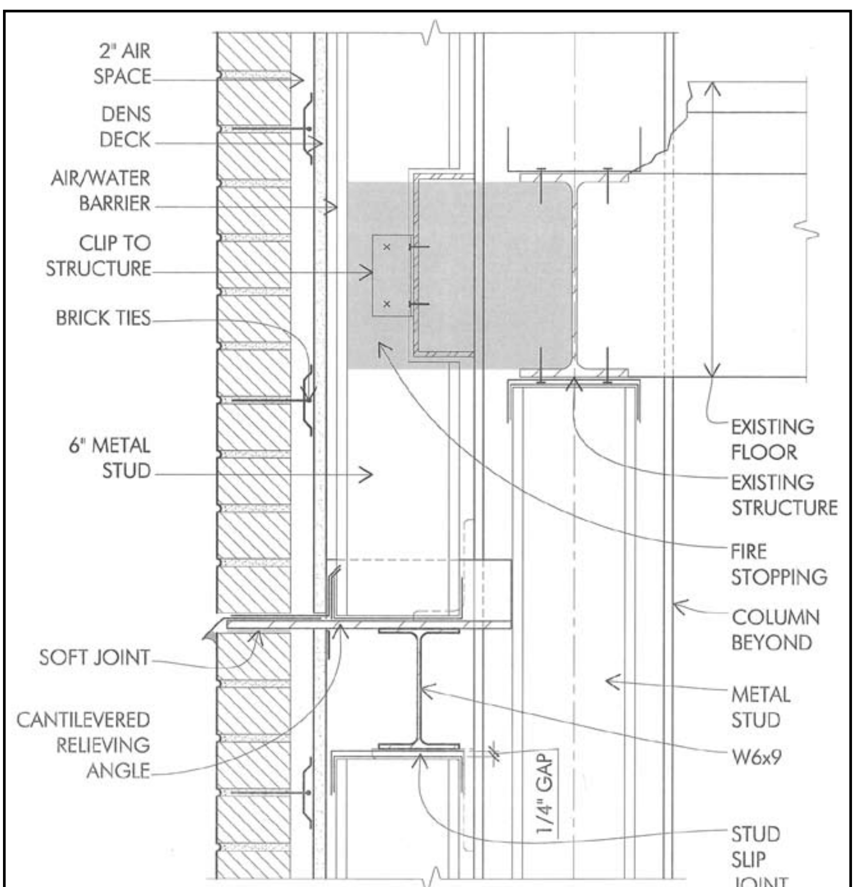
View of the column cutting during column removal

By Week 13, the exterior masonry work was completed and the majority of the dormitory rooms' interiors had been restored to preconstruction condition.

Week 14 became a scramble to the finish line by the general contractor. The dormitory rooms were turned over to the owner and the exterior pipe staging was disassembled.

The contractor completed the repair work on time.

The overall construction time was originally estimated to be four months, determined after the completion of the contract documents. With a hands-on approach, the general contractor, his subs, and the design team were able to compress the original construction schedule from four months to eleven weeks.▪



Section view of replacement veneer construction

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