Renovation and Adaptive Re-use of the Historic Corbin Building (as part of the Fulton Center project, Lower Manhattan)

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Ian is a Structural Engineer working in Arup's New York office, and has over 23 years' experience in structural design. His main area of expertise is related to the adaptive re-use of existing building structures. Ian has worked on several award-winning projects including Accident Fund Lansing, winner of 2011 AISC Presidential Award for Excellence in Engineering, and The Corbin Building, the particular subject of this paper.

Summary

Originally scheduled for demolition, the effective integration and rehabilitation of the historic Corbin Building within a modern transit hub is a paradigm for how adaptive re-use can significantly contribute to the overall project goals, while preserving important engineering heritage.

This paper presents a brief overview of the original building structure, and details how significant structural alterations and upgrades were made as part of the Fulton Center project. Engineers used multiple analysis techniques as appropriate, ranging from re-application of historic empirical methods to the computer modelling of both global and local structural behaviour through finite element (FE) models, to arrive at an Elegant Structural solution.

Keywords: Include a list of not more than ten keywords, cast-iron; guastavino; timbrel vaulting; corbel; adaptive re-use; FE modelling.

1. Introduction

The Fulton Center transit hub in Lower Manhattan is one of the most ambitious capital projects undertaken by the Metropolitan Transportation Authority (MTA). The goal of the $1.4bn scheme is to connect and rationalise access to 10 separate New York City subway services that converge in and around Broadway.

Central to the project is the redevelopment of approximately one third of a city block adjacent to Broadway to create a new multi-level mixed-use station and retail destination. The new development is topped by a new steel and glass pavilion.

Fig. 1: View of the overall project

2. The Corbin Building

The Corbin Building is a slender wedge-shaped on plan, 40ft (12.2m) wide at the east end but only 20ft (6.1m) wide at the west elevation overlooking Broadway. It has a hybrid structure of loadbearing masonry with wrought-iron beams and cast-iron columns. It has two basement levels, double-height retail space at street level, and seven full levels of office space above.

As part of the research and documentation prior to its proposed demolition it was revealed that the building was much more important than originally realized. Designed by NYC architect Francis Hatch Kimball the building a 'proto skyscraper' utilized pioneering 'fireproof construction' techniques championed by builder Rafael Guastavino. Ambitious plans were made to incorporate the building into the final design, reaching far beyond a mere refurbishment.

3. Engineering Challenges

The building was fully integrated into the final project, and incorporated a deep escalator linking a street level entrance to a new concourse three levels below. Upper level connections to the new Transit Center provided improved egress and shared lateral stability.

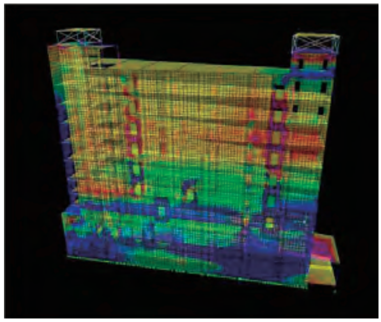

Fig 2. ETABS Model of Masonry

3.1 Modelling Masonry

To assess both the existing condition and the proposed alterations, Arup built two 3-D ETABS structural models, one for the existing and one for the proposed design. This allowed the current stress regime in the unreinforced masonry to be reviewed and then compared to stresses after the proposed changes, minimizing shotcrete reinforcement to localized areas.

Fig. 3: View of Lateral Stability Frame during construction above the new escalator wellway

3.2 Upgrading Lateral Stability

A new concrete Lateral Stability Frame was integrated within the masonry ETABS model and linked at level 2 and 3 to the adjacent steel frame of the Transit Center Pavilion by including flexible spring restraints. The steel frame was modelled in GSA. Iteration of the two models allowed the design to be optimized.

3.3 Escalator Wellway

The new deep escalators required that 3 levels of the slender floor diaphragm were penetrated and reinforced. The west half of the building which sat on sensitive soils also needed to be carefully underpinned. Complex construction sequencing was considered in planning the final design which utilized a combination of internal retaining walls, steel ring beams and a reinforced concrete u-framed pit to replace the loss of lateral support to the existing masonry basement walls.

3.4 Guastavino Floor Strengthening

The existing iron structure was not readily weldable and the arched underside of the existing floors were to be exposed. By using Hilti shear connectors screw-fixed to the existing beam flanges with self-drilling screws, the team provided a 30% increase in overall beam capacity while hiding the repairs from view; the design was verified using Arup's in-house Compos software.

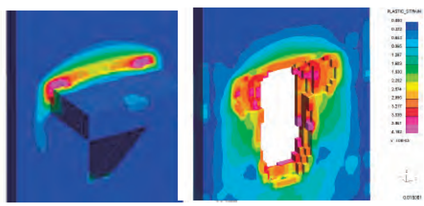

Fig. 4: FE Modelling of cast-iron corbels using LS DYNA

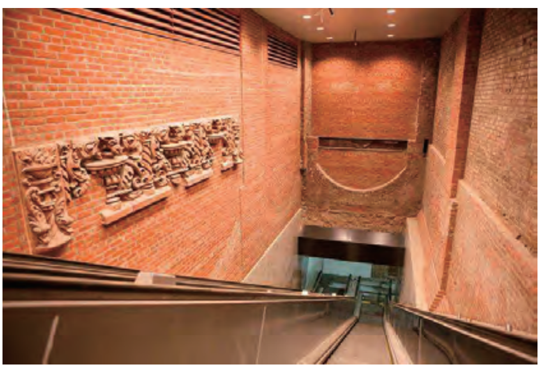

Fig. 5: Completed Escalator Wellway

3.5 Cast Iron Corbels

Research of historical sources had shown that the existing cast-iron corbels at the heads of columns were a potential weakness in the gravity frame. Arup used LS-DYNA to accurately model the strength of the corbels and verify that double-tee brackets had sufficient residual capacity to carry the new loads, avoiding the need for any visually intrusive retrofit.