

Problem Statement and Solution Overview

Problem Statement

Concrete structural floor systems and shear wall cores require a long erection time because they are labor intensive, require curing, and require shoring and re-shoring. However, what if Donald Trump wanted his hotel to open as soon as possible in order to generate revenue? Steel structural floor systems require much less time for erection compared to that of concrete systems. However, it was found in Technical Report Number Two (Reichwein, October 2007) that the structural depth of a steel system is often larger, requiring an increase in the building height to retain the same area of rentable space. The increase in building height will also conflict with the wind tunnel test issued by DFA because it was performed using a scale model. Can such a steel system be devised in order to retain the current height of the building?

While investigating the effectiveness of the current concrete shear wall core with the use of ETABS in Technical Report Number Three (Reichwein, December 2007), large inherent torsions were present under the wind loading specified by the wind tunnel test performed by DFA. This inherent torsion exists because the center of pressure of the wind and the center of rigidity of the shear wall core do not coincide. This occurs because each wall has a different stiffness, caused by the unsymmetrical layout of the core openings. The perimeter of the building is also not restrained torsionally, as this is a core only system.

Despite its inherent torsion, the stiffness of a concrete core shear wall was able to effectively handle the wind forces of Atlantic City, New Jersey. However, the long erection time of a concrete shear wall will delay the opening of Donald Trump's hotel. In order to reduce the construction time of the lateral force resisting system, a steel system will be considered. But, could a steel system provide adequate stiffness in order to meet the drift requirements in a hurricane prone region?

Problem Solution

In an effort to reduce the erection time of the structure, a steel redesign of the Trump Taj Mahal Hotel has been proposed as a viable alternative to the filigree floor system and concrete shear wall core system. The redesign includes both the floor system and lateral force resisting system of the tower. All steel framing will be designed in conformance with AISC Manual of Steel Construction, 13th Edition.

A core of braced steel frames will serve as the alternative to the cast-in-place concrete shear wall core. In order to meet the demands of hurricane force winds, the layout of the tower's core was redesigned to accommodate an efficient layout of braced frames. The redesign of the core will be discussed further as an architectural breadth. An ETABS model was constructed to distribute the lateral forces to each frame accordingly based on rigidity. The braced frames are designed for strength using AISC 13th Edition Manual of Steel Construction LRFD and meet a drift limitation of $H/400$, as recommended by both AISC Design Guide 3 – Serviceability Design Considerations; and ASCE 7-05 – Minimum Design Loads for Buildings and Other Structures. In order to provide the braced frames with adequate stiffness, built-up column sections are required at the lower levels of the tower.



The filigree flat plate floor system was redesigned as a steel frame with pre-cast concrete planks. However, it was found in Technical Report Number Two (Reichwein, 2007) that this type of system would be the deepest structurally. A deep structure will require a rise in building floor to floor height. After reviewing the mechanical and architectural requirements of the tower, it was found that a 10 inch increase in floor to floor height is required. The implications to cost of the increase in height are analyzed and evaluated.

Steel gravity frame designs were determined utilizing RAM Steel and conform to AISC 13th Edition Manual of Steel Construction LRFD and IBC 2003. The precast planks are specified by Nitterhouse, Inc. and have been designed utilizing proprietary loading charts.

The redesign of the tower in steel has affected the architecture of the tower in several ways. Because of the significant amount of changes made to the core of the tower, a study was conducted on the architectural impacts resulting from the newly designed brace frame core. The impacts to the architectural layout of the core will include alterations of the core openings, stairs, elevators, and service areas. A significant amount of changes are also being made to the floor system of the tower. In order to properly conceal the newly designed steel frame at the perimeter of the building, the addition of soffits above the windows of each guest room were required. A soffit was also provided in between some of the guest rooms in order to conceal the steel beams. A Revit model with each structural system was constructed in order to illustrate the key architectural impacts. These impacts are illustrated utilizing interior renderings and floor plans. The removal of the concrete shear wall core also created the need for fire-rated partitions. These partitions were selected from the Underwriter's Laboratory assemblies database. Additional costs incurred due to soffits, fireproofing, and partitions was analyzed using R.S. Means 2008.

The substantial differences between the construction of a steel and concrete structure merited a construction management study. Cost, scheduling, sequencing, and site conditions will all be affected by the redesign of the tower. The cost and schedule of the redesigned steel system was not easily estimated. Various interviews were conducted with contractors and design professionals in order to obtain accurate numbers. R.S. Means cost data was used to estimate the cost of additional items, such as fireproofing and the increased amount of curtain wall. Other cost data was obtained through interviews with the lead estimator on the current Trump Taj Mahal Hotel project. The estimated cost and schedule of the steel structure will be compared to the estimate and schedule provided by Bovis Lend Lease. Site conditions were also analyzed in order to determine the requirements of a steel structure.

