Executive Summary

This report is the culmination of a yearlong study on the Trump Taj Mahal Hotel tower, a 40 story luxury hotel located on the 1000 block of the boardwalk in Atlantic City, New Jersey. Given the architectural layout of the guest room spaces, a core only lateral force resisting system and flat slab concrete floor system were designed to accommodate the architectural requirements of the project. With only the core resisting the lateral forces acting on the tower, reinforced concrete shear walls with coupling beams were designed to in such a way as to limit the wind drift and effectively dissipate the hurricane force winds of Atlantic City. A concrete shear wall core of this nature was found to be extremely stiff and rigid. These properties will eliminate any torsional flexibility issues that usually result from a slender core only system.

The purpose of this study is to determine why a concrete shear wall core and filigree flat slab floor system were selected as the structural system of the tower. The proposed lateral force resisting system redesign consists of a core of steel braced frames, the majority of which will be concentric inverted “V” braces. Eccentric braced frames will be avoided as much as possible in order to benefit from the greater stiffness provided by concentric braced frames. The proposed gravity system redesign consists of a non-composite steel frame and precast concrete plank floor system; this floor system offers the key benefit of fast erection. Both systems were chosen on a basis to determine why a steel structural system was not chosen, given its superior erection time compared to that of a concrete system. With a steel system, the construction cost and erection time can be reduced; the hotel can open at an earlier date, thereby generating revenue sooner.

The braced frames in the core of the tower were designed to effectively limit the building drift to H/400, while providing enough strength capacity to meet the requirements of AISC LRFD 3rd Edition. To meet the recommended drift limitation of H/400, large built-up column sections were required at the lower levels of the tower. These built-up sections were pivotal in reducing the overall building drift because column axial deformations had the greatest effect on overall drift.

Minor architectural impacts resulted from this structural redesign. The elevator/service core at the center of the tower required redesigning in order to allow for more flexibility while determining the geometry of the braced frames. The core redesign involved the relocation of openings, elevators, and spaces. The floor to floor height of the tower was increase by 10 inches in order to accommodate the deeper steel structure; this 10 inch increase has many cost implications. Soffits are required in order to conceal the steel frame, particularly the spandrel beams and columns. These soffits will be visible in various guest rooms throughout the hotel. As these architectural impacts seem minor in the grand scheme of things, it is at the owner’s discretion to determine the acceptability of such changes. However, for the purposes of this study these changes were deemed acceptable

Despite all of the architectural impacts, construction management breadth studies left me with the conclusion that the cost of the steel structure is $1.5 million less than the concrete/filigree system. It was also found that the steel structure would top out almost a month before the concrete schedule. It seems like all design goals have been met.

However, drift and strength are not the only issues that need to be addressed in the preliminary design of a high-rise lateral force resisting system. Motion perception of building occupants can sometimes control the design of a structural system. In order to fully understand the structural dynamics of a building, complex wind tunnel studies must be performed.

For the purposes of this study, a parametric RMS acceleration study was performed in order to determine whether or not accelerations due to wind would be an issue. To better grasp the effects of accelerations due to wind, the concrete shear wall core was analyzed as a way of comparing the two systems. The concrete shear wall core was found to be an acceptable design based on this parametric study. However, the steel braced frame core RMS resultant accelerations at the top floor of the hotel were found to exceed the acceptable limit by a factor of 2.0. As the steel member sizes are already large, increasing the sizes of columns, braces, and girders is not an option and will not be a viable enough solution to the acceleration issue. Although nothing can truly be determined unless wind tunnel studies are performed, this still indicates the presence of acceleration issues.

Therefore, the proposed solution of replacing the concrete shear wall core with a core of steel braced frames is not directly feasible. Only with further investigations involving complex wind tunnel studies, the acceleration problem may be solved utilizing a liquid-tuned column damper or tuned mass damper. Keep in mind that such a solution will add upwards of $2 to $3 million to the project cost and will cause the steel structural redesign to cost more than the current concrete and filigree system by about $1 million. Therefore, for the purposes of this study the reinforced concrete shear wall core will be the accepted structural system of the Trump Taj Mahal Hotel.

It is important to keep in mind that high-rise design involves many factors that are best solved by that of a design professional with years of experience. This study has served more as a learning experience to the student and may shed some light on the advanced design topics of high-rise design.