Executive Summary

The study presented in this report is the culmination of a year-long research and analysis of Sherman Plaza, a 25 story condominium building, located in Evanston, IL. The building is made up of a complex reinforced concrete structural system that has been designed with careful consideration. While the existing system is an adequate and efficient design, the building will be reanalyzed in order to gain a greater understanding of the complexities involved in designing a high-rise building's gravity and lateral systems. This study investigates a different structural system in an attempt to produce a new system that will improve constructability, shorten construction time, and lower costs without decreasing the building's quality.

To accomplish this goal, the existing reinforced concrete system was replaced by a new steel gravity and lateral system. The existing structural system has some drawbacks that can be improved upon with the new system. The reinforced concrete structure is somewhat difficult and time consuming to construct due to the need to place the formwork and shoring. The system also has a high weight, which results in the need for large foundations. The shear walls also need large foundations and grade beams for support.

RAM Structural System was used to design the gravity and lateral system of the new structure. Composite steel beams were chosen for the floor framing to limit the overall building height as much as possible. The beam sizes were also restricted to W16s on floors 2-7 and to W14s on levels 8-25. Despite these limitations, the building height was still increased from 260.5 feet to 283.25 feet, which is an overall increase of 22.75 feet. The lateral system was made up of a combination of moment and braced frames. This design resulted in a total building drift of 5.6254 inches, which is less than the allowable drift of H/600, or 5.665 inches.

With this new design, the building weight was greatly reduced. The foundations sizes were able to be decreased. The original foundation sizes varied between a 15'-6" bell diameter and 6'-0" shaft diameter caisson to a 6'-0" bell and 2'-6" shaft. The new design results in caisson sizes that range between a 3'-0" bell and a 7'-0" bell.

By changing the primary structural system of Sherman Plaza from reinforced concrete to structural steel, other building systems were also impacted. Two breadth studies were performed to determine the effect the structural material change had on the construction management and on building acoustics.

An estimate was performed of the costs of the exterior cladding and structural materials for each system from R.S. Means. The steel system resulted in a total cost of $17.45 million, and the reinforced concrete system had a total cost of $25.63 million. The steel system, therefore, was $8.18 million less expensive than the concrete system. R.S. Means was also used to perform a schedule estimate. The steel system took a total of 1146 days to complete, while the concrete system took 2660

days. Therefore, the steel system could be erected 1514 days faster than the concrete system.

The first acoustical analysis was a study of the transmission loss of the floor system. The original floor system, an 8 inch thick reinforced concrete slab, was found to have an adequate transmission loss. The new system, however, was made up of 3 inches of concrete on top of composite metal deck and was not acceptable according to the NC-25 noise criteria curve. Even with additional sound absorbing floor and ceiling materials, the new system did not meet NC-25 criteria, but did fall below NC-30 standards. The second analysis investigated the transmission loss of one of the concrete shear walls from the original structural system. The shear wall was found to have an acceptable transmission loss to reduce the mechanical room noise. Based on the acceptable sound pressure levels, a new wall system was chosen to replace this wall. Three alternatives were analyzed. The chosen wall system was made up of 3 5/8" steel channel studs with two layers 5/8" gypsum board on both sides and 3" mineral-fiber insulation in the cavity and met the NC-25 criteria.

In all, the steel structural system was an effective design for this building. The composite steel produced an efficient gravity system that worked well with the given column layout. The drawback to this system, however, was that the structural system's ceiling to floor section depth was greater than that of the existing concrete system. The newly designed lateral system also produced acceptable results. The design, however, uses a large number of braced frames and moment connections that will increase construction time and costs. The architectural constraints also made the placement of the frames within the building difficult. Since the building was designed to have shear walls provide the lateral resistance, the architecture of the building did not provide many options for braced frame locations. The braced frame system could possibly have been improved if other locations for the frames could have been tested.

Despite any drawbacks of the new steel structural system, the cost estimate and comparison of the two systems showed that the steel system is less expensive by $8.18 million. This savings in cost could compensate for the increase in building height and the large number of lateral braced frames and moment connections. In addition, according to the schedule estimate, the steel system could be erected 1514 days faster than the concrete system. Therefore, the new steel redesigned system is a viable alternative to the existing reinforced concrete structural system.