PROBLEM STATMENT

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After an extensive analysis of Memorial Sloan-Kettering's structural system, it was apparent that the existing design of this building was expertly performed. Both hand calculations and software analysis arrived at the same conclusion that the structure of MSK was sufficiently designed. Even from an economic point of view, Memorial Sloan-Kettering left little room for improvement. In the north Jersey area, steel is less expensive to build in than concrete. The only reason the entire building wasn't erected in steel was due to vibration and noise issues from the adjacent underground parking. Also consider that concrete is a heavier material which will directly result in larger seismic forces and footing sizes. As a final point, the original floor system was contrasted to four alternate systems to determine its efficiency. After analysis and comparison, the composite slab on deck proved to be the most effective floor system of the group.

After further deliberation, it was resolved that instead of changing the existing structural system of MSK, it would be better to redesign the Outpatient Addition. As noted earlier, a four-story Outpatient Addition is currently in its design stage and plans on breaking ground around 2009. The current site plan calls for the addition to be erected on the north side of the MSK, extending the signature curved façade that it possesses an additional 120 feet. It is assumed that this lateral addition to the building is due to the amount of open space provided on the site. There are, however, a few drawbacks that arise when building the addition adjacent to the north face of the existing structure.

The main drawback deals with constructing the addition's foundation. Because Phase 2 of Memorial Sloan-Kettering is basically a reproduction of Phase 1, it would be fair to assume that the addition would need the same foundation to support its four stories. By doing so, the site would need to be excavated to provide that footprint. In addition, the footings for Phase 2 would need to be enlarged due to the findings of the geotechnical engineers. From their geotechnical report, it states that the Outpatient Addition would sit on decomposed rock and would need an over-excavation up to feet 10 or more just to reach the required bedrock. If the addition were to be built vertically above the existing structure rather then to its north side, these drawbacks would be eliminated all together. These issues summarize why an investigational thesis was preformed to conclude whether a vertical addition would prove to be a more beneficial design.

The objective of this thesis was to investigate the structural design of both the existing infrastructure and Outpatient Addition as if the original design called for the addition's four stories to be erected on top of the MSK. Without changing the existing structural floor plan, both the gravity and lateral system were analyzed and redesigned to maintain structural integrity from the loads generated from the increased height and weight. In order to keep the Rooftop Air-Handling Units where they are, the future 5th floor of Memorial Sloan Kettering acted as a mechanical floor and had five additional stories erected above it. In all, Memorial Sloan Kettering will stand nine stories tall.

SOLUTION OVERVIEW

STRUCTURAL REDESIGN

By building this addition vertically above the existing floors, the height of Memorial Sloan- Kettering more than doubled from 58 feet to 126 feet. Because of this, the first step in this structural redesign was to recalculate both the gravity and lateral loads acting on the building. Dealing first with the gravity loads, there were a number of factors which required the columns be re-evaluated in the existing structural system. These columns, intended to only support four floors, were dramatically under-designed to resist the weight that the addition provided. Because of that, those columns had to be redesigned to support the axial forces acting on them. While the size of each column increased, the sizing was required to remain a W12. After completing the redesign of those columns, it was then necessary to redesign the concrete piers located below the first floor. Once again, their dimensions of 24"x24" were maintained to ensure that there was no interference with the floor plan. When dealing with the gravity loads, only the columns were considered during this redesign. Because the floor loads and building materials are remained constant, there is not need to redesign the floor systems in MSK.

The next step to this redesign was to look at the structure's lateral system. After both the seismic and wind forces were recalculated, it was confirmed that the seismic and wind loads had significantly increased in both the north-south and east-west directions. Because of the noticeable increase, it was determined that the lateral system required additional braced frames to resist the forces and torsion acting on the building. Furthermore, the member components of each lateral system needed to be resized to ensure that an acceptable story drift of H/480 was maintained while resisting the lateral forces.

Finally, the foundation of Memorial Sloan Kettering was analyzed. Because more lateral systems were added to resist the updated lateral forces, the number of shear walls in each direction increased as well. Each shear wall needed to be analyzed to determine whether or not it was able to withstand both the base shear and overturning moment that acted on it. The footings supporting each shear wall were also resized in order to help resist excessive overturning moments. From the calculations performed, appropriate shear wall sizes and footing dimensions were allocated to maintain structural integrity.

To help assist in the analysis of the lateral loads and how each influenced the lateral frames, a three-dimensional model of Memorial Sloan-Kettering was created in RAM Structural System. RAM has the ability to both analyze and design a building based on the loads and parameters assigned in the program. Not only did RAM produce constructive output data relating directing to the structural design of this addition, but it also provided a way to double check all hand calculations.

CONSTRUCTION MANAGEMENT STUDY

After the structural analysis of Memorial Sloan Kettering was complete, it was necessary to look at the addition from an economic point of view in order to determine how efficient the redesign was. Because the Outpatient Addition is still in its design stage, there are no tangible costs that would allow for straight comparison. Because of this, an assumption was made that if the addition were built adjacent to the existing infrastructure, its structural components would cost roughly the same due to their similarities. From that assumption, structural costs were taken from the Financial Status Report provided by Barr & Barr Builders, Inc.. To find the cost of only the addition, it was necessary to add up the price of the entire infrastructure and subtract out the existing structure's cost. Doing so would find the price of the additional five floors and take into account the cost of resized members on the lower floors. For this study, the structural steel and concrete for both additions were analyzed and compared. Also, a schedule was created to determine how long the redesign would take to construct. That time frame was also compared to that of the original schedule.

MECHANICAL AND ACOUSTIC STUDY

When dealing with a multiple story addition such as the one proposed onto MSK, structural integrity is not the only technical issue that arises. A proper mechanical system must also be established for those stories, and an issue that arises within this subject is where to put that equipment. For the initial four stories, a large mechanical room exists in the basement along with three additional air handing units on the roof. Fortunately, the basement's mechanical room layout left open room for most of the equipment required for the addition. The only mechanical units still needing placement were the air-handlers for addition.

Due to the amount of room needed for those air-handing units, the logical option was to leave the existing units where they were. Because of this, the 5th floor of Memorial Sloan-Kettering has been converted into a mechanical floor for both the addition and existing building. The three air-handlers will remain where they are, and two additional units will be added on the level to supply the 6th and 7th Floors. The remaining 8th and 9th floors will receive air from units positioned on the addition's roof. In order to supply the required outdoor air to those units on the 5th floor, louvers were sized and positioned on all four exterior walls to allow air to flow freely through that level.

One consideration that this new building configuration brought up was whether there would be noise issues between the mechanical room and floors surrounding it. The 4th Floor is home to both examination rooms and surgical areas. The 6th floor will be home to practicing offices. To identify whether or not further acoustical measures were necessary, an acoustic study was performed to determine the noise levels experienced in both an operating room and private office.