The Residences of Sherman Plaza
Evanston, IL

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Senior Thesis Proposal

Executive Summary

The main structural system of Sherman Plaza consists of a reinforced cast-in-place concrete superstructure. This 25 story condominium building is comprised of concrete columns, beams, two-way slabs, and has a lateral system that is a combination of shear walls and moment frames. The building rests on a foundation of belled caissons. While this system is effective, it is somewhat inefficient in terms of material usage, time and constructability. The two-way slabs are difficult and time-consuming to construct because of their formwork and shoring. The high weight of the system results in the need for large concrete foundations. A large amount of concrete is also used for the building's shear walls, perimeter edge beams, and dense column grid.

This building redesign proposal will attempt to produce a new structural system that will improve constructability, shorten construction time, and lower costs without decreasing the building's quality. This goal will be accomplished by replacing the existing concrete system with a new structural steel system. This new system will be much lighter than the existing system, resulting in smaller foundations. It will also be easier to construct, because the formwork and shoring will not be needed. The number of columns could be also reduced, which will produce savings in material costs.

In addition to the considerations of the floor framing, the lateral resisting system will need to be reanalyzed. The seismic loads will need to be recalculated for the lighter building weight. The existing concrete moment frames will need to be replaced by steel frames. An all steel lateral system, comprised of moment frames or bracing, will be considered in order to eliminate the difficult steel beam to concrete wall connection. The steel moment frames, however, will require special connections.

These connections and other drawbacks of the steel system will have to be taken into account when determining the effectiveness of the new system.

The new structural steel system will be designed under the provisions of AISC LRFD 3rd Edition. The analysis of the gravity floor framing members will be completed using a RAM Steel model. These member sizes will be used to construct an ETABS model to analyze the building's lateral system. The steel connections for the moment frames will be calculated by hand.

This change in the building's structural material will affect other aspects of the building. A breadth study will be performed in two other disciplines to further investigate the new system's effectiveness. The first study will be an estimate of the new building's cost and construction schedule. The second study will be an acoustics analysis. It will be determined if the new system provides enough sound isolation between residential dwellings and between the retail and residential areas.

Building Background

Architecture

The Residences of Sherman Plaza are located in downtown Evanston, IL and provide residents with luxurious condominiums and many amenities, including a 54,000 square foot health club, a half acre rooftop garden, 152,000 square feet of retail space, and a new adjoining 1,585 car parking garage. The building has a two story rectangular base containing the retail spaces, which are occupied by tenants, such as Barnes & Noble Booksellers, Pier1 Imports, and Washington Mutual.

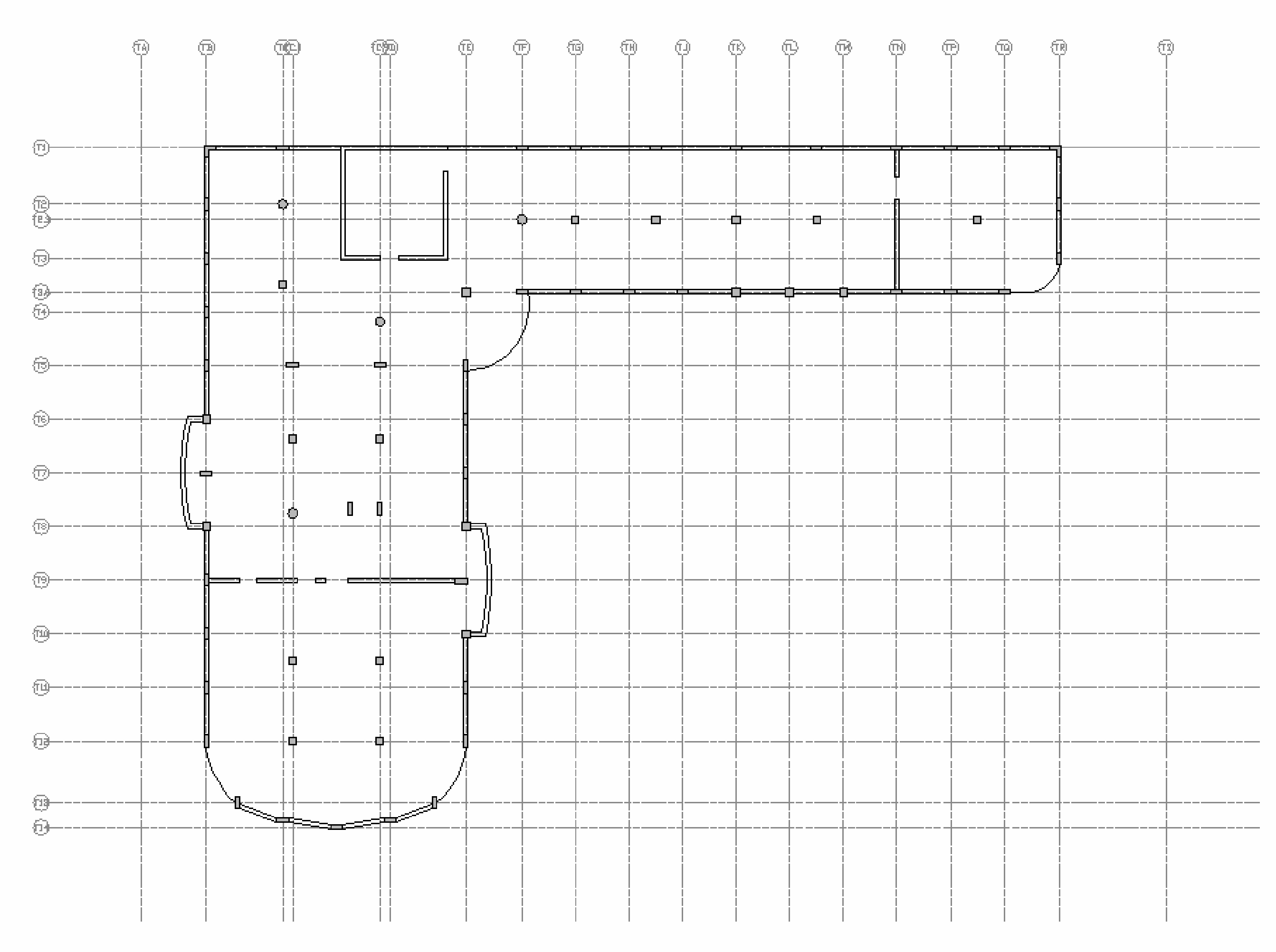
The retail portion of the building is topped by a 23 story L-shaped condominium tower. This residential portion contains 253 condominiums, lofts, and penthouses. The building steps back on the third, sixth, and seventh stories, creating roofs that are covered by an intensive roof garden. The top three floors are the penthouse levels, which are also stepped back, and have large concrete "eyebrows" covering their private terraces.

Structural System

Gravity Floor System

The primary floor system of Sherman Plaza is reinforced concrete two-way slabs. The slab thickness on every floor is 8", with the exception of the first floor, which has a slab thickness of 9". The building is surrounded by perimeter edge beams, and there are interior edge beams surrounding slab openings for stairs and elevator shafts. The slab reinforcement remains fairly constant from floor to floor, but the bay sizes, however, differ throughout the plan, which causes the reinforcement size and layout to change from bay to bay.

The two-way slabs are supported on reinforced concrete columns that are lined up along a grid, in general. Most bays are either 14'x14' or 21'x21' square bays. Exterior columns are spaced at 7' or 14' in general. Column sizes on the ground floor vary from 18"x54" on the building perimeter to 36"x36" as a typical interior column size. Column sizes on the upper floors and vary between a 20" diameter circular column, a 24"x24" square interior column and 13"x36" on the perimeter. The typical floor of the building begins on level 8 and is continued up to floor 22. The top three floors differ, because they are penthouse levels.



Typical Floor Plan: Levels 8-22

Foundation

The foundation of Sherman Plaza consists of reinforced concrete belled-caissons, extending to hardpan at approximately 70 feet below grade. All the caissons will bear on hardpan soil strata with a minimum allowable bearing capacity of 30 ksf, except where the drawings indicate a minimum of 50 ksf. The largest caissons have a 15'-6" bell diameter and a 6'-0" shaft diameter in size and are spaced at 28'-0", in general. The sizes vary down to a 6'-0" bell diameter and 2'-6" shaft diameter, spaced at either 14'-0" or 21'-0", in general. Above the caissons is a 5" slab-on-grade with one layer of 6x6-W2.1xW2.1 W.W.F. Grade beams are located underneath the building's shear walls.

Lateral Resisting System

The lateral support for the building is made up of a combination of reinforced concrete shear walls and perimeter moment frames. There are shear walls located around the elevator core, near the intersection of the L-shape of the building. There is also a shear wall in each arm of the L-shape. The elevator core shear walls are 18" thick for the first six floors, 16” thick for floors 7 to 22, and 12” thick for the last three floors. The shear walls located in the L-shape’s arms are 18” thick for the first six floors, 15” for floors 7 to 12, and 12” thick for the remaining floors. The reinforcement for the shear walls is #5@12”, in general. The moment frames are made up of deep edge beams around the building’s perimeter. A typical perimeter beam is a 13”x36” beam with 4 #7 reinforcement bars on top and bottom.

Problem Statement

Sherman Plaza is a complex building, and its structural system has been designed with careful consideration. While the existing system is an adequate and efficient design, the building will be reanalyzed in an attempt to produce a new structural system that will improve constructability, shorten construction time, and lower costs without decreasing the building's quality. Several floor framing systems were analyzed in Structural Technical Report 2 to determine which could provide a suitable alternative to the existing system. It was found that the existing system had several drawbacks:

- The current building design has a reinforced cast-in-place concrete structure. This system is somewhat difficult and time-consuming to construct due to the need to place the formwork and shoring.
- The existing structural system is somewhat inefficient in terms of material usage. Due to the limited strength of the structural material, the bay sizes are limited, resulting in a dense column grid. The lateral resisting system also uses a large amount of concrete for the shear walls and the large columns and edge beams that make up the moment frames.
- The reinforced concrete system has a high weight, which results in the need for large foundations. The shear walls also need a large grade beams for support.

Proposed Solution

The building redesign will attempt to produce a structural system that is efficient in material usage, constructability, time and has a lower weight than the existing system. To accomplish this goal, the existing reinforced concrete system will be replaced by a new structural steel system. A study will be performed to investigate the effectiveness of this system and the impact it will have on other aspects of the building.

In Structural Technical Report 2, two steel floor framing systems were analyzed to compare the pros and cons with the existing system. It was found that both a composite and non-composite system would work for the building, but each of the systems has its strengths and weaknesses. A drawback to the steel systems is that they have a large ceiling to floor section depth. This larger depth will cause an increase in costs, such as exterior cladding, mechanical equipment, etc. Therefore, the non-composite system will not be considered, because it has an even larger section depth than the composite system. Although the composite system depth is larger than the existing concrete depth, it will be determined if the other advantages to the steel system will outweigh this drawback.

The steel system will allow savings in time and cost in other areas and has the following advantages over the existing concrete system:

- The building's weight will be considerably reduced by switching to steel, which will in turn allow the size of the foundations to be reduced. Since the foundations are belled caissons extending 70 feet with a maximum diameter of 15 feet, a smaller caisson size will result in significant savings in concrete.
- The steel system will be easier to construct, because it will not be needed to use the formwork and shoring necessary for the concrete flat plate floor system. This will also reduce the construction time.
- Due to the added strength and versatility of structural steel, the beams will be able to span larger distances, which could allow a decrease in the number of columns. This will produce savings in material costs.

There are also several considerations other than the floor framing to take into account about the structural system when changing the structural material. As already stated, the foundations will need to be resized due to the decrease in building weight. In addition, the lateral resisting system will need to be redesigned. The current system incorporates both concrete moment frames and shear walls. The concrete moment frames will need to be replaced by steel frames. It may also be necessary, however, to investigate a lateral system comprised solely of steel moment frames or bracing, in order to eliminate the need to tie the steel beams into the concrete walls. A steel lateral system would require much less material to be used, because the shear walls and large grade beams underneath would be eliminated.

Despite the advantages of the new composite steel system, it will also have some drawbacks that need to be taken into account when determining the system's effectiveness as a replacement.

- The steel system will require additional fireproofing, which could increase both time and costs. It will need to be determined what the new fire rating for the building will be and if a sprinkler system is needed.
- The larger section depth of the steel system will result in an increase in overall building height. This extra height will cause an increase in building costs for the exterior cladding materials.
- The new steel lateral system will require more complex connections for the moment frames that will result in additional time and cost.

Solution Methods

The design of the new structural steel system will be based on provisions from AISC LRFD 3rd Edition. The gravity floor framing sizes will be determined using RAM Steel. These sizes will then be used to create a three dimensional model in ETABS to analyze the lateral system. The special connections used for the moment frames in the lateral resisting system will be checked by hand.

Breadth Study

When changing the building material, there are more factors to consider than just the structural concerns. The new structural system will impact several other building systems, such as the lighting, electrical, and mechanical systems. The breadth study for the building redesign will focus on two discipline areas.

The first discipline considered will be a construction management breadth study to produce a cost estimate and construction schedule of the new system. R.S. Means will be used to determine the material and labor costs and construction activity durations. This information will be used to compare the new and existing system to determine the efficiency of the new steel system.

The second breadth study will analyze the building's acoustics. The acoustics are a concern when switching the building's material, because the new material will have a different Sound Transmission Class. The new system will need to provide the same if not better sound isolation as the existing system. The sound transmission will be analyzed between the residential dwellings, and also between the retail and residential portions of the building. The transition between retail and residential is a critical area, because the retail area will have a higher sound level and require a greater barrier to isolate sound from the residential dwellings.

Summary of Tasks

Task 1: Structural Redesign

A. Set up a layout for the new columns and floor framing of the steel system.
B. Use RAM Steel to layout the typical floor plan and determine steel sizes.
C. Verify lateral loads and recalculate the seismic loads with the new building weight.
D. Construct a three dimensional ETABS model of the building using the sizes determined by RAM Steel.
E. Design moment connections for the lateral resisting system, using hand calculations.
F. Estimate new sizes for the belled caissons based on the new building weight.

Task 2: Construction Management Breadth Study

A. Calculate a cost estimate of the new structural system using R.S. Means.
B. Estimate the construction schedule of the new system.

Task 3: Acoustics Breadth Study

A. Determine acceptable sound transmission values for the residential and retail areas.
B. Determine the Sound Transmission Class of the material used in the floor assembly.
C. Consider noise reduction alternatives if necessary.

Schedule

Week #	Dates	Tasks
1	1/8 – 1/14	1A, 1B
2	1/15 – 1/21	1C, 1D
3	1/22 – 1/28	1D
4	1/29 – 2/4	1E, 1F
5	2/5 – 2/11	1E, 1F
6	2/12 – 2/18	2A, 2B
7	2/19 – 2/25	2A, 2B
8	2/26 – 3/4	3A, 3B
9	3/5 – 3/11	Spring Break
10	3/12 – 3/18	3B, 3C
11	3/19 – 3/25	Technical Report
12	3/26 – 4/1	Technical Report / Presentation
13	4/2 – 4/8	Final Paper due Wednesday 4/5
14	4/9 – 4/15	Presentations begin Monday 4/10