EDENWALD NEW TOWER

Thesis Proposal

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EXECUTIVE SUMMARY

The Edenwald New Tower is a 12-story building located in Baltimore, Maryland. Designed as an addition to an existing 15-story tower, its 253,000 square feet were designed to meet the demands of a continuous care retirement community for total project cost of $52 million. The project scope includes 60 apartments and 32 assisted living units, 4 levels of parking, as well as amenities such as an indoor pool, an enclosed walking track, a fitness center, a pub & lounge, a chapel, a great room and more.

The Edenwald addition's structural frame is comprised of flat-plate, post-tensioned concrete slabs supported by concrete columns and shear walls. The building is enclosed with a combination of brick veneer, precast concrete panels, and glass windows and curtain walls.

The area of interest for the proposed thesis design revolves around the building's main lateral force resisting system: 15 ordinary reinforced concrete shear walls. It was determined that when the building was in its initial stages of design, the code being adopted was IBC 2000. Accordingly, seismic analysis was performed according to this code. However, in the years since then ASCE-7 05 has become the most recently released code governing seismic design, as IBC currently directly references ASCE-7. Significant changes have been made to the code in the seismic chapters governing the S_1 and S_s values with which the seismic response coefficient, C_s, is calculated. The older code has much more stringent requirements, meaning that if the building was designed under the current code, seismic may not have controlled and the number and size of the shear walls would most likely have been reduced.

The goal of this thesis proposal is to redesign the main lateral force resisting system according to loads determined from ASCE-7. At the same time, alternative wall locations will be investigated to reduce the significant amount of torsion that the current design must handle due to the high eccentricities on each floor. Since the new code will likely allow for a reduction of the number of walls, reducing eccentricities by changing the wall arrangements (and thus reducing torsion) is quite feasible.

The proposed breadth studies include architectural and mechanical designs to reconcile the problems that will occur in each of their current designs from the revised layout of the shear walls. More can be found on these topics below.

STRUCTURAL SYSTEM OVERVIEW

Foundation:
The geotechnical analysis of the sub-surface conditions prior to construction revealed great variances in soil type and depth to bedrock, ranging from 50 to 150 feet deep, making deep foundations impractical. Given two recommendations from the geotechnical engineer, it was decided by the designers to use a geopier system as opposed to an alternative of driven HP 12x74 piles. Comprised of densified "rammed" stone aggregate piers, geopiers are referred to as "intermediate foundation systems" in that they strengthen, stiffen and reinforce soil layers beneath the building. The use of this option provided the opportunity to utilize a shallow foundation system of typical spread footings. (It should be noted, however, that pre-existing utilities only discovered upon excavation in the north end of the site required the use of the HP piles, in that localized area only.) The geopiers were determined to require a 30 inch diameter, and range from 20 to 30 feet in length. The allowable bearing pressure of the strengthened soil beneath the building was then determined to be 6 ksf beneath the tower, and 4 ksf beneath the parking garage. Total settlement expected from the geopier design amounts to one inch.

All concrete used in the Edenwald New Tower is normal weight (145 pcf dry unit weight). Footings, grade beams and slabs on grade have a minimum 28-day strength of 3000 psi. Shear wall footings have a minimum 28-day strength of 4000 psi. The slab on grade is reinforced with 6x6-W2.9x2.9 WWF on a vapor barrier on 4 inches of granular subbase.

Floor System:
The typical floor system used is a 9 inch, post-tensioned concrete slab having a minimum 28-day strength of 5000 psi. In specific locations where the post tensioned system is not feasible and/or practical, reinforced one way slabs were used, ranging in thickness from 8 to 9 inches, with cast in place concrete beams, both requiring a minimum 28-day strength of 5000 psi.

Roof System:
The flat roof system is almost identical to the typical floor system. Still utilizing the post-tension reinforcement, the slab thickness reaches up to 16 inches underneath the penthouse. The penthouse is supported by a steel braced frame and is covered by 1.5 inch deep, wide rib, 20 gage galvanized metal deck. The pentouse roof is supported by a combination of steel W shapes and 12k3 joists. The columns supporting the penthouse are W8x31 shapes.

Columns:
The building is supported by rectangular concrete columns laid out in a geometric grid. The columns range in size, the most common being 22x22 and 22x36. The largest column found in the building is 22x60. Column loads range from 203 kips in the garage to 1600 kips at the base of the tower. From the ground level to the seventh floor, the columns are required to have a minimum 28-day strength of 6000 psi. From the seventh floor to the roof, that value decreases to 5000 psi.

Lateral System:
The building is laterally supported in both the N-S and E-W directions by a total of 15 simply reinforced concrete shear walls, with thickness ranging from 12 to 14 inches. These shear walls are required to have a minimum 28-day strength of 5000 psi. Located throughout the building, the shear walls are often conveniently placed around stair and elevator shafts. All but one of the 15 shear walls run the entire height of the building.

PROBLEM STATEMENT

According to RGA, the structural engineer on record for the Edenwald New Tower, the design was performed according to IBC 2000, not IBC 2003, as listed. This was due to the fact that the design was started prior to the release of the new code, and so checks were made to ensure that the building was not in violation of the updated code. However, both of these codes reference more stringent seismic design than does the new code, as seen from the disparity between the S_S and S_1 provided and those determined in Technical Reports 1 and 3. Using the current code, ASCE-7 05, it can be determined that with the updated S_S and S_1 values, the C_s value used to determine the base shear drops from 0.022 to 0.01 – a 50 plus percentage decrease in the seismic base shear. (IBC 2006 directly references ASCE-7 05, a change from older versions of IBC.)

Additionally, the locations of the shear walls were dictated by architectural constraints and were not placed in the most efficient manner possible, creating significant eccentricities and thus significant torsion which the shear walls had to resist. These eccentricities and shear wall locations can be seen in the figure on the next page.

PROPOSED SOLUTION

The proposed enhancement design for the Edenwald New Tower is to redesign the building's main lateral force resisting system. The goal is two-fold: first to reduce the number and/or size of the walls needed by recalculating the loads derived from ASCE-7 05, and second to reduce torsion by exploring alternative locations for the shear walls. As it stands, the building is reinforced with 15 shear walls, varying from 12 to 14 inches in thickness. Eliminating some of these would save the owner a significant amount of money.

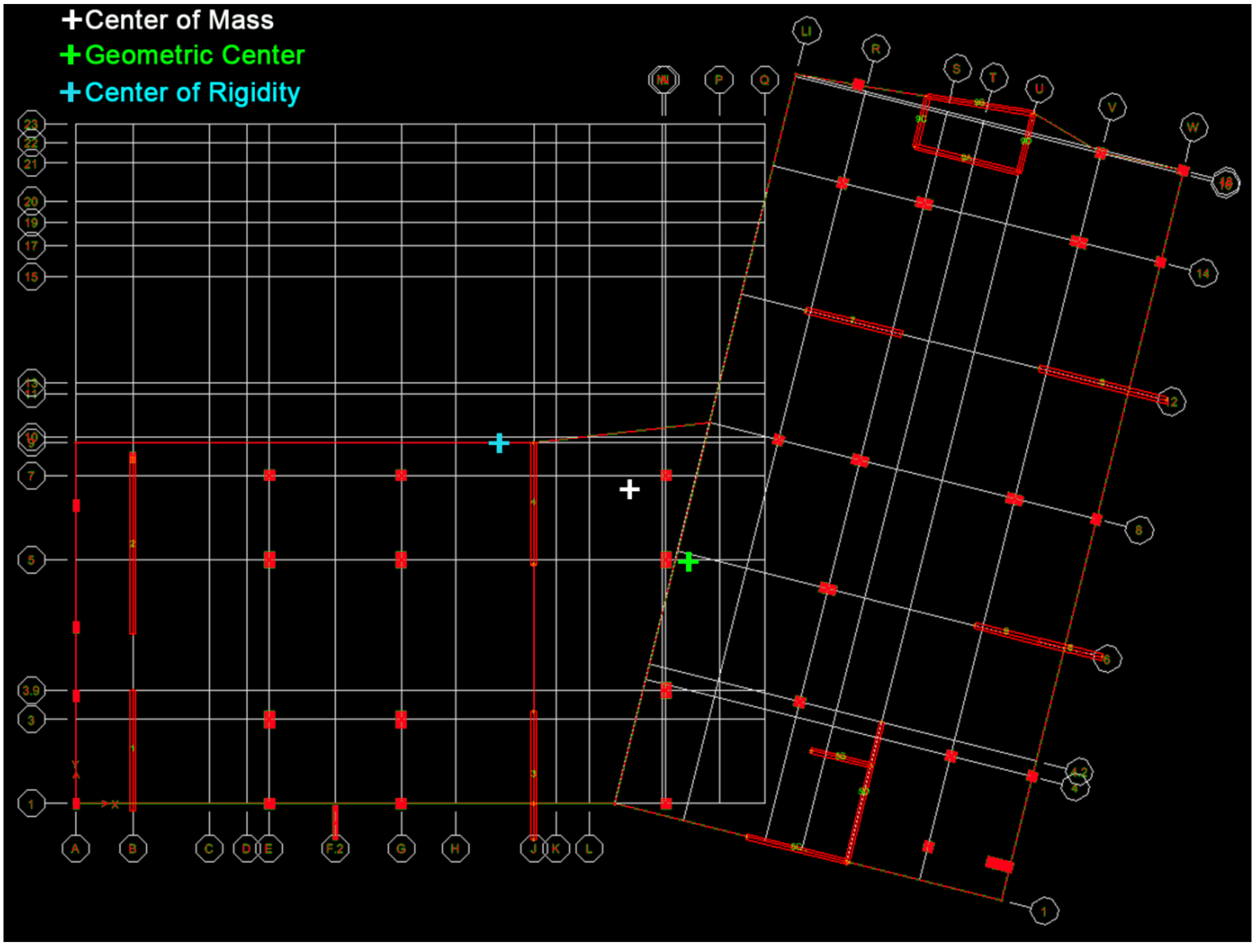
Using the updated C_s value of 0.01, the base shear from seismic forces drops to 470 kips. Since the original base shear was near 1000 kips, it can be expected that wind will become the controlling condition and the number of shear walls needed will become less.

Currently, the east wing has very little stiffness provided in the North-South direction. It is clear in the figure below that the eccentricities mentioned above exist mainly the East-West direction, and so another wall along column line W would bring the center of rigidity eastward, reducing torsion. At the same time, reducing the number of walls in the western most part of the building would also be advantageous.

There is one significant drawback to this solution, and that is the changes which will be necessary to the floor plans. More will be spoken of this in the breadth sections below.

The proposed solution would also include a comprehensive cost analysis of savings incurred from the redeveloped shear wall design.

TYPICAL FLOOR PLAN



BREADTH TOPICS

Architecture:

Changes to the layout of the shear walls will obviously affect the floor plans of each level. If the location of each shear wall is calculated with the aim of minimizing eccentricities in the building, then the shear walls will take priority in a revised floor plan. It will be the goal of this breadth study to reconcile a typical tower floor plan with the redesigned shear wall placements. It will be determined whether the given typical floor can still achieve what the as-designed floor plans do, or whether sacrifices in the architecture would have to be made to accommodate the revised shear wall placements. It is important to keep in mind that the new load conditions will reduce the number of walls necessary, and it is hoped there will be additional flexibility in the new placements when considering the space saved in the reduction of the total number of walls.

Mechanical:

The movement of the shear walls is likely to cause problems for MEP systems that are run through the areas of change. The goal of this breadth is to review the design of the mechanical systems, specifically the ductwork. The ducts will be redesigned and rerouted on a typical floor to adjust to the new structural layout as needed. Additionally, where changes in the placement of the ducts are encountered, they will be resized to most efficiently meet the demands of the new design. Lastly, the ductwork will be checked for acoustical performance to determine whether insulation is needed to reduce noise created from potential high airflow through narrow cross sections.

TASKS

Structural

1A: Contact RGA to discuss issues they faced in design
1B: Redevelop ETABS model to include gravity loads
1C: Calculate torsion in current design for every wall at every floor
1D: Develop new load cases from ASCE-7
1E: Derive required stiffnesses
1F: Hand calculate size and placement of shear walls to align center of rigidity with geometric center, or two reduce distance between the two as much as possible
1G: Use ETABS to model changes in shear wall locations
1H: Calculate torsion in revised design for every wall at every floor
1I: Redesign any necessary changes in column grid
1J: Redesign any necessary changes in post tensioned tendon design
1K: Finalize Report

Architectural

2A: Determine requirements of typical floor
2B: Discuss options with Professor Holland
2C: Redesign typical floor plan in AutoCAD

Mechanical

3A: Reroute ductwork for typical floor
3B: Calculate airflow requirements for typical floor
3C: Size Ductwork
3D: Determine acoustical effects of airflow

SCHEDULE

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
1A	■	■	■											
1B	■	■												
1C			■											
1D				■										
1E					■									
1F					■	■								
1G							■							
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