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**STRUCTURAL OPTION
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AE 481W
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**555 12TH STREET
OAKLAND, CALIFORNIA**



REVISED THESIS PROPOSAL

Executive Summary

BUILDING DESCRIPTION

555 12TH Street is a 21 Story, 300 foot, 487,000 square foot complex that features class-A office space, retail space, and dining in one location. The majority of framing is structural steel W-shapes with a composite metal deck. The lateral system is a combination of eccentric braced frames at the core, and special moment resisting frames on the perimeter. This is a dual system acting in both major axes directions.

PROPOSAL

The gravity systems and lateral systems were looked at previously and determined to be excellent choices given the buildings location, size, and required floor plan. However, I propose to use a core only concrete shear wall design for the lateral system. This will allow the open floor plan to be kept, and may allow for a reduction in foundation size.

SOLUTION

Removal of moment frames and eccentric braced frames to allow for the core-only system. The adequacy of this design to resist the high seismic base shear in Oakland, CA will be evaluated. ETABS will be used to model and analyze the building, along with the guidelines from ASCE7-05.

BREADTH TOPICS

An investigation to the impact on overall cost, schedule, and constructability of each alternative will accompany the depth worth. Also, a lighting design of a typical office floor layout, or exterior LED's will be performed. An architecture breadth will also be considered if the alternate structural system has a large impact.

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INTRODUCTION

555 12th Street is a 21 story, 487,000 square foot complex that features Class-A office space, retail space, and dining in one covenant location. Located in the heart of downtown Oakland, California, the building provides great views of the San Francisco Bay, as well as the East Bay Hills. It is one of several buildings that make up what is known as the Oakland City Center. Its use of vision and spandrel glass on the façade, mixed with precast concrete panels, compliments the surrounding landscape and architecture perfectly.

The building was completed in April 2002 after two years of construction, and is owned by the Shorenstein Company. Korth Sunseri Hagay Architects was hired to lead the architectural design of the building while Nishkian Menninger Inc. was in charge of structural systems design. Charles Pankow Builders were the general contractor in charge of the \$75,000,000 design-build project. There are two levels of underground parking available on site, a ground floor plaza, nineteen elevated office floors, and a mechanical floor. Each office floor has a gross area of 24000 square feet with the stairs, elevators, and HVAC towers located in the core of the building. The main support columns occupy the core and the perimeter walls which allow for a column free work space for tenants.

BACKGROUND

Foundation:

The foundation was designed based on soil reports by URS Greiner Woodward Clyde, dated April 13, 2000. The soil bearing capacity was found for three different load combinations. For dead load, dead + live load, and dead + live + earthquake, the capacities are 5000, 7500, and 10000 PSF respectively. A surcharge load at street side was calculated as 150 PSF. All concrete for the foundation has a 28-day strength of $f'c = 4000$ PSI. The reinforcing steel is ASTM A615 GR 60 deformed bars.

Over 650 truckloads of concrete – 24 Million lbs.- were required to pour the mat foundation. The foundation has a 5 foot thickness near the exterior walls, and transitions to 7 feet thick as it approaches the interior core. The entire mat is reinforced with #9 @ 8" Top EW and #10 @ 8" Bottom EW.

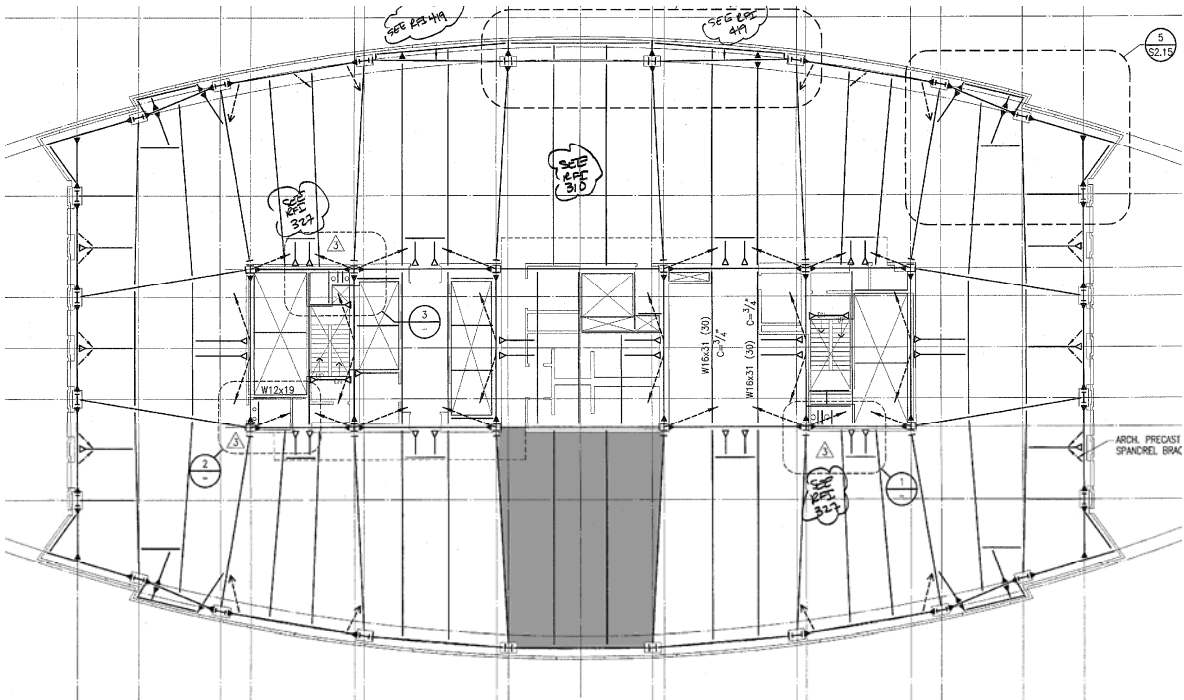
Spread and continuous footings are used to support the columns of the parking garage and first floor columns that extend beyond the footprint of the elevated floors. Spread footings, 3' thick and reinforced with #5 @ 12" Top EW and #9 @ 8" Bot. bars EW are used to support the interior columns of the parking garage. Their sizes range from 10' to 20' for both length and width. Typical exterior and interior wall footings are continuous and 2'-6" thick. They are reinforced with #6 @ 14" bars T&B EW, unless otherwise noted.

Columns:

Most of the columns in the building are part of lateral resisting frames. They will be described in that section. They attach to base plates and anchor to the top of concrete columns that run from the foundation up to the first floor. The EBF concrete column is 4'x4' reinforced with (40) 1 3/8" diameter DYWIDAG treaded bar(ASTM722) and #5 @ 3" Ties Baugrid. The SMRF frame concrete columns vary in size from 3' to 3'-9" square. They larger columns are reinforced with (20) 1" diameter DYWIDAG with #5 ties @ 3". The 3' columns are reinforced with (20) #11 vertical and #5 ties @ 3". TS 8x8x3/8 are used typically as columns for the 21st floor up to the roof for the mechanical floor. All frame concrete columns are required to have a 56 day strength of $f'c = 7500$ PSI.

All non-frame gravity steel columns range from W14x109 at the 21st floor, up to W14x500 at ground level. The canopy columns at the 1st floor are W14x53 and W14x48. The base plates are 30"x30"x3" with (4) 1 1/2" Anchor bolts with 24" embedment.

Floor Systems:



Typical Elevated Floor Framing and Plan

A 4" slab on grade(SOG) reinforced with #4 @ 18" EW is placed over a layer of class 2 aggregate fill, over the mat footing. All other SOG is 6" thick, reinforced with #4 @ 12" EW typically. All concrete for the SOG has a strength of $f'c = 4000$ PSI. Floors for level P1 and the 1st floor are cast-in-place(CIP) one way slab systems, supported by precast and CIP members. The thickness ranges from 6-12", depending on location, and reinforcing varies from #4-#7 bars @ 12" T&B.

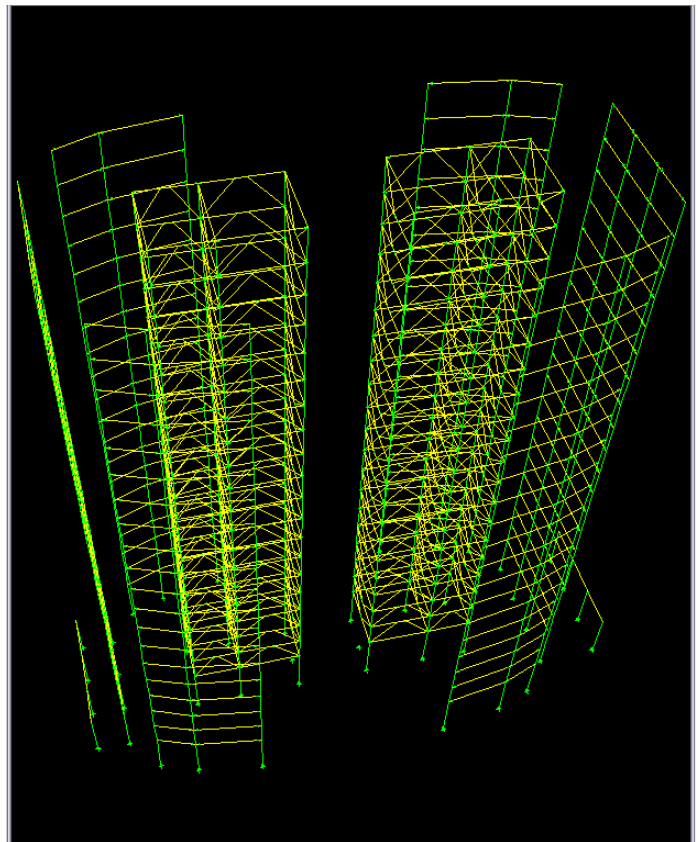
The majority of the structural system is designated as ASTM A992, Gr 50 steel, unless otherwise noted. The building takes advantage of two lines of symmetry, one in the N-S direction, and the other in the E-W direction. The typical floors, 2-21, have the same framing, unless otherwise noted. The elevated slabs are supported by wide flange beams with varying lengths, the longest being about 44', because of the curved exterior wall. They are typically W18x35 up to W18x55, unless otherwise noted.

The girders, which are not part of the moment frames, are sized from W24x55 up to W27x84 and span at the greatest, 35'. Smaller W-shapes are used on the interior core area to support the slabs. The 22nd floor-mechanical floor has the same location of beams and girders, but different sizes. The typical beam is a W24x55 up to a W24x94. The typical girder is slightly larger, being a W27x84 on the exterior wall, and W30x124 on the interior core. The roof uses W12x22 up to W21x44 for its beams and girders, along with TS shapes for exterior beams, sized as TS10x8.

The elevated floors, starting from level 2, are composite metal deck systems. The 2nd floor is 3" 18 gage composite decking with 4" of normal weight concrete cover. It is reinforced with #4 @ 16" EW. Typical floors 3-21 are 3" 18 gage composite deck with 2 1/2" of normal weight concrete cover. The slabs are reinforced by either #6 @ 13" EW or WWF6x6 W1.9. The mechanical room on the 22nd floor, along with its mezzanine level, uses a variety of composite decking. There is either 3"-16 or 18 gage composite deck with up to 7" of normal weight concrete over it. Reinforcement is typically #4 @ 12" unless otherwise noted. The roof uses 3"-18 gage composite decking with 2 1/2" of lightweight fill. It is reinforced with #3 @ 16" EW.

Lateral System:

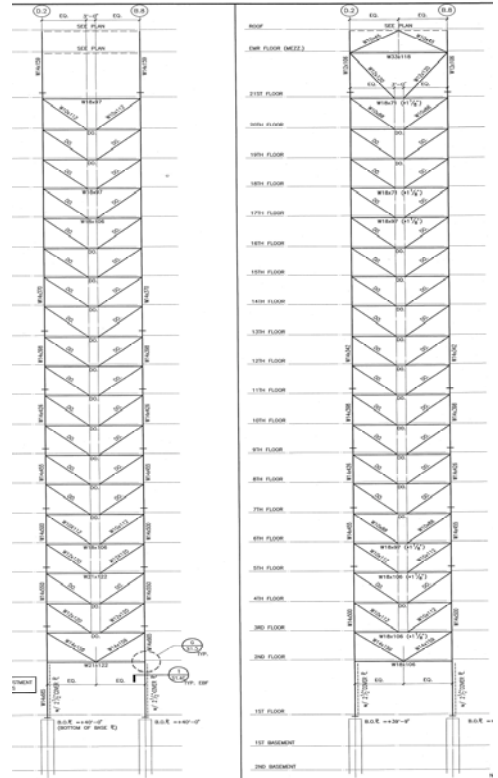
The lateral system of 555 City Center is considered a dual system in the N/S and E/W directions. Dual systems are systems with shear walls and/or braced frames and moment frames working in parallel to resist lateral forces. The building has a steel braced frame core and Special Moment Resistant Frames (SMRF) at the perimeter. From the basement to the 2nd floor, a concrete shear wall core was utilized to help stiffen the structure at the first floor, which has a high floor-to-floor height of 24 feet. A steel braced frame was used from level 2 through the roof. The steel braced frame "jamb" columns extended into the concrete shear wall. A more detailed description of each component of the lateral system is provided on the next page.



Eccentric Braced Frames (EBF)

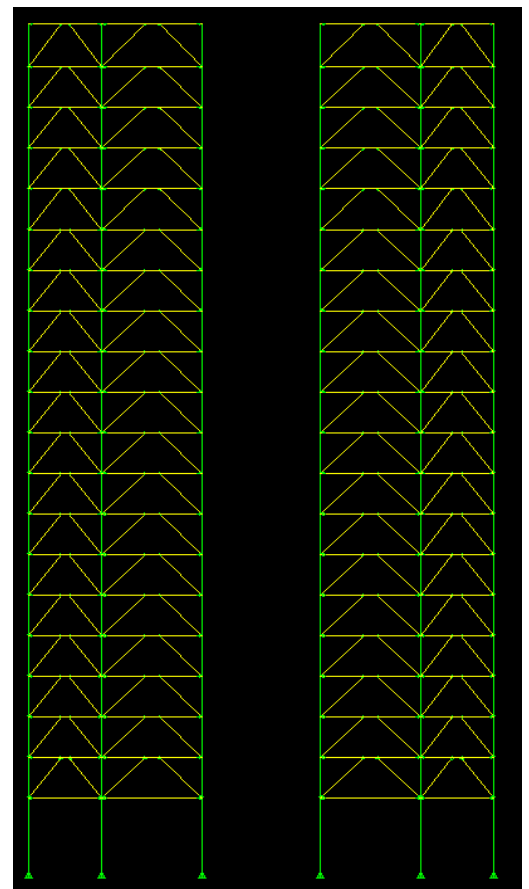
- *North-South direction*

These frames are fairly typical, and run from just below the first floor, all the way up to the roof. They occupy one bay width, 31'-4", from B.8-D.2, and there are six of them. The following frames are similar; EBF 1 and 6, EBF 2 and 5, and EBF 3 and 4. The heaviest column members are located at the bottom, and are a robust W14x665. They progressively get smaller as they reach the roof, where they have fell to W14x106 or W12x159, depending on the gridline. The beams spanning the brace also depend on which EBF it is, but range from W18x71 to W21x122, from top to bottom. Lastly is the lateral bracing, which makes it an eccentric braced frame. These members form an upside down trapezoid with the columns and beams. Their sizes range from W10x88 up to W14x159 at the bottom. On all EBF's, a distance of 3' in the middle creates the eccentricity. This 3 foot section allows for energy absorption due to cyclical loading from lateral forces.



- *East-West Direction*

There are four of these frames in the E-W direction. They are all similar, and use the same sized members. Two of them are located between 3.3 and 4.9 on gridlines B8 and D2, and the other two are located between 6.1 and 7.8 on gridlines B8 and D2. Columns for these frames are shared with the EBF's in the N-S direction. Beam sizes range from W16x57 to W18x97, and brace sizes range from W8x58 to W14x159. These braces form right-side up trapezoids between columns, the opposite as the N-S. There is eccentricity of 2'-6" and 4' on the link beams that allow for energy absorption from cyclical loading. This eccentricity also allows for doorway and elevator openings in the walls.



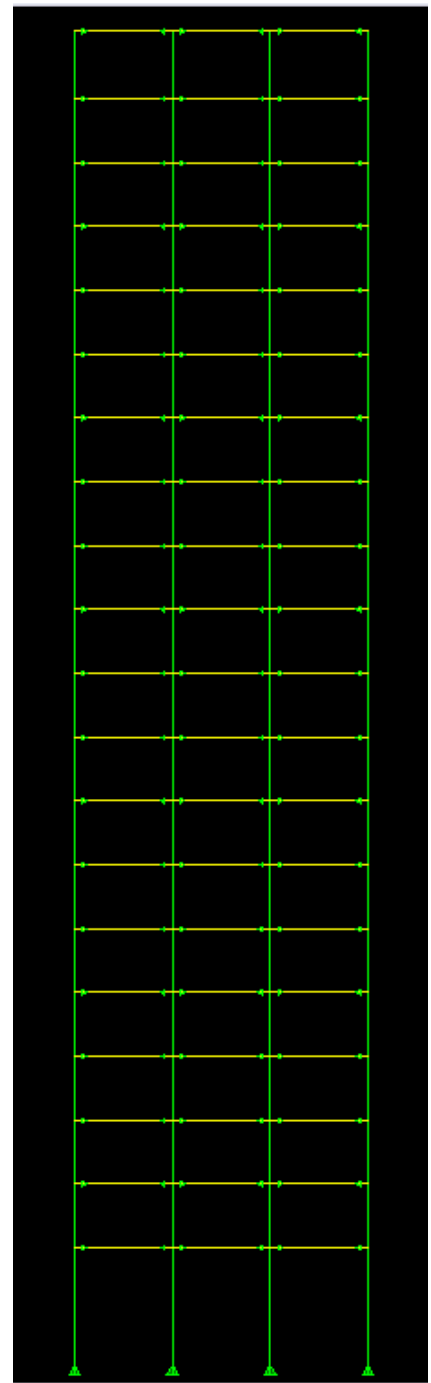
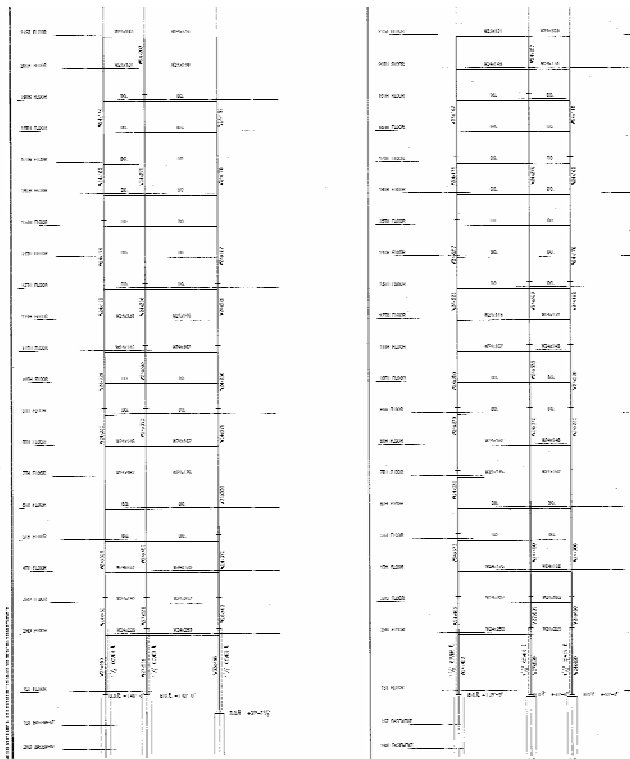
Top: EBF (E/W Faces)
Bottom: EBF (N/S Faces)

Special Moment Resisting Frames (SMRF)

Moment frames have good ductility and are more flexible than braced frames. All connections within the frames are moment connections. These frames are located on the perimeter walls of the building. Four of these frames are located on the curved portions of the North and South faces, and the other four are on the East and West faces. Two on the E-W faces only go from the first to second floor, as represented by the larger first floor footprint, compared to the upper levels. The other two go all the way to the roof. These frames use only W shapes for beams and columns. Beams for the N-S faces are W24's and the columns range from W24-W33. On the E-W faces, for the frames that reach the roof, there beams are W33's and columns are sized W36's.

Shear Walls

The shear walls provide stiffness to the eccentric frames of the core at the first floor level. The shear walls are located directly under the EBF frames, and occupy the same gridlines. They run from the mat foundation up to the second floor, where they meet the beams of the frames. They are typically 24" thick and reinforced with #6 @ 12" each face each way, unless otherwise noted. 25" thick walls exist on the grid lines D2 and B8. All core shear walls are required to have a $f'c = 5000$ psi



Above: SMRF (E/W Faces)
Left: SMRF (N/S Faces)

PROBLEM STATEMENT

555 12th Street in Oakland, California is located directly near a major fault line on the west coast. The design spectral response acceleration parameters for short and long period range are 240.95% and 94.95%, which create great demand on the lateral force resisting system; much more than from wind. The dual system used to distribute lateral loads in 555 12th Street gives it a high response modification factor of 8 for the use eccentrically braced frames and moment frames. The high modification factor decreases the seismic response coefficient, and in turn, the overall base shear to the building. This is an effective solution that the designers used based on code requirements and location of the building. It was also determined from the technical report on alternative floor systems, that a composite steel beam frame is the most efficient gravity system. It does not appear to be worth while to investigate alternate floor systems other than composite beam.

The floor plans of the building are set up to create large column free work space, where supporting elements are found in the core, and perimeter. This core is the most logical location to provide the lateral resisting system.

The complexity of the dual system of braced frames and moment frames is something that has not been encountered before in the architectural engineering program. I will investigate the original system to gain a better understanding of how loads are distributed to each component.

The connections for the moment frames and EBF's are costly and labor intensive. It is proposed that a core-only concrete shear wall design be designed to eliminate this. These new systems will be designed based on the most recent codes of the International Building Code, ACI 318 for concrete, and ASCE-7, as well as supplementary material on lateral systems in high rises and high seismic regions.

PROBLEM SOLUTION

The existing lateral system will be analyzed further with the aid of the computer model, already started in ETABS. Consultation with the structural engineer of the building will help in determining accuracy of assumptions and calculations performed by hand.

The proposed concrete shear wall system will be designed to provide adequate strength, stiffness, and energy dissipation capacity to withstand the design ground motions within the prescribed limits of deformation and strength demand. Collector elements will be designed to adequately transfer seismic forces originating in other portions of the structure to the shear walls, which provide resistance to those forces. This system will come with a decrease in the response modification factor, from 8 to 5, and may increase seismic base shear. If an efficient shear wall system cannot be designed, a dual system using concrete shear walls and moment frames will be used.

SOLUTION METHOD

Trial shear wall and collector sizes will be determined with hand calculations. These will be designed based on ACI 318 for structural concrete design. While working with Technical Report Three, a computer model of the building was completed using ETABS. ETABS is a finite element program that can be used to analyze buildings subjected to various load combinations. The model has errors, but was saved so that they could be fixed, and used for future work. A working model with concrete shear wall core will be completed, and a dynamic analysis will be implemented. The ETABS results will be based on the LRFD load combinations, and the ASCE7-02 for gravity and lateral loads.

BREADTH OPTIONS

Construction Management

Changing the lateral system of the building will have an impact on construction time, material cost, and foundation cost, among other things. A cost analysis of each system will be performed with references to RS Means Catalogs, along with schedule effects and issues with constructability.

Lighting

The façade of the building is almost entirely composed of spandrel and vision glass. It could be beneficial to research day lighting issues and a lighting design for a typical office floor of the building. Also, creating an LED lighting design for the exterior of the building could be possible with the aid of available computer programs.

Architecture

Changing the core from steel to concrete may require changing the layout of a typical floor plan. Appropriate changes will be made if necessary. Also, a typical layout of a possible office environment will be made up in AutoCADD.

TASKS AND TOOLS

Phase I. Depth Studies

- Task 1. Verify Wind and Seismic Loads
 - a) Use ASCE-7 chapter 6 – Analytical Procedure for Wind
 - b) Use ASCE-7 chapter 9 – Equivalent Lateral Force for Seismic
- Task 2. Determine Trial Member sizes with Hand Calcs
 - a) Use ACI 318 to determine shear wall sizes
 - b) Use ACI 318 to determine collector sizes
 - c) Determine replacement members for steel moment frame
- Task 3. Test Concrete Shear Wall lateral system
 - a) Reconfigure ETABS model for Shear Wall
 - b) Refine original ETABS dual system
 - c) Compare analysis of both systems
- Task 4. Foundation design
 - a) Determine new foundation loads
 - b) Design new foundations if loads are different

Phase II. Breadth Studies

- Task 4. Construction Management
 - a) Determine site layout plan
 - b) Create cost estimates with RS Means and MC² software
 - c) Use Project Primavera to create schedule for project
 - d) Compare original and new designs
- Task 5. Lighting
 - a) Determine day lighting issues
 - b) Model interior lighting system
 - c) Model exterior LED lights
- Task 6. Architecture
 - a) Determine if changes from structural affect architecture
 - b) Layout typical office space with moveable partitions, etc.

Phase III. Completion

- Task 6. Final Report and Presentation
 - a) Draft final report
 - b) Powerpoint presentation
 - c) Clean up website

SCHEDULE

This is a preliminary schedule of when I hope to complete main items.

Week of	15-Jan	22-Jan	29-Jan	5-Feb	12-Feb	19-Feb	26-Feb	5-Mar
Revise Proposal and get final approval								
Determine Superimposed Live/Dead Loads								
Determine trial shear wall sizes and locations								
Determine Trial Collector beam sizes								
Refine ETABS model of original lateral system								
Create ETABS model of new lateral system								
Run analysis of models under lateral loads								
Analyze foundation size for new design								
Construction Manage. Breadth Work								
Week of	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr
Architectural Breadth Work	S P							
Write/Review Final Report	R I							
Print/Bind Final Report	N G							
Create Powerpoint Presentation	B							
Practice Presentation and Revise Slides	R E							
Present for Faculty and Friends	A K							
Final CPEP Updates and ABET Eval/Reflection								

CONCLUDING REMARKS

Using a core only concrete shear wall design may require a peer review because it is in a high seismic region. Height limitations can affect what lateral systems can be used according to code. If it cannot be shown that a core only system is a viable option, the dual system of concrete shear walls and exterior moment frames will be implemented.