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

THESIS PROPOSAL

Executive Summary

BUILDING DESCRIPTION

555 12TH Street is a 21 Story, 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. Because of this I propose to redesign a dual lateral system for 555 12th Street. This will allow the open floor plan to be kept, and for seismic base shear to be reduced because of the high response modification factor of 8 for a dual system.

SOLUTION

Several alternatives of lateral system will be investigated, to find an efficient system that satisfies strength and drift criteria. Removal of moment frames and eccentric braced frames will be investigated, as well as different bracing configuration within the braced frames. Other designs that surface during investigation will be looked at as well. ETABS and RAM Advanse will be used to model 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.

*This proposal is subject to change

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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.

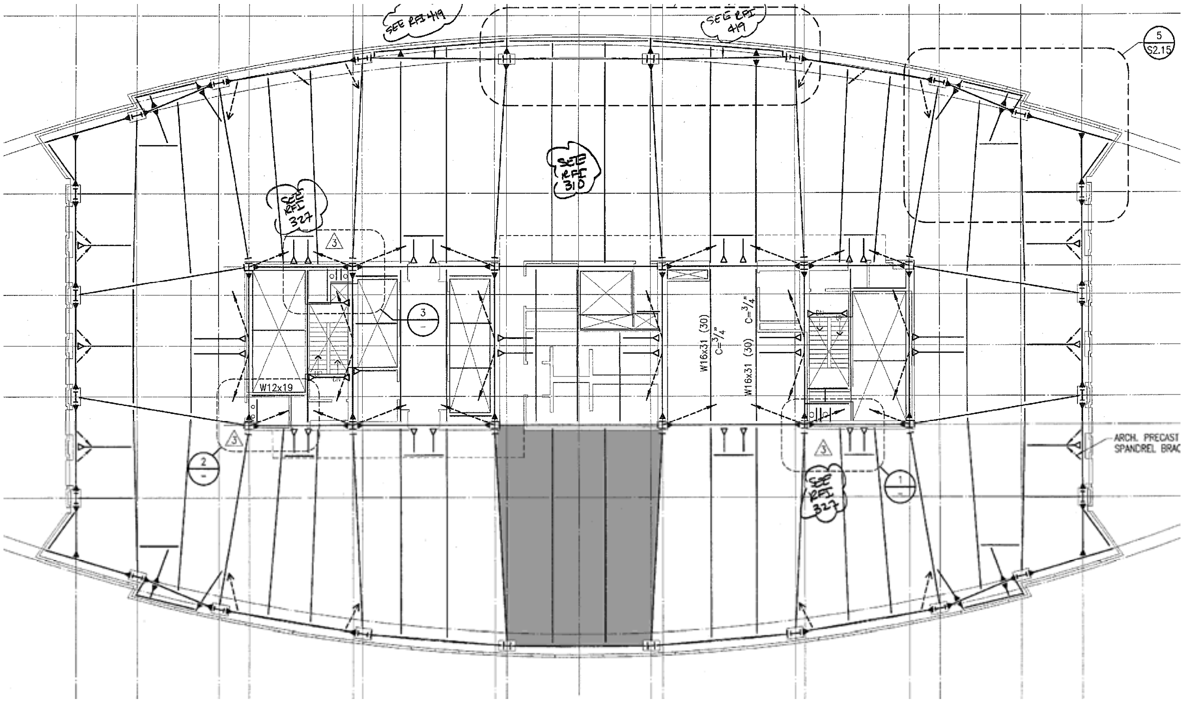
Spread and continuous footings are used to support the columns of the parking garage and first floor columns that extend beyond the footprint of the elevated floors. Spread footings, 3' thick and reinforced with #5 @ 12" Top EW and #9 @ 8" Bot. bars EW are used to support the interior columns of the parking garage. There 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 ½” 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.

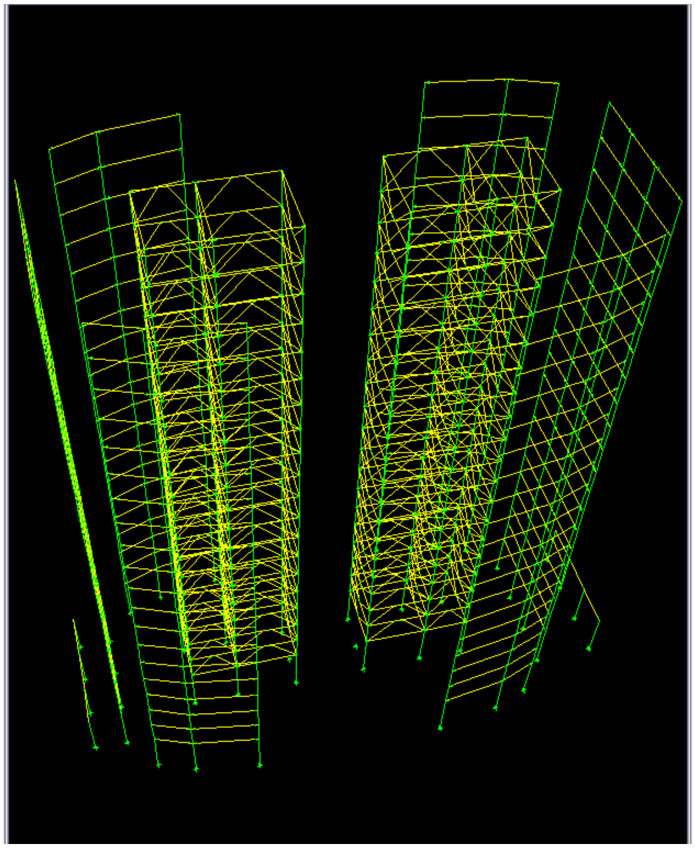
The majority of the structural system is designated as ASTM A992, Gr 50 steel, unless otherwise noted. The building takes advantage of two lines of symmetry, one in the N-S direction, and the other in the E-W direction. The typical floors, 2-21, have the same framing, unless otherwise noted. The elevated 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 ½" 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 ½" of lightweight fill. It is reinforced with #3 @ 16" EW.

Lateral System:

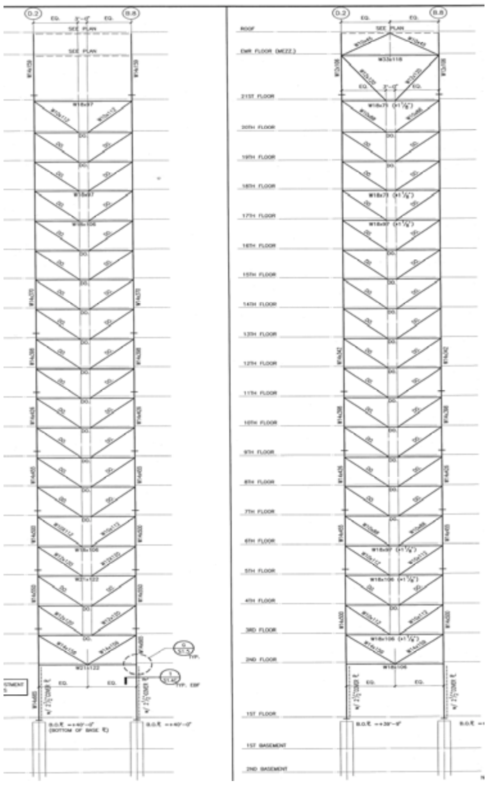
The lateral system of 555 City Center is considered a dual system in the N/S and E/W directions. Dual systems are systems with shear walls and/or braced frames and moment frames working in parallel to resist lateral forces. The building has a steel braced frame core and Special Moment Resistant Frames (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)

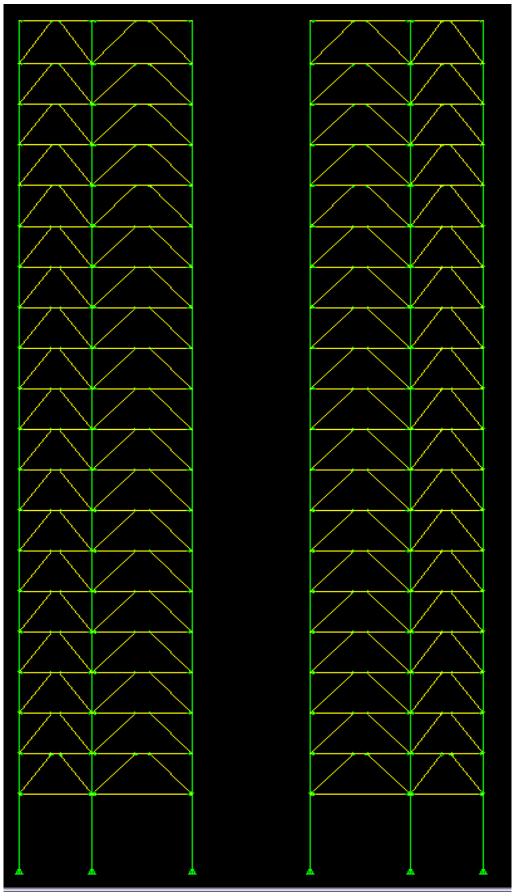
- *North-South direction*

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 knee 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. The collector portions of the frames are 2’-6” and 4’ and allow for energy absorption from cyclical loading. This eccentricity also allows for doorway and elevator openings in the walls.



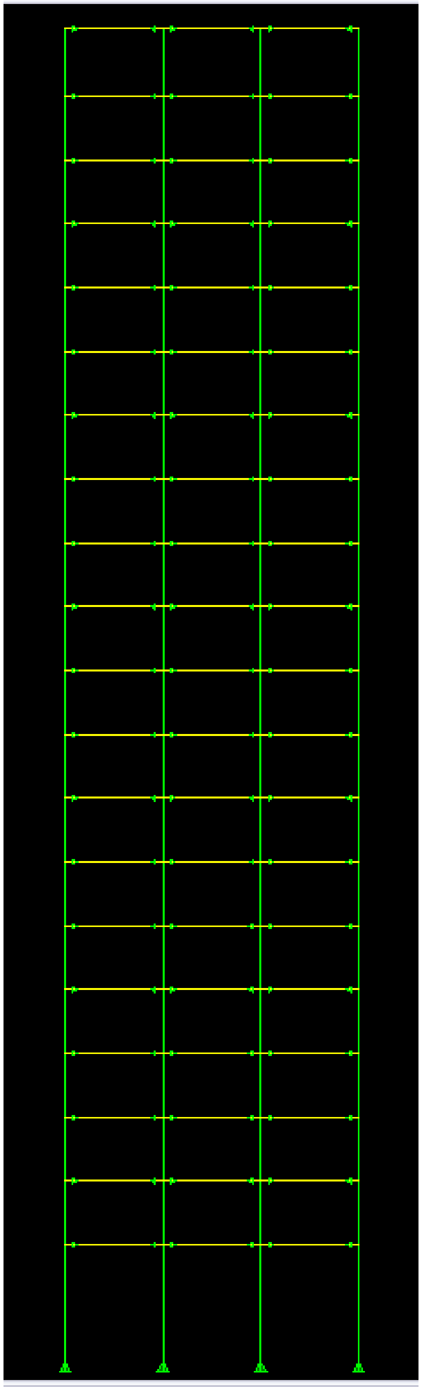
Top: EBF (E/W Faces)
Bottom: EBF (N/S Faces)

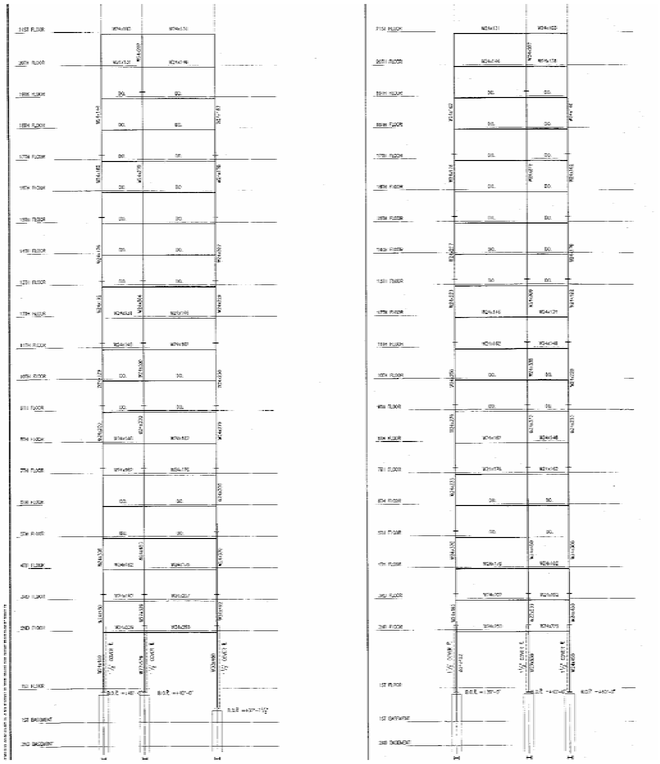
Special Moment Resisting Frames (SMRF)

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 short and long period response values 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 limits possible alternatives to the lateral system, where columns would be needed else where.

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 propose further investigation of the original system to gain a better understanding of how loads are distributed to each component. Also, I propose to investigate alternative designs of the lateral system to maximize efficiency and possibly decrease the amount of braces needed, or number of moment connections.

These new systems will be designed based on the most recent codes of the International Building Code, 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. From that model, strength and drift of frame members will be evaluated, to determine loading on the members. Consultation with the structural engineer of the building will help in determining accuracy of assumptions and calculations performed by hand. With this information, an investigation into the following alterations will occur:

- Removal of Moment or Eccentrically Braced frames
- Removal or rearrangement of braces of the braced frames
- New layout of moment frames and braced frames

If braced frames or moment frames are shown to take a relative low percentage of load, it could be economical to remove these frames altogether, and increase the size of the remaining frames. Also, changing the arrangement of braces to a diamond formation could be economical because it will decrease the number of beams that have eccentric connections. Once a working model is completed, each of these solutions can be tested, and then compared on the basis of constructability, cost, and efficiency.

SOLUTION METHOD

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. Also, individual frames were modeled using RAM Advanse v.6.0. These same programs will be used to achieve a working model of 555 12th Street. If they are found not to be accurate, other programs are available that could be used. Once a working model is complete, alternative layouts and lateral systems can be tested and compared to one another. The ETABS results will be based on the LRFD load combinations, and the ASCE7-02 for 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.

*Breadth Options are still open to change

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 distribution of Lateral Loads
    - a) Input loads into ETABS with load combinations
    - b) Run Analysis
    - c) Spot Check Critical Members
- Task 3. Test Alternative Lateral systems
    - a) Reconfigure ETABS model for each variation
    - b) Run analysis and compare

Phase II. Breadth Studies
- Task 4. Construction Management
    - a) Determine site layout plan
    - b) Create cost estimates with RS Means and MC^2 software
    - c) Use Project Primavera to create schedule for project
    - d) Repeat for each alternative researched
- Task 5. Lighting
    - a) Determine day lighting issues
    - b) Model interior lighting system
    - c) Model exterior LED lights

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 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Verify gravity and Lateral Loads	🟥	🟥						
Get Working ETABS Model		🟥	🟥	🟥				
Determine Distribution of lateral Loads				🟥				
Test Alternative Lateral Systems				🟥	🟥	🟥		
Compare Results and spot check						🟥	🟥	🟥
Investigate Construction Management Breadth							🟥	🟥
🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14		
Investigate Lighting Breadth	SP.	🟥	🟥					
Compile Final Report	B		🟥	🟥				
Create Powerpoint Presentation	R E			🟥	🟥			
Present for Faculty and Friends	A K					🟥		

CONCLUDING REMARKS

Because of the positives of using a dual system in a high rise in a high seismic region, and the high base shear of the building, it will be beneficial and economical to stick with it. Also, the ASCE7-02 limits the type of system that could be used in the building, because of its 306 foot height.

If the lateral resisting frames layout changes, it will prompt a change to the floor system. I propose an alternate layout of composite beams in the elevated office floors of the building, if this occurs.

A more specific proposal pertaining to the lateral system redesign will follow after this semester has concluded.