

101 *Eola*



Thesis Proposal – Revision 2

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101 Eola Drive, Orlando, FL

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Executive Summary

101 Eola Drive is a 12 story, 130 foot tall precast concrete structure located in the heart of Orlando, Florida. The building features 7 floors of luxury condominiums, 3 levels of spacious covered parking, and retail shops on the ground floor.

Gravity framing is provided by precast concrete hollowcore planks supported by unique concrete truss beams, which are placed on every other floor and also transfer forces due to wind and seismic loads between long direction shear walls and the central core as part of the lateral resisting system.

The primary goal of this thesis project will be to redesign the structural system of 101 Eola. The current precast hollowcore plank floor construction will be utilized within a steel frame structure instead of the current precast concrete construction. The

massive concrete trusses that are unique to this project will be redesigned as staggered steel trusses with the same load carrying capabilities. The concrete parking area will be retained as such due to bay spacing and design restrictions, as well as cost impact. The shear walls will also be redesigned as steel braced frames capable of resisting both the gravity loading and lateral loading of the structure. Once the redesign is complete, the new structure will be assessed for its ability to resist the application of lateral forces on the building.

The secondary goal of this thesis project is to investigate two breadth topics beyond my structural option. The first investigation will be a study of the impact on the building cost and schedule that will result from the changes made to the building's structural system. Comparisons between the cost and schedule of the existing and proposed systems will be made and evaluated for feasibility and value engineering. The second investigation will be a study of the feasibility of this building achieving a LEED rating. Some important efforts have already been made in the building to achieve occupant comfort and energy savings. A few credits will be investigated in depth to determine if, with a few key additions, this building could join the growing community of "green" buildings.

These activities will give me experience in the design of a steel structure. I will also gain a deeper appreciation for the cost and schedule implications of choosing a structural system. Finally, I will apply my knowledge of sustainable building design to a real world situation.



101 Eola Under Construction: *Courtesy of Finrock Industries*

I. Existing Structural System

Foundation System

The site for 101 Eola Drive is located in the Central Floridian Aquifer region. The soil in this area can generally be described in terms of three sedimentary layers. The superficial layer is composed of fine sands. This is underlain with a layer of clay, clayey sand, phosphate, and limestone which are locally referred to as the “Hawthorn Group.” This layer is underlain with limestone bedrock. The results of ten test borings, drilled 50 feet to 100 feet in depth, indicated the subsurface soils would be suitable to support shallow spread footings after subsoils had been improved with vibro-replacement stone columns, a process where a probe is advanced into the soil and gradually removed while backfilling the space in lifts with crushed stone, then vibrated to densify the soil/stone matrix.

Footings are placed on top of groups of the stone columns, which are grouped and positioned according to the size of the footing they support. Footings are either a spread design (shear walls, core, and columns) or a continuous strip footing (east wall and retaining wall). Depths range from 12” to 39”.

A slab on grade is used as the ground floor level with a minimum thickness of 5”, typical, and a 8” slab on grade in the loading dock area, with expansion joints no more than 15 feet apart.

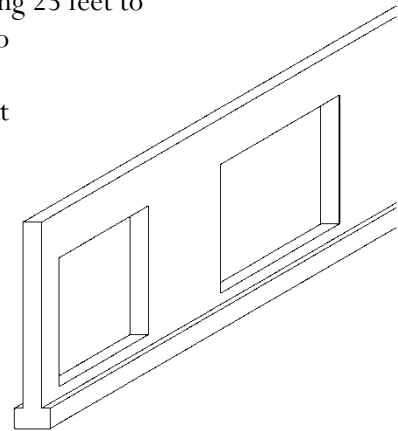
Typical Floor Framing

There are several variations in the floor framing of 101 Eola, depending on their location and usage characteristics. Most floor elements consist of precast double tee beams or hollowcore planks.

The ground floor consists of slab on grade construction and areas of exposed soil behind precast retaining walls. 6 inch equipment pads are placed beneath mechanical and electrical equipment on top of this slab. Additionally, ramping for the parking structure begins on this level with precast double tee beams supported by precast walls on either end.

Floors 2 thru 4 comprise an open air parking facility. Construction is precast double tee beams with single tee beams at edge spans and periodic intervals between double tees. Corbels on precast walls are stepped and rotated to eliminate need for blocking in order to support sloped garage ramps. Average span is 62 feet E-W, but spans range from 20 feet to 68 feet in length depending on location. Floor 3 also adds precast flat slabs above the loading dock (used for storage) with span of around 23 feet. Floor 4 is typical of floor 2 with the exception of 12 foot wide precast single tee beams spanning 23 feet to support a pool and hot tub located on the 5th floor roof. These tees are also covered with a 6” structural concrete topping slab.

At floor 5, the entire building profile steps back an average 10 feet and the upper levels take shape. An accessible roof with pool and hot tub is located on the south side roof. Roof area construction is a mixture of precast flat slabs, single tee beams, and hollowcore planks with a C.I.P. topping sloped to roof drains. Interior floor makeup is 8” thick hollowcore slabs. These slabs span N-S with length 25’-5” to 26”-7”, and are supported by unique precast trusses 45’-0” in length that attach to the lateral shear wall system to transfer shear loads (see illustration to right). These truss beams have a height of 12’-0”, and are placed on every other floor. E-W edge planks are supported on the exterior wall by precast beams 2’-8” in width. Precast flat slabs form balconies on the exterior edges of the structure,



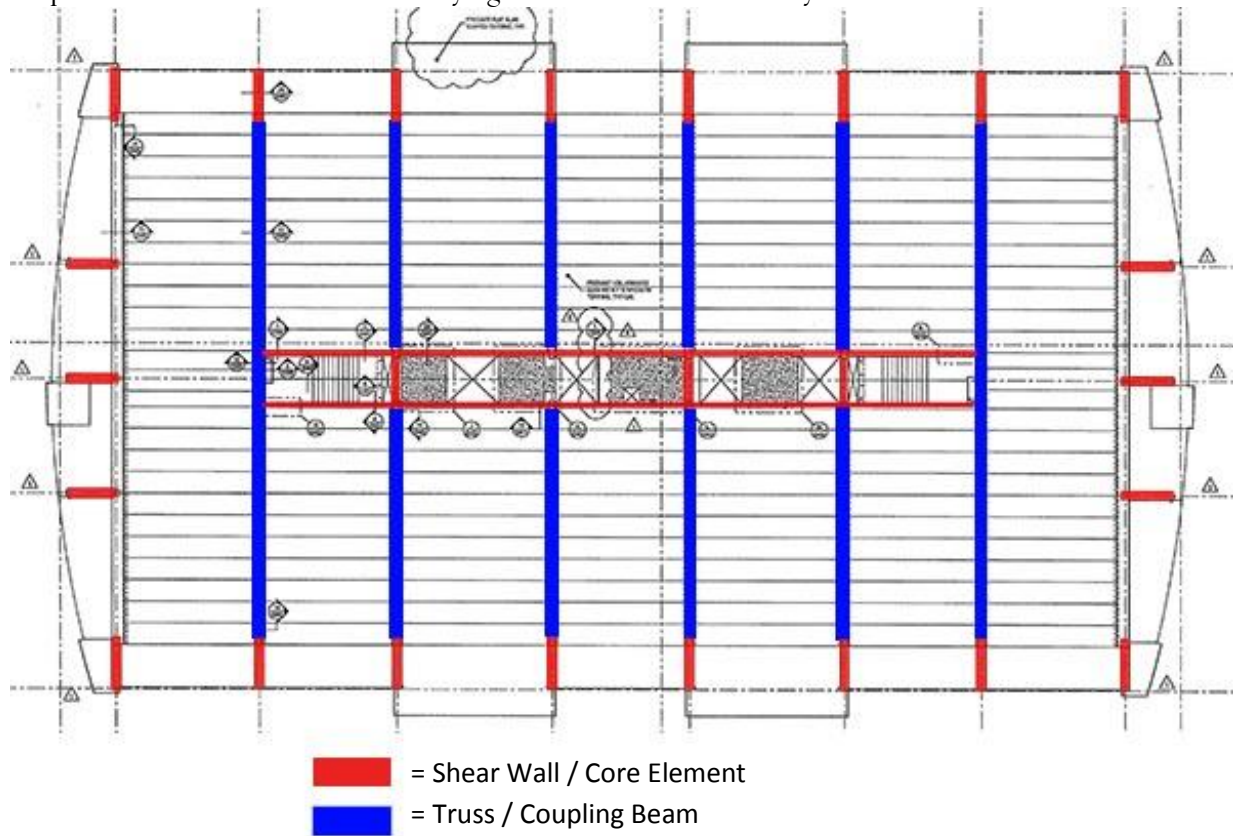
spanning between the shear walls that run up the building's exterior. Please refer to the appendix for a floor plan illustrating the system layout.

For more information on the existing floor systems of 101 Eola, please refer to Technical Report 2.

Lateral Load Resisting System

101 Eola has an extensive lateral load resisting system that is comprised of 16" thick shear walls around all sides of the building. These walls also act as the principle gravity load carrying elements as well for the exterior of the building. The east and west sides of the structure contain 8 shear walls with spacing ranging from 21'-5" to 24'-7" apart. The north and south sides employ 3 shear walls 21'-2" apart. These shear walls run vertically up the side of the structure all the way to the roof and become an integral part of the building's architectural facade. From ground level to level 4, the walls are 18'-6" in width. As the structure steps back at level 5, the shear walls also step back, reducing to 9'-2 1/2" in width. At penthouse and roof levels, east-west shear walls reduce further, in some spots to only 3'-0" in width. For further reference see page 11.

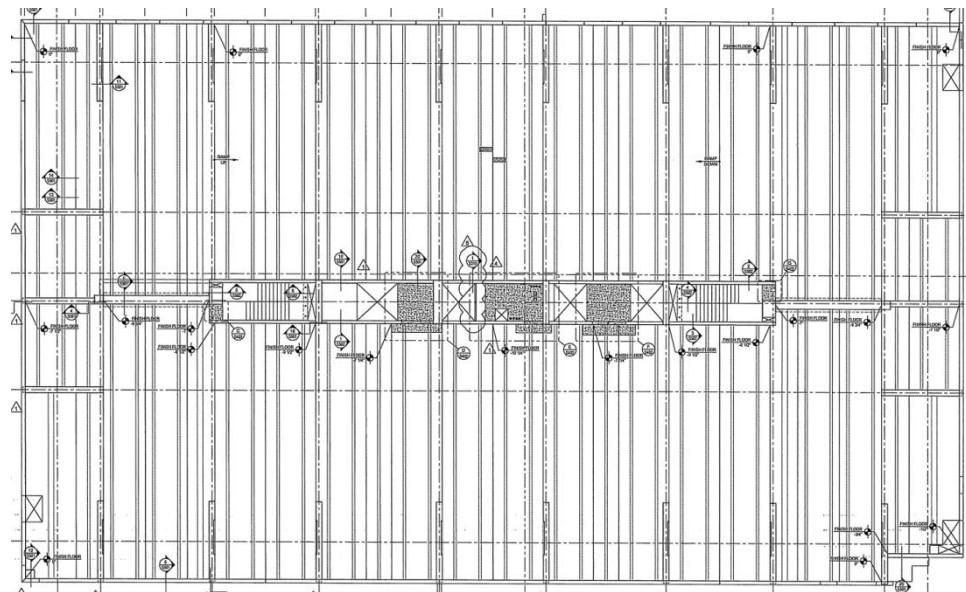
The precast concrete core of the building contains stair towers and elevator shafts, also provides some lateral resistance. Walls are 8" thick in this long narrow core that runs north-south, and 3 internal shear walls running east-west provide shear force transfer between the precast trusses that connect the exterior E-W shear walls on every other floor. Precast L beams handle tying the external edge of the east-west system to the north-south shear walls. Please refer to the appendix (pg 19 and 20) for a detail of these unique trusses and shear walls. A clarifying illustration of the lateral system can be found below.



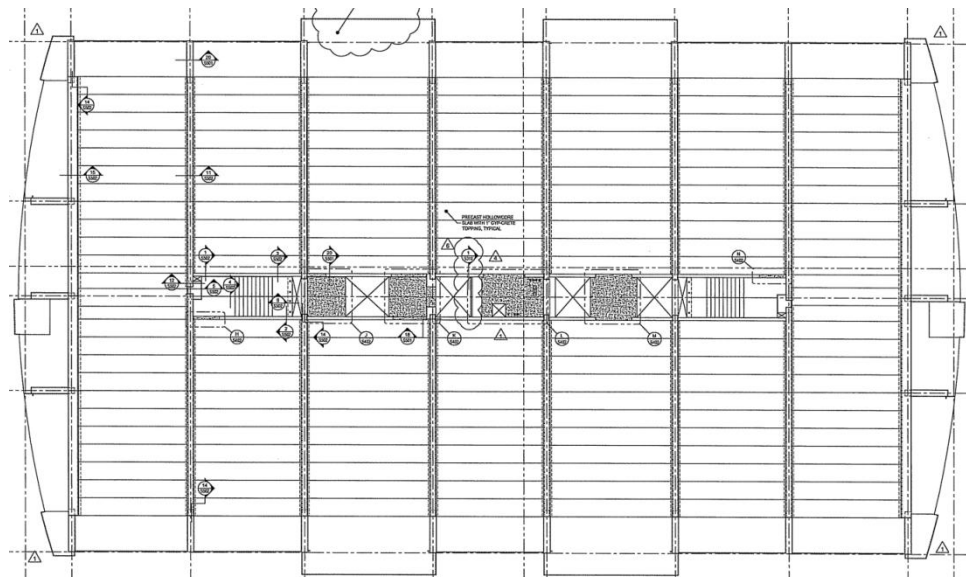
Gravity Load Carrying System

As stated above, the shear walls around the exterior of the building act as the main gravity load carrying system as well. The load is carried from the floor system (double tee beams or hollowcore/flat slabs) to the precast trusses and edge beams, and then into the shear wall system or the central core. In addition to these elements, there are miscellaneous columns in key places in the structure. One 24”x24” column in each corner of the west elevation runs vertically until reaching the 5th floor step-back in order to carry the corner load. Corner loads on the opposite side of the building is carried by precast walls that run monolithically up to the 5th story as part of the system that carries the pool and hot tub loads. 2 columns of the same size assist in carrying load surrounding a large garage door on this elevation also. The two main supporting columns in the structure are at either end of the central core strip. Each precast column is 36”x48”. Typical plans and sections are shown below for reference.

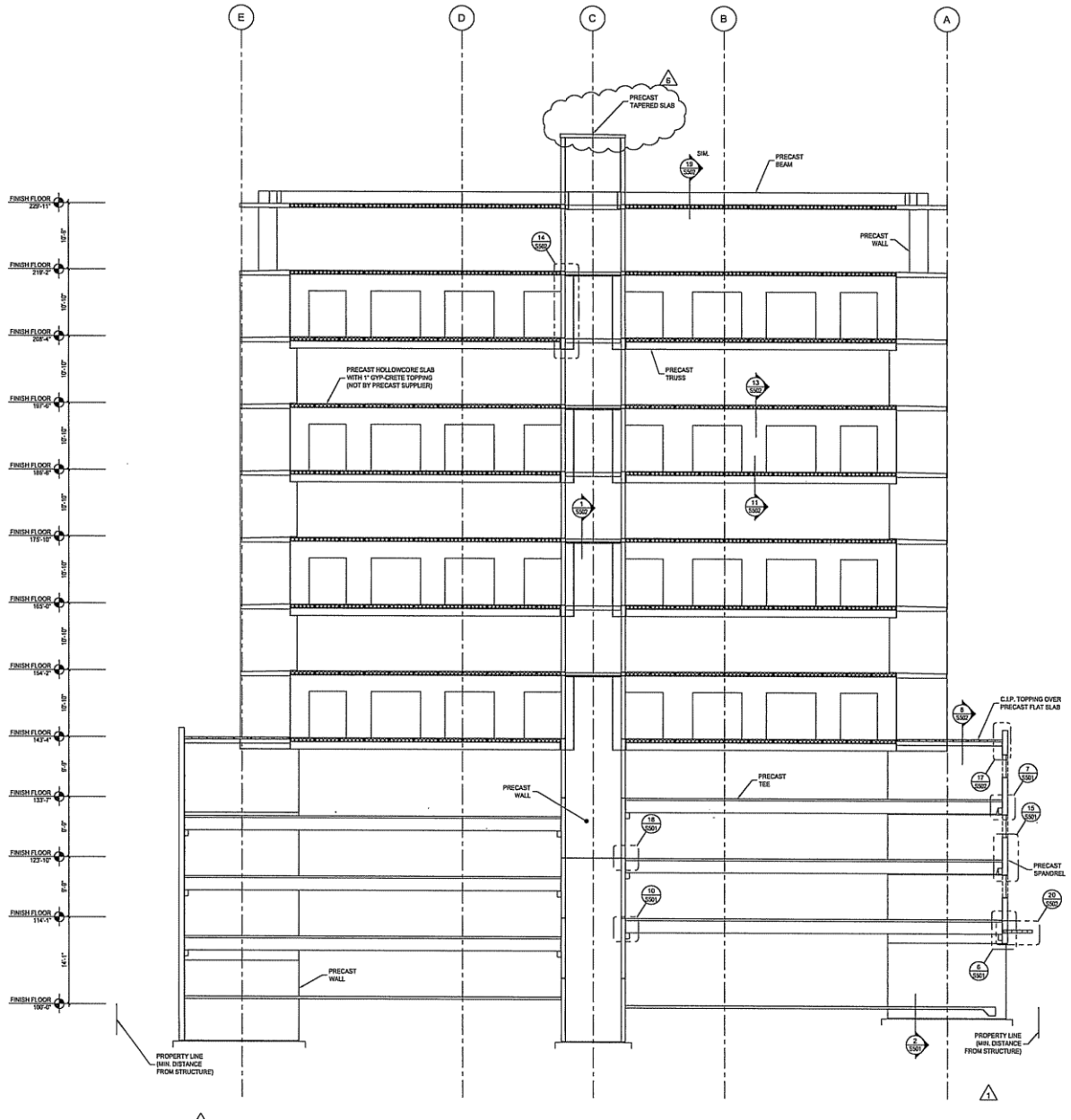
Levels 2-4:



Levels 5-12:



E-W Building Section (lateral system)



II. Problem Statement and Proposed Solution

Problem Statement

When 101 Eola was originally conceived, it was designed as a cast-in-place concrete structure. The change to the current design of precast concrete elements saved the owners over \$1 million in construction and material costs. Being the principle structural building material in the Orlando area, concrete was the favored choice for the owners. However, this may not be the most economical and efficient choice for the building's structural needs. The shear mass of some of the concrete elements tend to suggest another material might be more economical to serve these needs. Since column-free tenant spaces are important to this project, it is not acceptable to shorten the spans and to add columns. At the same time, since the current design places the trusses within the partition wall system, depth is not an issue for elements placed in the same location. This opens up the possibilities of structural systems to other materials.

Another big issue with precast concrete construction is the reduced ability to place holes for infrastructure to pass through the structural elements. Any penetrations have to be submitted before the construction and engineered around since they must be cast at the same time as the piece of concrete. Holes cannot be drilled or cut later without clearance from the designing engineer, as well as careful and tedious measurements to avoid cutting through pre-stressing cables.

Some efforts have already been made to reduce energy usage and increase occupant control and comfort within the building. These efforts can be added to however to make the building more eco-friendly, a design idea known as sustainable or "green" building. With a few seemingly small efforts this building can be viewed as a sustainable structure, paving the way for future green building ventures in the surrounding area and adding credibility to the structure in the design community.

Problem Solution

Structural Depth Solution

A steel structural system seems to be a viable alternative to the current precast concrete system. The unique, massive concrete trusses that span from the central core to the outer shear walls, a distance of over 45 feet, could possibly be replaced with steel trusses, eliminating the problem of infrastructure penetrations. It will take in-depth analysis to determine whether a steel truss is capable of spanning this length while carrying 2 floors of hollowcore planks as well as lateral forces between shear walls.

By retaining the current precast concrete hollowcore planks as the floor construction with the steel trusses, a thin, lightweight floor system is retained while allowing for the long, open floor plans specified by the owners and demanded by the tenants occupying the luxury condominiums. Depth of the trusses is not an issue if placed in the same location as the concrete trusses, and may in fact cause the wall thickness to decrease, increasing floor area.

The remainder of the structure will be retained as designed. I originally was investigating a redesign of the lateral shear walls using steel braced frames in their place. However, after further research, I have eliminated this from my thesis work. The concrete shear walls currently play a large role in the aesthetic properties of the building. Reproducing this using steel braced frames would require some type of covering solution. This is neither cost effective nor desirable, especially when it must match the rest of the building's exterior.

Construction Management Breadth Solution

The decision to use a precast concrete structural system was originally determined to be the economical one for the area where the site is located. Although the site was congested towards the end of the project, the design saved the owner over \$1 million in construction and material costs over the previously designed cast in place concrete construction (according to the precast concrete provider). Changing the precast concrete construction to steel would not pose much of a change in the situation, since steel also requires a staging area. It is unknown at this point how a steel system will affect the schedule, but it is expected to be somewhat comparable because it has the same erection and welding requirements as a piece of precast concrete. The biggest impact is expected to be in the cost. Using the information obtained from a cost and scheduling analysis, a recommendation will be made regarding which system provides the optimal solution.

Sustainability Breadth Solution

It is the goal of many designers today to design buildings to be ecologically friendly. This sustainable or “green” building design is now looked upon as the future of the construction industry, to the point of having awards for the level of effort the building’s design makes to protect and conserve the rapidly decreasing natural environment. Especially in a city setting, the trends of such things as green areas being paved over and diminished air quality are of growing concern. Sustainable design hopes to change this or at least hinder its progress.

101 Eola already has a significant start towards achieving a rating as a “green” building in this highly regarded practice. The LEED (Leadership in Energy and Environmental Design) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high-performance green buildings. The checklist contains 69 possible achievement credits in sustainable design. A minimum of 26 is required to become certified as a green building.

Items already incorporated into 101 Eola’s design that count toward credits include instantaneous water heaters beneath each lavatory, individual fan boxes for each condominium, large floor to ceiling windows, and the latest in energy saving appliances. A study will be performed to determine whether a LEED rating is achievable for 101 Eola considering that the construction has already been finalized, and what sort of impact achieving some of the credits may have on the building and costs.

III. Tasks and Methods

The following tasks will be completed during the spring semester to obtain the global goals just mentioned. These tasks may be completed in parallel for a faster completion time. Please see the proposed schedule beginning on page 12.

Structural Depth

A. Redesign Gravity System with Steel Truss

1. Form preliminary design of steel truss to support hollowcore floor w/ superimposed loads using AISC Design Guide 14 – Staggered Steel Trusses.
2. Estimate truss self weight
3. Determine lateral influence from wind and seismic loads that pass through truss
4. Distribute forces through truss elements
5. Size elements to meet design needs using STAAD
6. Recompute self weight
7. Recheck design using new self weight loads
8. Check deflections using STAAD
9. Check Foundation Impact

Construction Management Breadth

A. Perform detailed cost comparison between existing and proposed systems

1. Obtain actual cost information from GC and precast company, if possible.
2. Perform takeoff of existing structural system.
3. Perform takeoff of proposed structural system using R.S. Means and professional input.
4. Include fire protection and other additions required with steel system.
5. Adjust for location.
6. Compare the two takeoffs.

B. Perform scheduling comparison between existing and proposed systems

1. Obtain actual scheduling information from GC and precast company, if possible.
2. Analyze site for usage issues that could be related to scheduling.
3. Establish time requirements
4. Create a new schedule using Primavera or MS Project
5. Compare new schedule with original

Sustainability Breadth

1. Complete preliminary LEED Checklist using current building data
2. Determine feasibility of other credits
3. Investigate a few credits in depth for feasibility and application
4. Investigate impact on building cost and schedule to implement LEED standards
5. Establish whether 101 Eola can realistically become LEED rated.

IV. Proposed Schedule

The following timeline indicates what aspects of the thesis will be addressed during different weeks. Important intermittent deadlines are noted in boldface. Each intermittent report will be submitted for review and comment before its inclusion into the final report.

January						
	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Week 1	14	15	16	17	18	19/20
	- Design Steel Gravity Trusses (Staggered Truss System)					
Week 2	21	22	23	24	25	26/27
	- Design Steel Gravity Trusses - Investigate Steel Lateral Trusses Progress Report					
Week 3	28	29	30	31	1	2/3
	- Gravity Truss Design					
February						
	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Week 4	4	5	6	7	8	9/10
	- Gravity Truss Design - STAAD Model					
Week 5	11	12	13	14	15	16/17
	- STAAD Model Go/No Go Progress Report					
Week 6	18	19	20	21	22	23/24
	- Retrieve Cost & Schedule Information - Cost takeoff for proposed system - STAAD Model					
Week 7	25	26	27	28	29	1/2
	- Structural Report - Cost takeoff for existing system					

March						
	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Week 8	3 - Review / Catch up - Foundation Impact Analysis - Structural Report	4	5	6	7	8/9
Week 9	10 ----- Spring Break -----	11	12	13	14	15/16
Week 10	17 - Cost & Schedule Analysis - Sustainability Study - LEED Checklist	18	19	20	21	22/23
Week 11	24 - LEED Checklist - Construction Management Breadth Report - Sustainability Breadth Report	25	26	27	28	29/30
April						
	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Week 12	31 - Final Report Assembly	1	2	3	4	5/6
Week 13	7 - Prepare Presentation - Final Report Due	8	9	10	11	12/13
Week 14	14 -----9am 107 EUA----- ----- Final Presentation -----	15	16	17	18	19/20

V. Conclusions

During the upcoming spring semester, a complete redesign of the existing structural system will be performed. The redesign will be evaluated for its ability to resist gravity and lateral loads. The cost and schedule implications of the redesign will be analyzed and evaluated. An investigation of the feasibility of this building achieving a LEED certification will also be investigated.

These activities will have several main outcomes. The first is that I will gain experience in the design of a steel structure. This experience will diversify my abilities and help prepare me for practicing engineering and for the professional engineering exam. The second is that I will gain a deeper appreciation for the cost and schedule implications of choosing a structural system. Developing an understanding for the construction management side of the structural system selection will make me a more marketable structural designer. Finally, I will take a look at the LEED rating system as it pertains to this building and note any improvements in the building's design that would allow it to achieve such a rating, increasing my experience in the sustainable design market.