Pearl Condominiums

9th & Arch Street
Philadelphia, PA

Thesis Proposal

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Structural Option

http://www.engr.psu.edu/ae/thesis/portfolios/2008/jgl138/

Executive Summary

Pearl Condominiums is located on 9th and Arch Street in Philadelphia, Pennsylvania. This structure is a mixed use development building. The building includes a retail floor at the ground level containing 10 units and five floors of housing above containing a total of 90 condominium units. One of the main design considerations for the site was the location of an existing SEPTA commuter rail tunnel which runs under the site.

The gravity system of this building is comprised of load bearing walls and precast concrete planks. The main component in the lateral system is the use of concrete masonry units as shear walls in the stair towers and the elevator core. The ground floor contains moment frame to transfer lateral loads from the stair tower shear walls which end on the second floor. Finally, the use of metal stud walls with metal strapping is used to help resist lateral load in the east to west direction of the building. From research and analysis comprised during this semester the existing structural system used in Pearl Condominiums, was a very efficient and economical construction type to use for this type of building.

The purpose of this paper is to propose an alternative structural system for Pearl condominiums. The major factor influencing the redesign is the use of interior load bearing walls. For the redesign, they will be eliminated, which will result in a more flexible floor plan. This objective will be completed through the structural breadth study of the flex frame system to be used as an alternative to the wall and plank type of construction. The flex frame is composed of a special type of steel beam called a d-beam. The d-beam is created by cutting a wide flange beam in two and adding a smaller plate to act as a top flange. This system also employs the use of steel columns and precast concrete planks used for the floor. The lateral system will be changed to the implementation of concrete shears walls compared to the concrete masonry shear walls present in the existing design.

The second major topic that will be discussed in the paper is the foundation system. The analysis will focus on a possible alternative to the use of drilled pier, but will also include the effect on the train tunnel that runs underneath the site. This will help to determine if the drilled piers was the most economical system for the foundation of Pearl Condominiums.

The paper will also briefly discuss two breadth topics concerning construction management and sustainability. It is proposed to analyze the effect of the flex frame system on construction cost and scheduling. Proposed for the issue of sustainability is the certification of the building for a bronze LEEDS rating and how this will affect the building redesign.

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Introduction

Pearl Condominiums is located on 9th and Arch Street in Philadelphia, Pennsylvania. This structure is a mixed use development building. The building includes a retail floor at the ground level containing 10 units and five floors of housing above containing a total of 90 condominium units. The maximum height of Pearl Condominiums is 72 feet 4 inches. The building's gross floor area is 111,570 square feet. One of the main design considerations for the site was the location of an existing SEPTA commuter rail tunnel which runs under the site.

Background

Foundations:

Pearl Condominiums' primary support for its foundation is in the use of drilled piers. The drilled pier option was performed, so the loads from the building would be transferred from the pier to the soil below the SEPTA commuter train tunnel. The drilled piers range in size of diameter from 3'-0" to 3'-6" and 4'-0". To help distribute the load to the drilled piers the use of grade beams was employed. They range in width from 12" to 40" and in depth from 18" to 30". The slab on grade is 6" reinforced with 6x6 W2.9xW2.9 WWR over 6" crushed stone over 6 mil. vapor retarder.

Columns \ Load Bearing Walls:

The columns in Pearl Condominiums are used in two different types of loading. The HSS columns are used to take gravity loads, which occur at the ends of the building to support the precast concrete planks and the Wide flange columns are used to resist lateral loads which occur on the ground floor in the moment frames. There are also locations on the first floor where the wide flange columns are used to support transfer beams of the second floor. The interior bearing walls are comprised of 8 inch metal studs that are spaced at 12 inches and 16 inches on center depending on the floor location of the wall.

Floor System:

The floor system for the upper floors consists of a 10" Precast Concrete Plank with a ¾" concrete thick topping. These planks are supported by the use of 8" metal stud bearing walls and concrete masonry unit walls, which are used as load bearing walls as well as shear walls. Also supporting portions of second floor, the use of steel wide flange beams and columns are used to transfer the loads from above to the foundation. This results in the maximization of retail space for the floor below. (See Figure 1A&1B for Second Floor Framing Plan)

Lateral System:

The Lateral system is composed to three different types of elements. The first and main lateral resisting system of this building is the use of concrete masonry units (CMU) acting together as shear walls. The locations of these CMU shears walls exist at the stair towers and the elevator core. There is a difference in the type of construction of these two locations. At the two stair towers the walls are made up of 10 inch CMUs and in the elevator core, the CMUs are 12 inches wide.

The second element is found on the first floor, this system is the result of the stair case ending on the second floor and the discontinuation of the 10 inch CMU wall. To help distribute the lateral loads from the stair tower shear walls to the foundation the use of moment frames was implemented. The moment frames main components are steel W12x120 columns and steel W36x135 beams.

The third and final lateral component is the combination of metal stud with metal strapping which are found on the upper floors. These shear walls resist the lateral forces by the strength of the metal strapping and connection which then transfer the forces into the metal studs and end connections of the straps. These walls are comprised of 8 inch metal stud which vary on number of studs and gauge depending on location of floor level. The metal strapping and connections type vary also per floor. (See Figure 2 for ETABS Model of Main Lateral Systems)

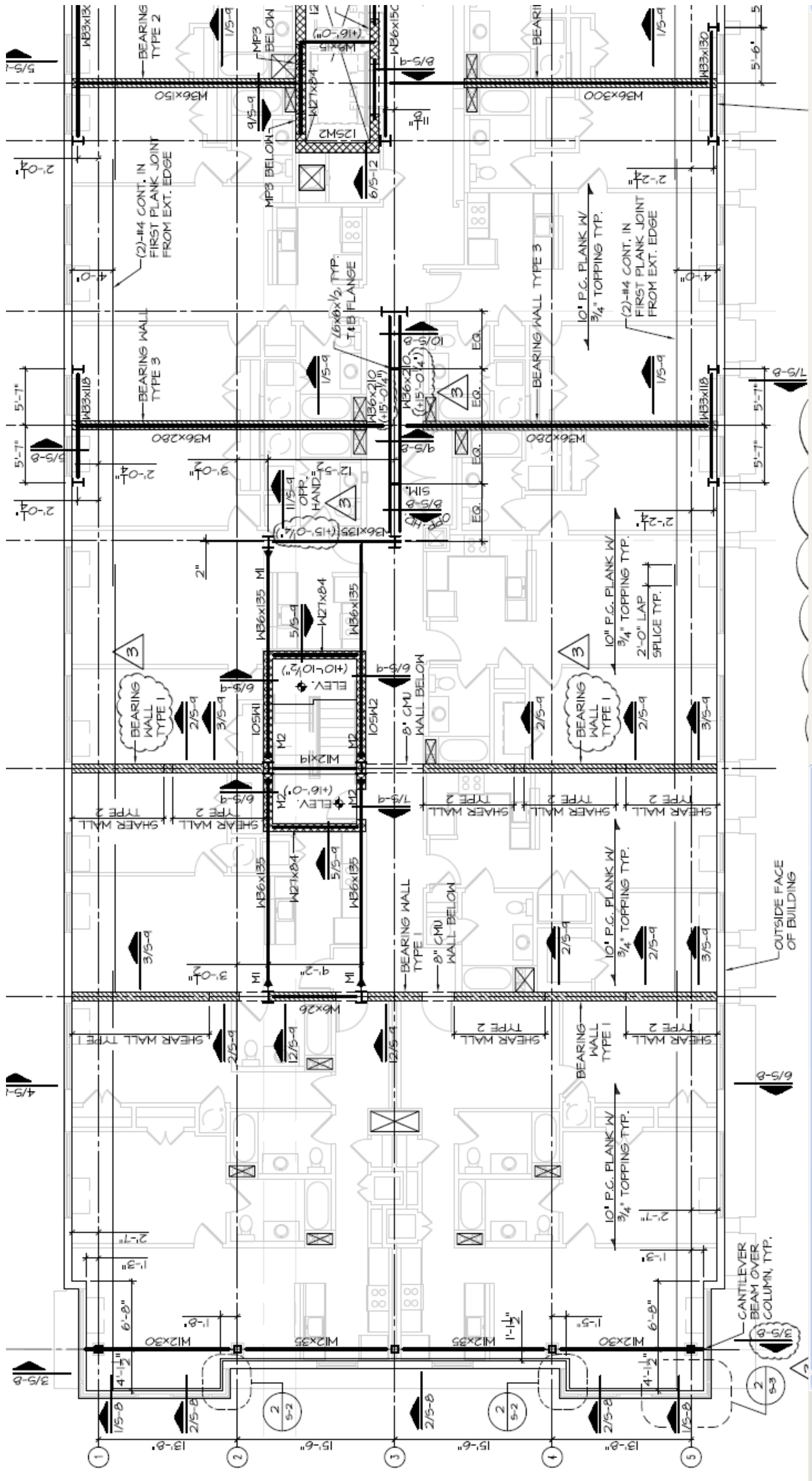

Figure 1A – Second Floor Framing Plan (North Side)

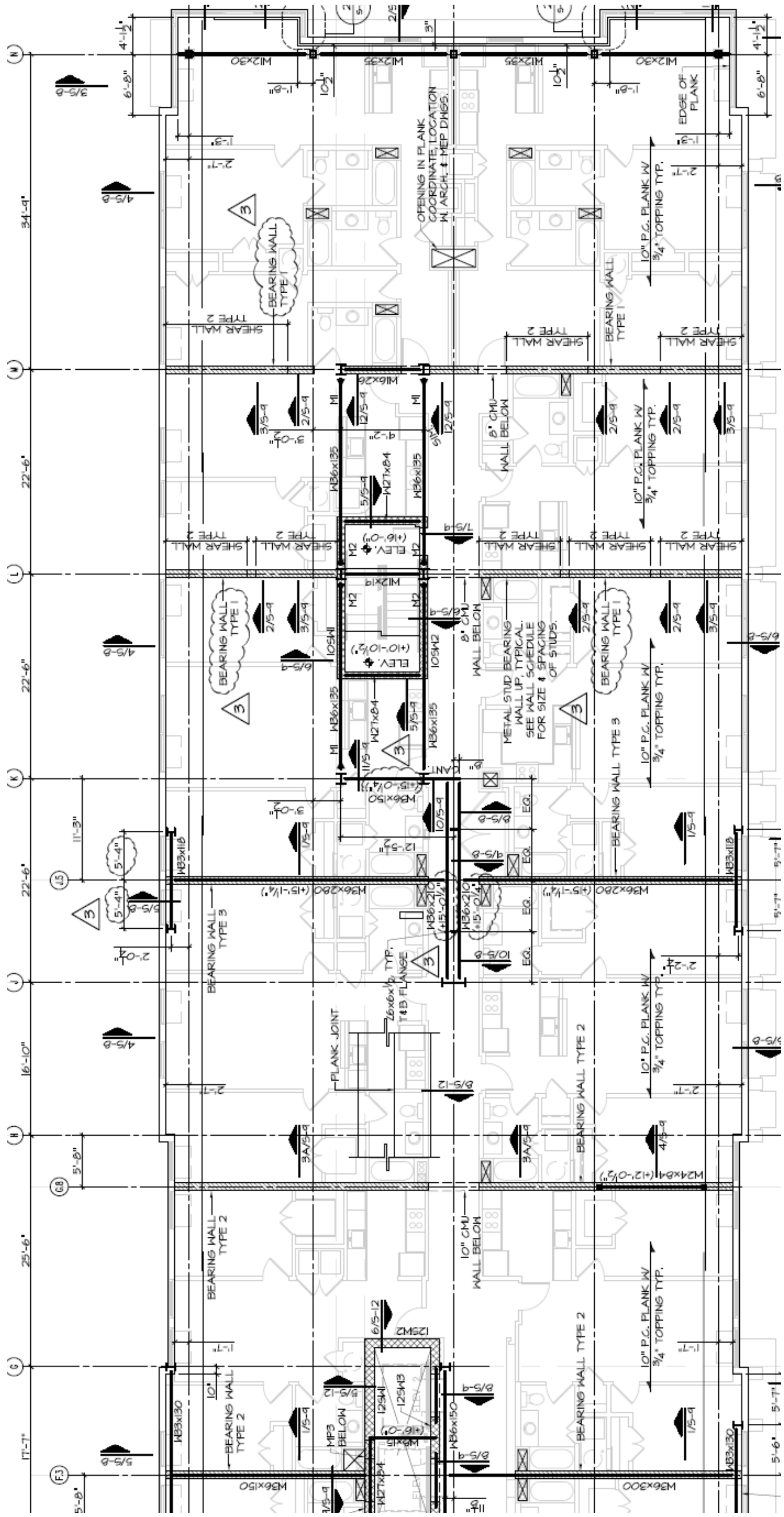

Figure 1B – Second Floor Framing Plan (South Side)

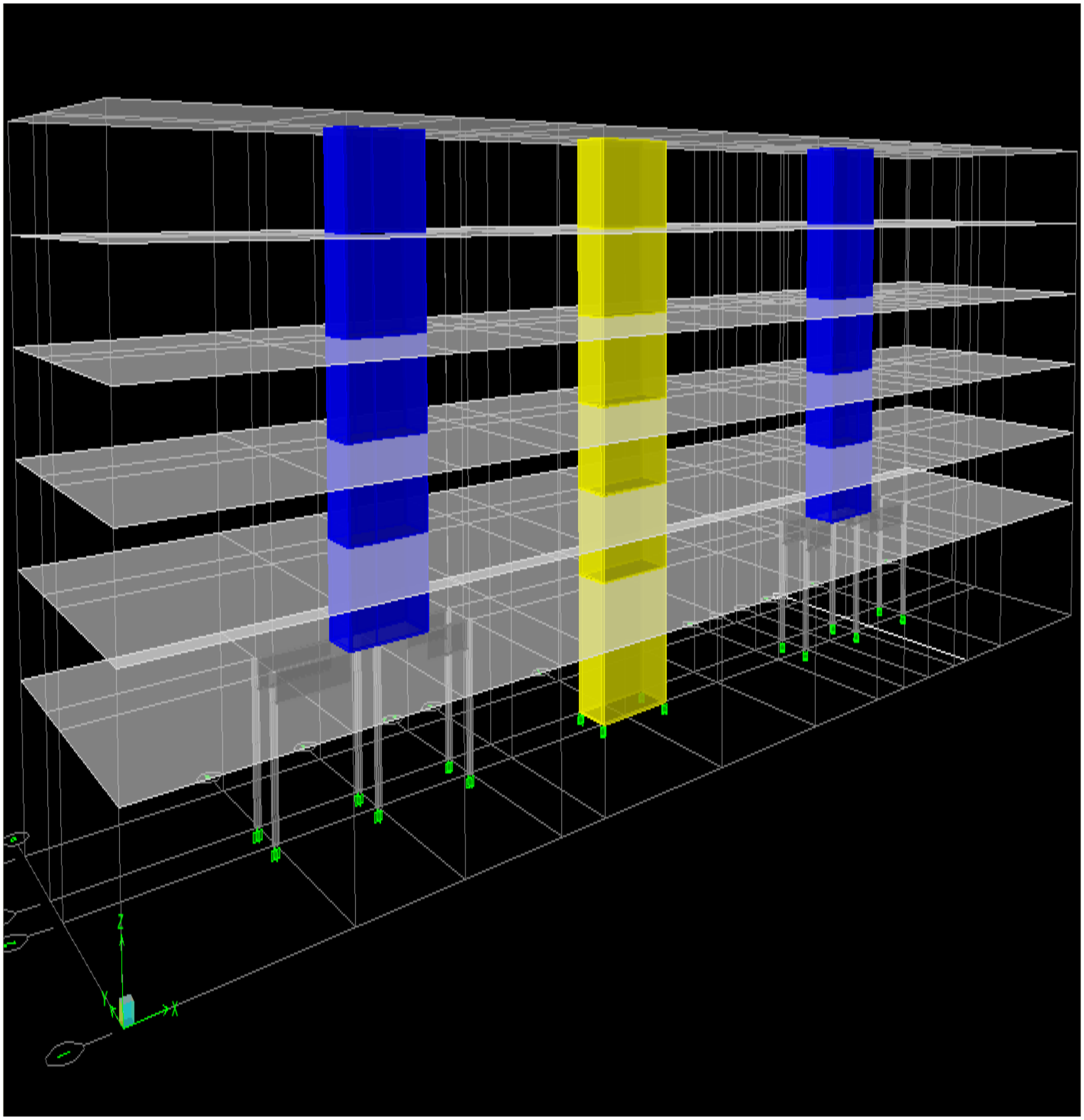

Figure 2 – Isometric of Lateral Resisting System Present in Pearl Condominiums

Problem Statement

During the analysis of the gravity and the wind force resisting systems present in Pearl Condominiums, it is clear that the systems chosen by the design team is currently the most efficient possible. The gravity supporting system was built extremely well with the use of metal stud and concrete masonry units as bearing walls to support the precast concrete planks. Also the current shear walls and their layouts are also very efficient in keeping the deflection of the building low and in resisting the torsion forces.

With the current system performing so well it will be a difficult to job to try and find another system that will be able to match the performance abilities of the existing structure. Having this in mind, I will attempt to redesign the floor system, trying to see if another structural system is possible to be able to create a more flexible floor plan by eliminating the need for the interior load bearing walls. With respect to the foundation system, I will attempt to compare other possible systems to the existing drilled piers system to see if any are a viable alternative. This will prove if the current system was the most economical and efficient system used because of the impact of the SEPTA commuter train tunnel that runs underneath the site.

Problem Solution

Floor system:

The redesign of the system includes first and foremost the removal of the interior load bearing walls. To compensate for the loss of the interior load bearing walls, the proposed structural system to be implemented is a flex frame system. This floor system is comprised of precast concrete planks which are supported by special steel d beams. The precast planks are grouted solid around the d beam to create the beam to plank connection. The d beam is a specialty beam which is created by cutting a wide flange beam in half and adding a plate, with a smaller width than the bottom flange, to create a top flange.

With the flex frame system there are a few limiting factors such as the deepest member that is currently available is a nine inch d beam, this will decrease the possible span and tributary width that the beam can carry. From this the spans of the precast concrete planks will be reduced, in turn reducing the size of the typical bay. The overall geometry of the building will not be changed but the implementation of a column grid will be used to facilitate in the. This column grid will be beneficial in seeing the impact of the new system on the layout of the space on the floor plans.

Foundation System:

The existing foundation system present in Pearl Condominiums is comprised of drilled piers, which are constructed to a depth below the SEPTA commuter train tunnel, so not to disturb the soil around the tunnel. This way no additional reinforcing will have to be added to the tunnel. For the redesign, I will implement the use of mini-piles or piles as an alternative foundation system. With the use of piles I will also have to investigate the effects of this system on the current train tunnel and determine if any additional reinforcement for the tunnel will be needed.

Solution Method

To determine whether or not the proposed structural system will be able to handle the loads imposed on Pearl Condominiums, hand calculations will be used to establish preliminary sizes. Hand calculations will be done with the use of ACI 318-05, the Thirteenth Edition Steel Manual, and information provided by flex frame fabricators. These sizes will then be placed into computer program along with the gravity and lateral loads. RAM will be used to determine preliminary sizes for the columns. ETAB program will be used to analyze the lateral effects on the building. The foundation system will be done through the use of hand calculations, which will help to determine the effect of the piles on the soil around the train tunnel. Loads will be based off of ASCE 07-05 and the IBC 2006. This building then will be analyzed according to standard limitations such as drift, story drift, strength and serviceability.

Breadth Options

Topic 1:

The first topic that will be covered is in the field of construction management. With this new design I will compare the effect of cost and scheduling of the new system to the existing system in Pearl Condominiums. This information will then be used to see if the flex frame system is an economical and efficient alternative to the existing structural system.

Topic 2:

The second topic that will be covered is in the field of Sustainability and its impact on the overall building systems and its architecture. During this process, the objective will be to gain at least a bronze LEEDS certification for this building. I will try to see how using these ideas will change the systems used in this building. With the use of this idea, the architecture aspect will have to be considered with respect to the floor layouts and the façade. During this analysis, the pros and cons of using the sustainable design will be discussed and a conclusion will be made on whether this could have been done with the current design or if it would have been too costly to use.

Task & Tools

The main tasks to redesign the current system to reflect the new system outlined are below:

1. Determine Superimposed Loads
    a. Determine superimposed loads from construction documents

2. Establish Trial Size Members
    a. Establish trial size d-beams to replace the interior load bearing walls
    b. Establish trial size for columns

3. Plan Redesign
    a. Layout new columns location on plans with minimal alterations to architectural plan

4. Gravity Computer Analysis
    a. Place column grid and preliminary members sizes into RAM model for gravity analysis

5. Lateral Load Analysis
    a. Determine lateral loads applied to the building from the result of wind and seismic forces
    b. Calculate required concrete shear walls and moment frames to resist lateral forces
    c. Place lateral elements into ETABS model
    d. Check to see if lateral elements meet strength and serviceability requirements

6. Foundation Analysis
    a. Determine loads that will be applied to the building foundations from the previous gravity and lateral analysis
    b. Calculate required preliminary foundation member sizes to resist loads
    c. Calculate force transferred to the soil around the train tunnel
    d. Determine best type of construction to eliminate the forces from being applied to the train tunnel

7. Breath Topic 1
    a. Develop detailed take-off for the new system and a total cost for the construction
    b. Create a schedule for construction process
    c. Compare the approximate cost of the proposed system to the existing
    d. Discuss any possible concerns for the proposed system

8. Breath Topic 2
    a. Develop and create an agenda to gain a bronze LEEDS certification
    b. Discuss how this will be implemented into the redesign
    c. Determine the effects imposed on the proposed structural system

9. Finalization
    a. Compile material into final report
    b. Compile material into final presentation
    c. Finalize CPEP site
    d. Present presentation to faculty

Timetable

Activity	Date							
	January			February				
	14-18	21-25	28-31	1	4-8	11-15	18-22	25-29
Research Flex Frame System								
Breath Topic 2								
Determine Superimposed Loads								
Establish Trial Size Members								
Plan Redesign								

Activity	Date							
	March					April		
	3-7	10-14	17-21	24-28	29-31	1-2	7-11	14-18
Gravity Computer Analysis								
Spring Break								
Lateral Load Analysis								
Foundation Analysis								
Breath Topic 1								
Finalization								