CHRISTIANA HOSPITAL 2010 PROJECT

NEWARK, DE

Thesis Proposal

Joseph G. Sharkey
Structural Option
Faculty Consultant: Dr. Memari

Table of Contents

Executive Summary

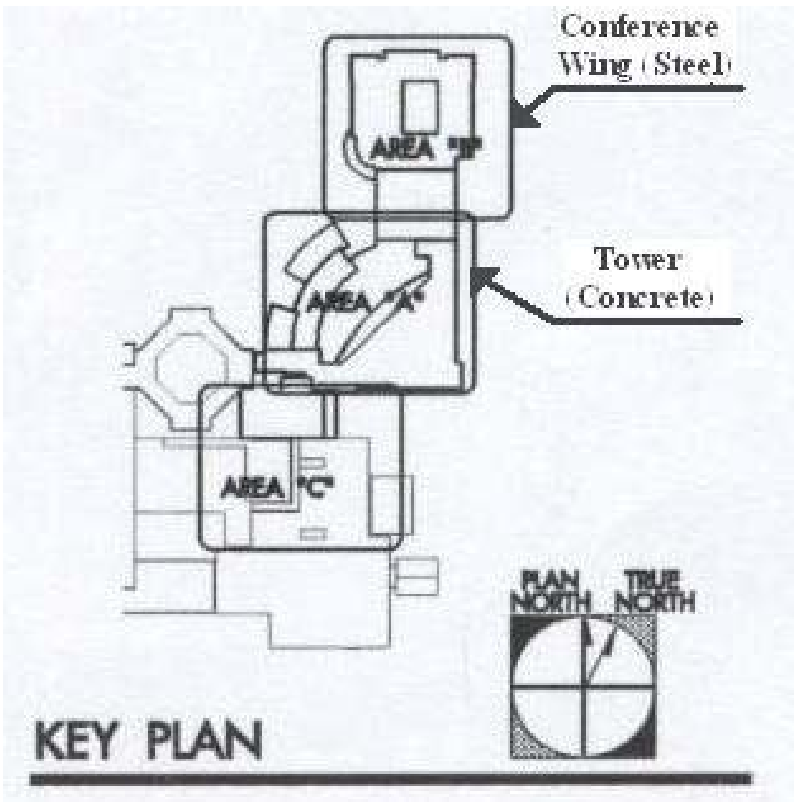
The Christiana Hospital project is a 299,000 square foot addition to the Christiana Medical Campus. This expansion, designed by architects at Wilmot/Sanz, will expand the hospital's clinical capabilities along with adding a new medical education center capable of providing this teaching hospital with the latest techniques and learning tools. Structurally the building has been designed essentially into two separate buildings. These two buildings consist of a three story education wing using steel construction and an eight story clinical tower that takes advantage of reinforced concrete construction.

This paper is designed to propose an alternative design for the Christiana Hospital. The design will consist of dividing the main clinical tower into separate structures coming together at an expansion joint to decrease the torsional effects on the lateral force resisting system while still maintaining the building's functionality and architectural appeal. Secondly the current 9½" thick two-way concrete floor system will be redesigned using post-tensioning in an attempt to decrease the slab depth. Designing the building in this manner will require a redesign of the shear walls along with the complete redesign of the floor system. This new structure will be compared to the original design regarding efficiency and constructability.

Along with the redesign of the Christiana Hospital's structural system two breadth topics will be discussed focusing in fields of construction management and mechanical engineering. Regarding construction management, the impact of the redesign on overall project cost and the construction schedule will be addressed. Concerning the mechanical breadth, air in the Christiana Hospital is currently cooled using chilled water provided by an outside source. I propose to research and design a chiller that will be capable of creating this chilled water on site and compare its cost and functionality to the current system.

Introduction

The Christiana Hospital project is a 299,000 square foot addition to the Christiana Medical Campus. The addition, designed by architects at Wilmot/Sanz and the structural engineers at Cagley & Assoc., will expand the facilities and capabilities of the hospital along with advancing this teaching hospital's educational abilities with a new medical education center. This project consists of two separate types of framing. The majority of the building, an eight story hospital tower, is designed using reinforced concrete while the adjacent conference wing is a three story steel structure.



This report is designed to propose an alternate design to the hospital's structure along with two separate breadth topics. The main structural issue proposed is sectioning the building by creating an expansion joint at grid line 66 (refer to Figure 3 on page 11). This design will hopefully reduce the torsional effects on the shear walls and allow them to be smaller in size. Secondly a post tension floor slab will be designed and compared to the current 9½" two-way flat slab with 5½" drops around the columns. This slab will most likely allow for a smaller slab depth allowing a higher ceiling height or extra room in the ceiling for MEP.

Codes

Codes Used for Original Design

- International Building Code – 2000
- ASCE 7-98, American Society of Civil Engineers – Minimum Design Loads for Buildings and Other Structures
- ACI 318-99, American Concrete Institute – Building Code Requirements for Structural Concrete
- ACI Manual of Concrete Practice – Parts 1 through 5 – 1997
- Manual of Standard Practice – Concrete Reinforcing Steel Institute
- AISC Manual of Steel Construction – Allowable Stress Design, Ninth Ed., 1989
- AISC Manual of Steel Construction – Volume II Connections – ASD Ninth Ed./LRFD First Ed.
- AISC Detailing for Steel Construction
- American Welding Society – Structural Welding Code ANSI/AWS D1.1-96
- Steel Deck Institute – Design Manual for Floor Decks and Roof Decks
- Drift Criterion – h/400

Codes Used for Thesis Design

- International Building Code – 2003
- ETABS Model – International Building Code – 2000
- ETABS Model – ASCE7-98
- Wind Loads – ASCE7-02
- AISC Manual of Steel Construction – Load and Resistance Factor Design, Third Ed., 2005
- Drift Criterion – h/400

Current Structural System

Foundation:

The building consists of two separate types of foundations. In the concrete tower area the building rests on a 42" thick mat foundation. This mat is reinforced with #9's at 12" o.c. each way, top and bottom, with additional reinforcing added where needed.

In the area of the conference wing, steel columns rest on concrete spread footings. These footings range in size from 4'x4'x 15" deep up to 16'x16'x 48" deep. The allowable soil bearing pressure for this site is 4000 psf.

Applications	**Concrete Strengths (f'_c)**
Footings	4000 psi
Mat Foundation	6000 psi
Grade Beams	4000 psi
Slab-On-Grade	3500 psi

Columns:

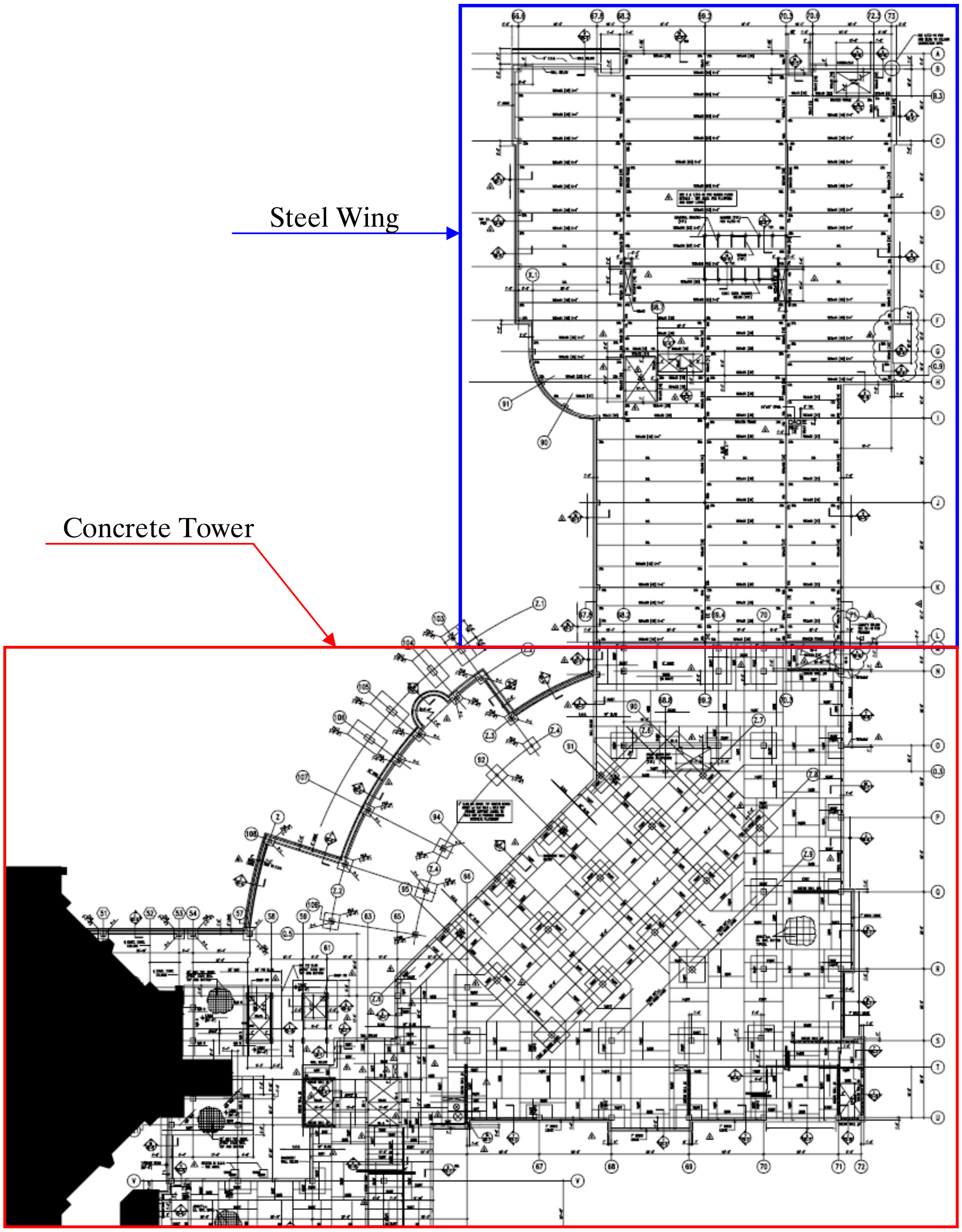
In the tower area a majority of the columns are 24"x24" reinforced concrete columns with only a few occurrences of 12"x24" columns. At the eighth floor nearly all the concrete columns stop and off of them W8 steel columns are posted. The 3 story conference wing is composed of W10 and W12 steel columns.

Applications	**Material**
Steel Columns	ASTM A992, Grade 50
Concrete Columns (Below Third Floor)	4000 psi
Concrete Columns (Above Third Floor)	5000 psi

Floor System:

Throughout the tower, spans are accomplished using 9½" thick two-way flat slabs with typical 5½" drops or shear caps at each column. Reinforcement for the slabs varies throughout the building.

The conference area uses a completely separate type of floor system. Here steel girders span between columns in one direction while beams, spanning in the opposite direction, frame into the girders. This steel framework works in composite action with the floor slab placed on top. The slab is constructed of 3¼" lightweight concrete over a 2" deep x 18 gage galvanized composite metal deck. The slab is then reinforced with 6x6-W2.1xW2.1 WWF. The bulk of the spans vary anywhere from 20 to 40 feet. Although, running across the middle, is a large 63 foot span made possible using W30x90 beams and the composite action.



Lateral Force Resisting System:

The lateral forces acting on the building are resisted differently in the two areas of the building. In the concrete portion of the building, lateral forces are resisted by reinforced concrete shear walls which run the entire height of the building until they are replaced by concentrically braced frames at the eighth floor (Figure 1). These shear walls are placed in specific areas to also oppose the torsion effect that the lateral loads place on the building due to its L-shape.

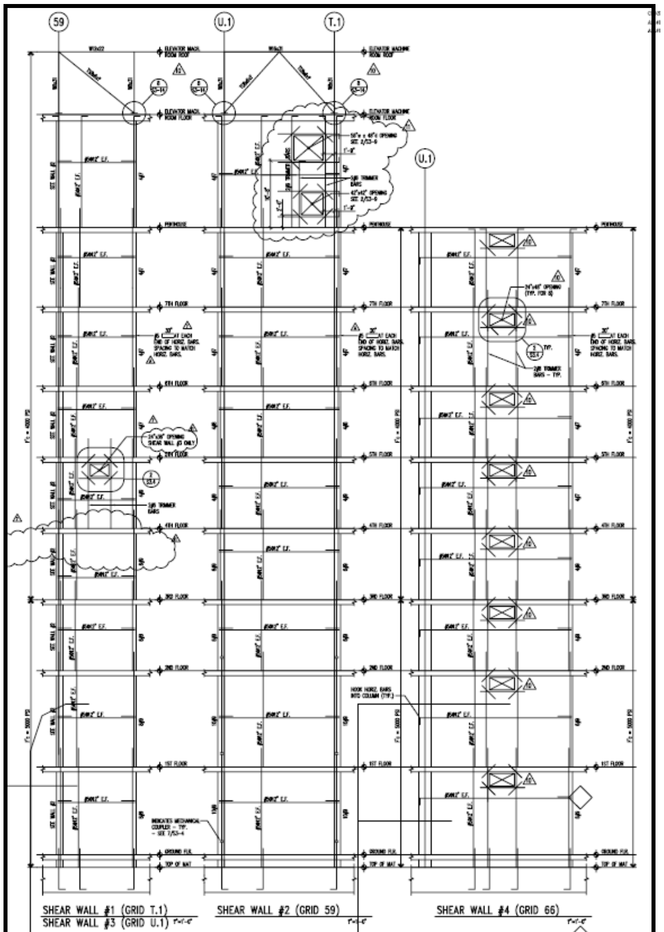


Figure 1 Shear Walls

In the conference wing lateral loads are taken care of with the use of concentrically braced frames (Figure 2). These frames are constructed using rectangular HSS steel. This framing is field welded to gusset plates. These gusset plates are attached in the fabrication shop, by means of a weld, to select beams.

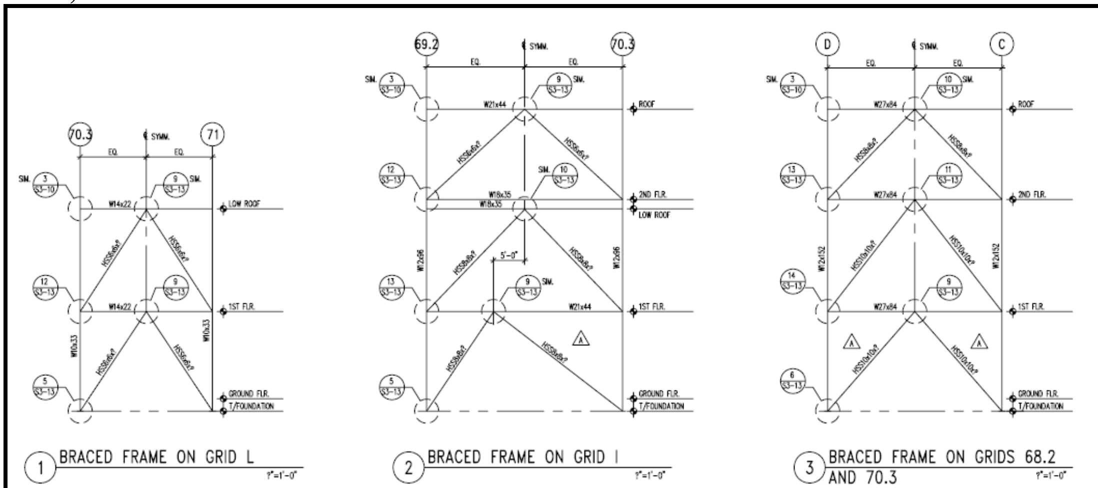


Figure 2 Concentrically Braced Frames

Roof System:

The framing of the roof is done entirely with steel and metal decking. The decking used is a 1½" deep, wide rib, 20 gage galvanized metal deck. On top of the decking is a one hour fire rated roof construction. This consists of a 45 mill fully adhered roofing membrane on tapered insulation on 5/8" exterior gypsum board. The metal decking is also sprayed with a fireproofing at the soffits.

Gravity Loading

Floor Live Loads	
Occupancy or Use	**Uniform Live Load (psf)**
Assembly Space	100
Typical Hospital Floor	60
Corridor	80
Mechanical Rooms	150
Stair	100
Roof	15
Partition	20

Floor Dead Loads	
Occupancy or Use	**Dead Load**
Reinforced Concrete	150 pcf
Steel Members	Varies
Floor Superimposed	15 psf
Roof Superimposed	15 psf

Snow Loading	
Item	**Value**
Ground Snow Load (P_g)	25 psf
Exposure Category	B
Roof Exposure	Partially Exposed
Exposure Factor (C_e)	1.0
Thermal Factor (C_t)	1.0
Occupancy Category	IV
Importance Factor (I_s)	1.2
Flat-Roof Snow Load $P_f = 0.7C_eC_tI_sP_g$	21 psf

Problem Statement

Through the analysis of the gravity and wind force resisting systems done in technical assignments numbers 1 and 2 it is clear that the system chosen by the design teams is currently the most efficient possible. The use of a 9½" two-way flat slab with 5½" drops around the columns allows for a shallow floor system and makes the unique geometries and column layouts possible. The current shear walls and their layouts are also very efficient in keeping the deflection of the building low and resisting the torsional forces caused by the buildings geometry.

Because the current system performs so well it is a difficult job to try and improve or make beneficial changes to the building. With this in mind I will attempt to redesign the floor system checking to see if it is possible to create a shallower floor thickness along with sectioning the building to reduce the torsional forces on the shear walls.

Problem Solution

Floor System:

The proposed floor system is one which utilizes the strength capacity of post-tensioning. This floor system will potentially create a shallower floor depth along with the possibility of creating larger spans by reducing the amount of columns required. Column sizes may also be capable of being decreased due to the reduced self weight of the new floor system.

Lateral Force Resisting System:

To reduce the torsional loading effects created by the building's geometry on the shear walls sectioning the building with the use of an expansion joint is proposed. This expansion joint will be investigated further but currently the best location for this joint appears to be on column line 66 (Figure 3). This will essentially separate the main medical tower of the building into two separate buildings acting independently of one another. By this being done shear walls will potentially be capable of being designed smaller in size which could result in a cost savings.

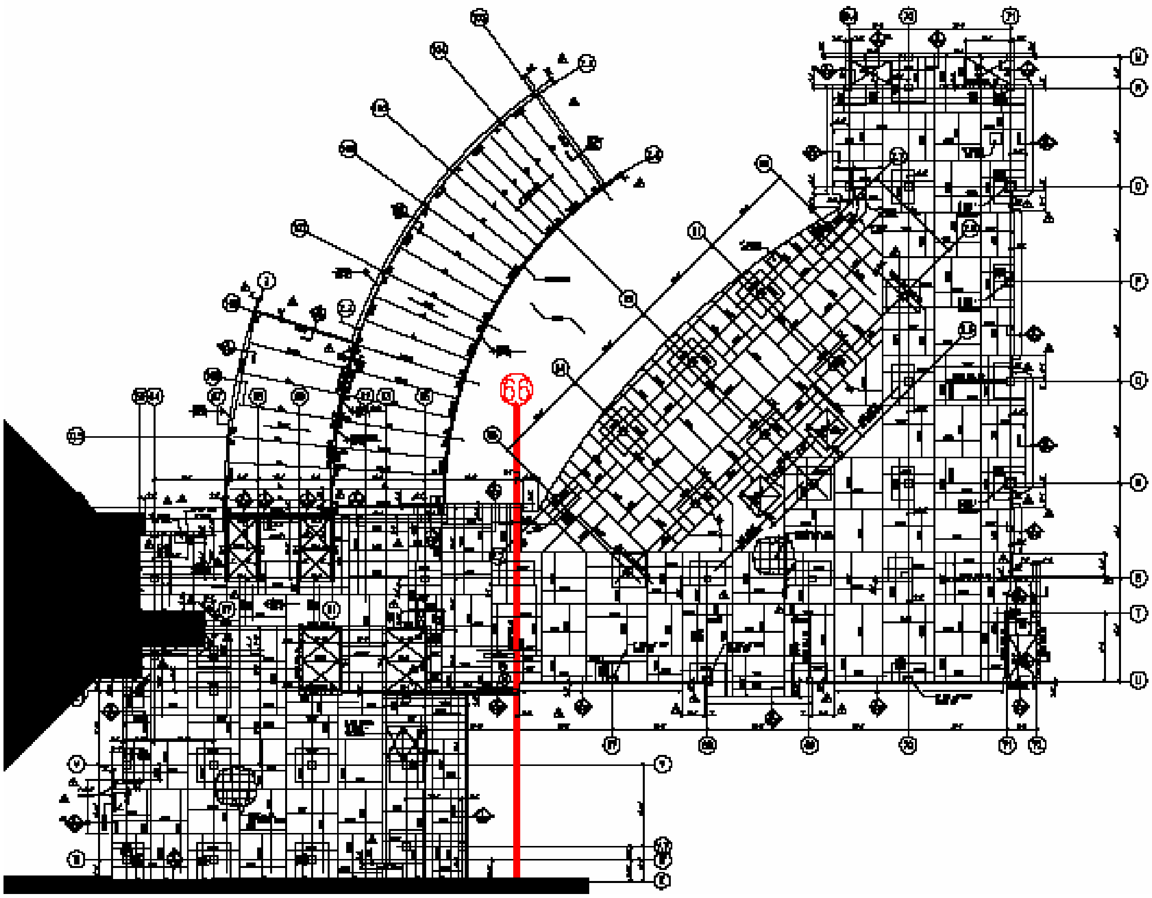


Figure 3 Expansion joint located on grid line 66

Solution Method

Floor System:
The design of the post-tensioned slab will be completed in accordance with ACI 318-05 chapter 18 with help from a computer model created using RAM Concept. The slab will be designed using the loadings stated on page 9 of this paper. After obtaining this new slab, column load takedowns will be performed to acquire the new vertical loads imposed on the columns and checked using a computer model created in ETabs. With these new loads the columns will then be redesigned.

Lateral Force Resisting System:
With the building now being divided into two separate structures, shear walls will be reviewed by adding, subtracting, or moving them to new locations that will serve the new design more effectively. With these shear walls now in place both seismic and wind loads will be placed on the building using hand

calculated loads in accordance with ASCE7-02 and distributed to the shear walls with the help of an ETabs model. Finally the shear walls will be designed for the new loads imposed on them.

Breadth Topics

Topic 1:
The first topic which will be covered is in the field of construction management. With these new designed being implemented I will make a comparison between the costs and schedules of the actual design to my proposed design. This information will then be used to determine whether or not the proposed design is beneficial or detrimental in comparison to the actual design.

Topic 2:
The second topic to be covered will be in the field of mechanical engineering. Currently the Christiana Hospital creates its cool air with the use of chilled water that is supplied by an outside source. I propose to design a chiller for the building that will be capable of creating the chilled water for cooling purposes in house. With this design a cost comparison will be performed to see if money can actually be saved by having a chiller on site or if pumping in chilled water, as is currently done, is more cost effective.

Tasks & Tools

Phase I: Post-tensioned Floor System Analysis
- Task 1: Determine Loading
- Task 2: Design Slab
  - A) Determine minimum slab thickness
  - B) Find applied moments
  - C) Check capacity of slab
  - D) Check deflections

Phase II: Redesign Columns
- Task 1: Determine loading
- Task 2: Take into consideration any columns that may not be required

Task 3: Design columns in accordance with ACI with help from the program PCA Column

Phase III: Redesign Shear Walls for new Expansion Joint Design
- Task 1: Determine most efficient locations for shear walls
- Task 2: Find wind and seismic loads on building using ASCE7-02
- Task 3: Distribute loads to shear walls using ETabs model
- Task 4: Design Walls

Phase IV: Breadth Studies
- Task 1: Construction Management
  - A) Compare costs and schedules of the actual design to the proposed design.
- Task 2: Mechanical Engineering
  - A) Design Chiller
  - B) Compare costs to run chiller as opposed to pumping in chilled water from outside source

Time Table

	Week 1 1/14 - 1/20	Week 2 1/21 – 1/27	Week 3 1/28 – 2/3	Week 4 2/4 – 2/10	Week 5 2/11–2/17	Week 6 2/18–2/24	Week 7 2/25 – 3/3
Research post-tensioning							
Create RAM Concept Model							
Design post-tensioning floor							
New column Designs							
Determine shear wall locations							
Create ETabs Model							
Determine wind/seismic loading							
Distribute lat. forces and design shear walls							
Breadth 1- Construction Management							
Breadth 2 - Mechanical Engineering							
Create final report							
Create final presentation							
Present to faculty							

	Week 8 3/4 - 3/10	Week 9 3/11 – 3/17	Week 10 3/18 – 3/24	Week 11 3/25 – 3/31	Week 12 4/1–4/7	Week 13 4/8–4/14	Week 14 4/15 – 4/21
Research post-tensioning		SPRING BREAK					
Create RAM Concept Model							
Design post-tensioning floor							
New column Designs							
Determine shear wall locations							
Create ETabs Model							
Determine wind/seismic loading							
Distribute lat. forces and design shear walls							
Breadth 1- Construction Management							
Breadth 2 - Mechanical Engineering							
Create final report							
Create final presentation							
Present to faculty							