Thesis Proposal

University Hospitals
Case Medical Center
Cancer Hospital

11100 Euclid Avenue Cleveland, Ohio

January 22 , 2009

Daniel C. Myers

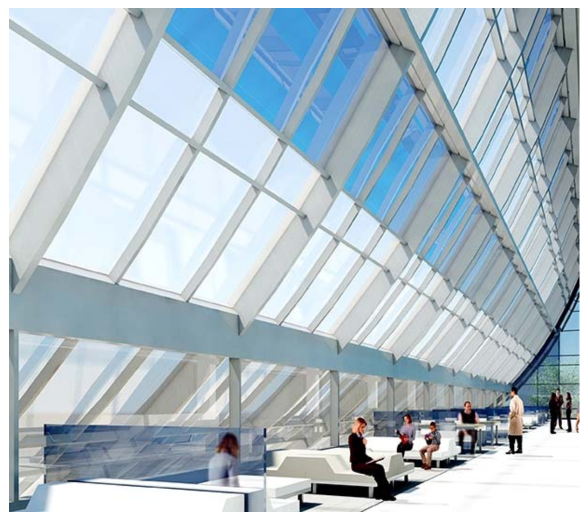
Structural Option
Advisor: Dr. Ali Memari

http://www.engr.psu.edu/ae/thesis/portfolios/2009/dcm234

Executive Summary

The University Hospitals Case Medical Center Cancer Hospital is a 9 story research and patient care facility located in Cleveland, Ohio. Its infrastructure consists of steel and steel composite members which have been carefully arranged in order to conform to the modular architectural design system known as the *Universal Grid*, allowing full optimization of available space for varying use. Sloped curtain walls envelope the Cancer Hospital, consisting of exterior glazing and curved steel. The new Cancer Hospital will serve as an addition to the adjacent Case Medical Center which will integrate medical services once spread through 7 different buildings.

The Cancer Hospital has been evaluated in 3 previous technical assignments involving a study of the overall structure, various slab systems, and the existing lateral frames. Information obtained from these reports specifically *Technical Report 3*, revealed that the irregular “L” shape challenges the placement of the lateral system and causes a significant amount of torsion and drift in the hospital. This movement greatly affects the efficiency of the Cancer Hospital, due the location of the imaging rooms, surgery rooms, and advanced researched equipment.



In order to gain knowledge and experience in the seismic design of a movement sensitive and abnormally shaped structure, the Cancer Hospital will be theoretically relocated to a high seismic region. New loads will be established using a Modal Response Spectral Analysis and then used to redesign the current lateral system. In order to more efficiently handle the increased seismic loads, the existing building design will be split by use of an isolation joint between the tower portion and the lower “L” shaped extension.

In addition to research conducted on the structure of the Cancer Hospital, two breadths are presented for study. These breadths include a construction management evaluation which will determine the impact of the proposed revisions on the cost and schedule of the project as well as a building envelope study which will evaluate and compare different envelope systems in effort to improve energy efficiency and architectural effect.

Tasks have been presented which are necessary to obtain sufficient information needed to propose a revised design. This design will improve the serviceability of the Cancer Hospital and thereby improve the efficiency of its sensitive areas.

A schedule has been developed and presented in order to more accurately depict the progress of research and design over the course of spring semester 2009.

Table of Contents

Introduction

The University Hospitals Case Medical Center Cancer Hospital will integrate patient care and cancer research in a new and innovative way. Architecturally, the Cancer Hospital will reflect this cutting edge link by joining adjacent buildings together while serving as a primary gateway to the UHCMC campus located in Cleveland, Ohio.

The Cancer Hospital design fulfills the wishes of former facility cancer patients in creating an appealing and comfortable environment as opposed to the sterile feel of the past. This is accomplished through use of strong architectural accents including the Cancer Hospital's most dominating feature, its curved facade. A universal grid system consisting of 31'-6" modular bays has been incorporated into design to optimize floor space for varying uses. Clinical pods have been designed for treatment of specific patient populations.

Medical services which were previously distributed among seven facilities will now be performed under one roof to optimize cancer research, education, and patient care while providing an architecturally appealing exterior as well as a warm and inviting natural interior.

In order to gain knowledge and experience in the seismic design of a movement sensitive and abnormally shaped structure, the Cancer Hospital will be theoretically relocated to a high seismic region. New loads will be established using a Modal Response Spectral Analysis and then used to redesign the current lateral system. In order to more efficiently handle the increased seismic loads, the existing building design will be split by use of an isolation joint between the tower portion and the lower "L" shaped extension. In addition to the structural research to be performed, two breadths are presented for study. These breadths include a construction management study which will determine the cost and schedule effect the proposed revisions will cause, as well as a building enevelope system comparison to determine the most efficient design.

This proposal will present the intended tasks necessary to complete the previously mention tasks. A schedule has been developed in order to more accurately depict the progress of research and design over the course of the spring semester of 2009.

Existing Structural Systems

Foundation

The Cancer Hospital consists of drilled piers transferring load to caissons for the gravity columns with the combined use of grade beams for the lateral force resisting frames. The drilled gravity piers/caissons range 30" to 60" in diameter depending on location. The drilled piers/caissons receiving lateral load are typically 66" in diameter. Along the south side, 36" thick spread footings, typically 48" by 72", have been used to carry gravity load along the existing adjacent Case Medical Center Hospital. The grade beams which carry the lateral load to the drilled piers/caissons are typically 24" by 24" and consist of Grade 60, #7 reinforcement bars. All foundations are made from concrete having a compressive strength of 4000psi with the exception of the caissons and spread footings, which have a strength of 3000psi.

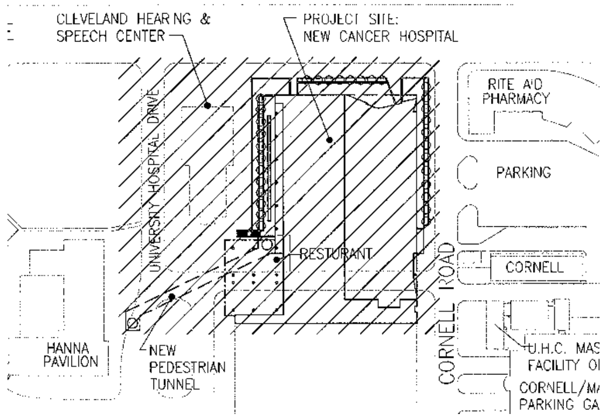


Figure 1

The soil on site has been classified as hard shale (see Figure 1). Thus, giving the caissons used in the foundation an end bearing capacity of 50kpf with a skin friction capacity of 10psi below the first 5' of shale. The typical minimum penetration depth for the gravity piers/caissons is 3'-0" and for the lateral, 16'-6".

Floor System

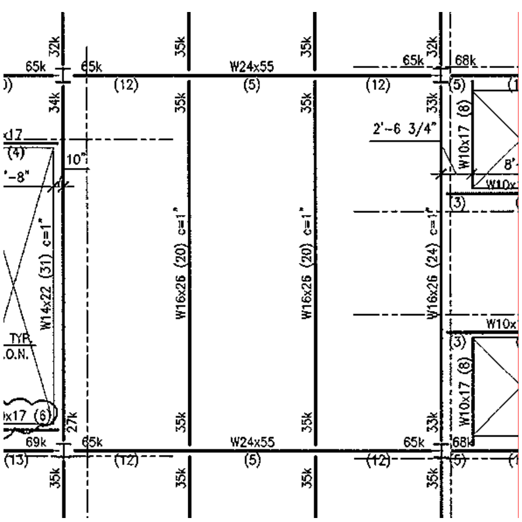


Figure 2

Being a primarily steel structure, the Cancer Hospital has a fairly typical composite steel beam and girder framing system. The typical composite floor slab is 5-1/4" thick using 3000psi lightweight composite concrete, an 18 gauge 2" galvanized steel deck, and 3-1/2" metal studs. This composite floor slab is used on all but the 2nd and 8th floors. The second floor requiring a thicker slab with normal weight concrete due the vibration requirements of the surgery and imaging rooms and the 8th due to the increased load from the mechanical system. The slab used on these floors consists of 6-1/2" thick 3000psi normal weight concrete, an 18 gauge 2" galvanized steel deck, and 3-1/2" metal studs. Both decks are reinforced with 6x6 Welded Wire Fabric; W4.5xW4.5 for the first floor, W3.5xW3.5 for the second and eighth floors, and W2.1x2.1 for the remaining floors.

Framing

Bay sizes conform to the universal grid, having a typical size of 31’-6” by 31’-6”. Infill beams are typically W16x26 around the interior and W14x22 around the exterior framing into W24x68 girders (see Figure 2). For the larger breaks in the slab, such as the elevator shafts, HSS 8x4x1/4 tubes have been used. On the 4th and roof level, moment connections are utilized in conjunction with cantilevered beams in order to support the curved exterior façade. Smaller breaks used for mechanical, plumbing, etc., consist typically of W10x17. Columns consist of a typical W14 member decreasing in size with elevation and spliced every other floor starting with the second. All steel members conform to ASTM A-992, Grade 50 unless otherwise noted.

Ground Level

At the ground level, a 6” thick slab-on-grade is used with Grade 60 #5 reinforcement bars spaced @ 18”oc EW. The slab rests on a 10 mils min. vapor barrier on compacted granular material over a 2000psi mud slab. In the northeastern and southeastern section of the building special research equipment has been placed requiring a 12” thick slab-on-grade with Grade 60 #5 reinforcement bars placed @ 12”oc EW.

Machine Room

A 31’-0” by 63’-0” machine room is located on the 8th floor. Framing is similar to the rest of the structure however with shorter spans and larger members to account for the additional weight. Beams range from W21 beams to W40 beams depending on specific equipment.

Roof System

The roof of the Cancer Center is a sloped deck with a 63’-0’ by 63’-0” elevator penthouse perched at the southern corner. The roof slopes downward along the east and west sides of the building and allows drainage to the center third. The roof system consists of a 3”x20ga type ‘N’ galvanized steel deck. The roof deck rests typically rests on W14x22 beams framing into W21x44 girders with W18x35 beams being used to support mechanical equipment spaced uniformly across the building’s center. Roof decks lower than the top of the 8th level consist of 1.5”x20ga. type ‘B’ galvanized steel deck (see Figure 3).

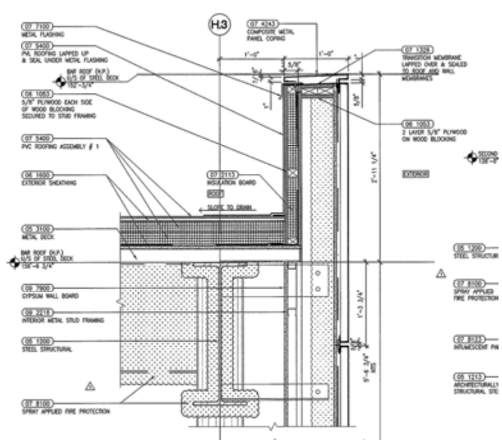


Figure 3

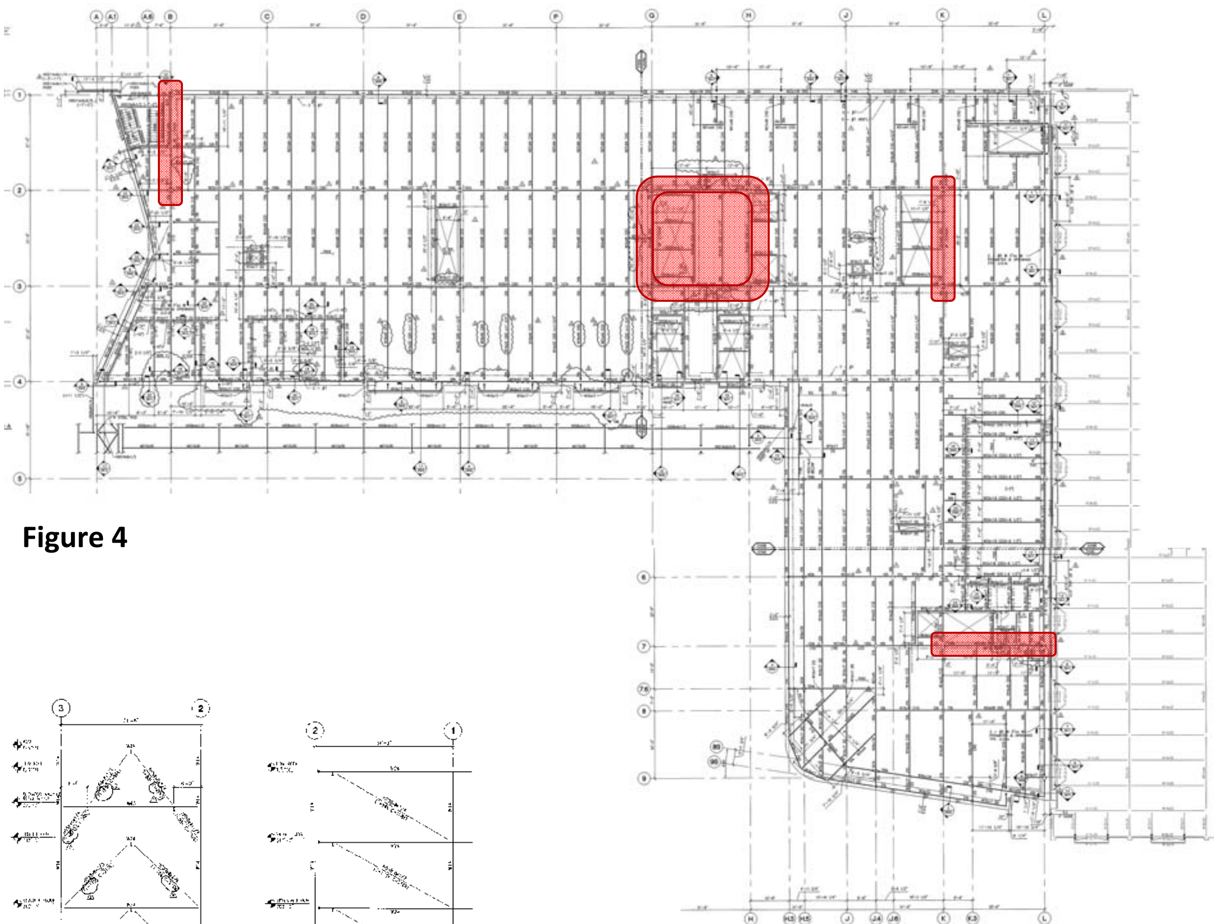


Figure 4

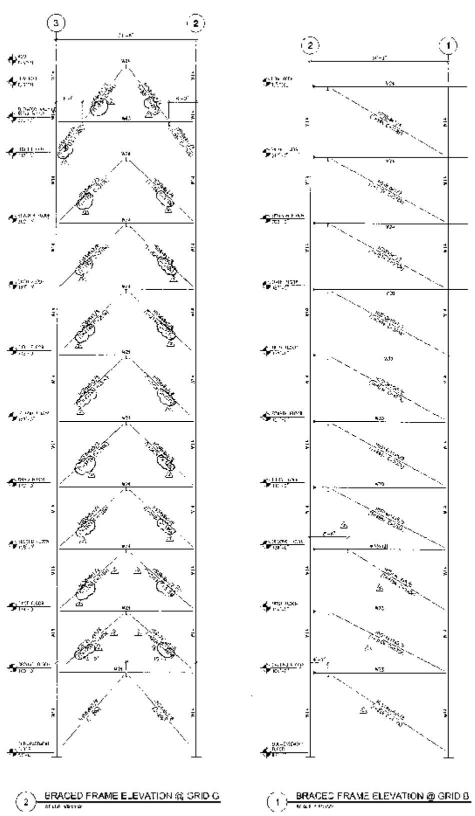


Figure 5

Lateral System

Lateral forces are resisted by a series of concentrically braced frames located at the center of the building near the main elevator core and along isolated points of the exterior bays (see Figure 4). This system consists of four chevron braces and two diagonal braces, which are used both in the north/south direction as well as the east/ west direction. Each brace typically consists of a 31'-6" wide W24 beam, a 15'-0' tall W14 column, and two HSS8 size diagonal members (see Figure 5). Structural brace members beyond the 8th floor increase in size due to increased lateral loads.

Background

Through the analysis of the University Hospitals Case Medical Center Cancer Hospital in 3 different Technical Reports involving the overall structure, various slab proposals, and a lateral system evaluation, certain key areas of concern were developed. These areas are based on the strict movement limitations required due to the certain uses of the Cancer Hospital.

The abnormal "L" shape and use of the Cancer Hospital make this building especially susceptible to a serviceability decrease as result of any movement which would exceed the movement criteria. The previous technical reports addressed many of the key characteristics of a building however further investigation would increase the understanding of the effect dynamic loading on such an atypical structure. Movement of this type appears to exhibit the amount of challenge in design.

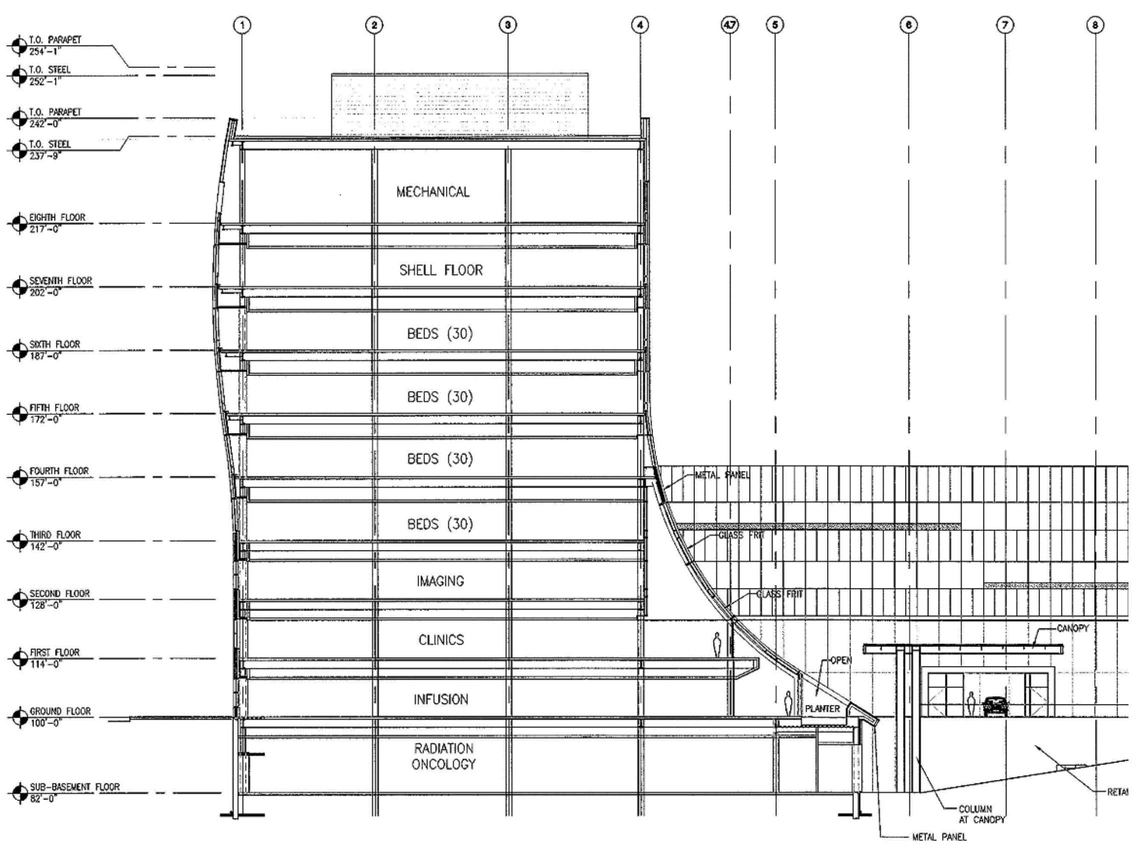


Figure 6

Problem Statement

Previous technical assignment have found the Cancer Hospital design to adhere to all drift limits and strength requirements as per all applicable codes given its current location. However, the irregular "L" shape of the hospital causes a significant amount of torsion and drift from lateral loads. This movement greatly affects the efficiency of the Cancer Hospital, due the location of the imaging rooms, surgery rooms, and advanced researched equipment. The technical reports provide only a general amount of information on the response of the structure to increased movement, specifically dynamic loading.

Solution

High Seismic Region Relocation

In order to gain knowledge and experience in the seismic design of a movement sensitive and abnormally shaped structure, the Cancer Hospital will be theoretically relocated to a high seismic region. This relocation will cause current loads to be higher and more dynamic. In-depth study of the ramifications of this new loading will be conducted in effort to create a building architecturally similar to the Cancer Hospital but with a structure designed to withstand movement in a high seismic region.

Lateral System Redesign

Clear loads will be established using a Modal Response Spectral Analysis. These loads will then be used to redesign the existing lateral system. This will include a separation of the tower from the "L" shaped portion of the 4 story base through use of an isolation joint. The optimal locations for bracing systems in both structures will be determined based on calculation. Once these locations are established an ETABS model will be created to further evaluate the effect of the new seismic loads on the structure. This model will be proven to be an accurate representation of the design using manual calculations. Values for drift and torsion occurring in the revised design will be evaluated and any elements requiring alteration will be relocated or redesigned in order to produce acceptable results.

Breadth Options

Construction Management

Upon final selection of the optimal structural system to reduce vibration, drift, and torsion, a cost comparison will be conducted to evaluate the cost and feasibility of the existing Cancer Hospital design and the proposed design change. In addition to cost, scheduling of project phases and tasks will be performed for the revised system and will be compared to that of the existing design.

Building Envelope

Due to the atypical curved facade of the Cancer Hospital, an investigation into the construction, efficiency, and cost of the current building envelope will be conducted. Alternative building envelopes will also be investigated and compared to the original design. Specific improvements to be identified in the comparison include energy efficiency, light exposure, and architectural effect. Upon completion of the evaluations of the different systems, a building envelope will be chosen and proposed as an improvement.

Codes and References

Codes

IBC 2006 *International Building Code*

ASCE-7-05 *Design Code for Minimum Design Loads*

LRFD Specifications for Structural Steel Design – Unified Version, 2005

References

CRSI Handbook

United Steel Deck Manual

RS Means Building Construction Cost Data (2009)

ETABS V9.2.0

RAM Structural Systems

PCA Slab

PCI Design Handbook/6th Edition

Seismic Design Guide

Tasks

Seismic Research

- Research structural effect of loads in high seismic regions.
- Determine an acceptable relocation area from evaluation of different regions.
- Find seismic design parameters based on selected region and coordinate with commonly used design aids.

Lateral System Redesign

- Research *Modal Response Spectral Analysis* and use to calculate required lateral loads to be carried by structure.
- Configure proper location for isolation of "L" shape extension from tower.
- Apply newly configured loads to both tower and "L" shape extension and use to relocate and add additiona braces as required.

Lateral System Evaluation

- Build ETABS model of both tower and extension based on the newly proposed redesign and evaluate movement involving drift and torsion.
- Check accuracy of model using manual calculation.
- Reconfigure proposed design in order meet movement reduction requirements if necessary.
- Design and detail isolation as requirements and limits of redesign.

Construction Management Breadth

- Compare added cost of proposed lateral changes and revisions for vibration reduction using *RS Means* .
- Create a schedule which has been revised based on the proposed changes and compare with existing schedule.
- Configure the impact that the proposed changes make on the project and prepare for presentation.

Building Envelope Breadth

- Research and analyze existing building envelope using provided specifications and design documents.
- Investigate additional envelopes.
- Evaluate and compare envelope systems in respect to energy efficiency, light exposure, and architectural effect.

PROPOSED SCHEDULE									
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
	Task	Jan 12-16	Jan 19-23	Jan 26-30	Feb 2-6	Feb 9-13	Feb 16-20	Feb 23-27	Mar 2-6
Seimic Research	Proposal Change								
	High Seismic Region Study								
	Relocate Building								
Lateral System Redesign	Apply New Parameters								
	Modal Response Load Calc.								
	Locate Isolation Jt / Apply Loads								
	Create New Lateral Design								
Lateral System Eval.	Build ETABS Model								
	Reconfigure design								
	Detail Isolation Joint								
CM	Compare Cost of Proposed Changes								
	Create Schedule								
	Compare Cost and Schedule to Exsisting								
Building Envelope	Research Existing Envelope								
	Evaluate Areas of Concern								
	Propose Solution if Necessary								

PROPOSED SCHEDULE

		Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
	Task	Mar 9-13	Mar 16-20	Mar 23-27	Mar 30 -3	Apr 6-10	Apr 13-17	Apr 20-24	Apr 27-1	May 4-8
Vibration	Investigate Vibration	Spring Break					Presentation			Final Exams
	Apply Research to Cancer Hospital									
	Establish Limits and Value for Reduction									
	Propose Solution and Evaluate Using									
Drift	Gather Information on Proposed Lateral									
	Model Each System and Check for Accuracy									
	Evaluate Results and Compare Systems									
Torsion	Investigate Bracing Irregularities									
	Model Location Changes and Evaluate									
	Propose Solution for Even Distribution									
CM	Compare Cost of Proposed Changes									
	Create Schedule									
	Compare Cost and Schedule to Exsisting									
Building Envelope	Research Existing Envelope									
	Evaluate Areas of Concern									
	Propose Solution if Necessary									

Conclusion

By analyzing a theoretical relocation of the University Hospitals Case Medical Center Cancer Hospital to a high seismic region, personal knowledge and experience will be gained in the seismic redesign of an abnormally shaped, movement sensitive structure.

Upon completion of the design proposal, a final report will be prepared and subsequently presented members of the structural engineering profession during end of spring semester 2009.