2011

Thesis Proposal

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Patient Care Pavilion; Albany, NY

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Executive Summary

The purpose of this proposal is to present a structural thesis depth as well as two breadths in two of the 3 other architectural engineering options. Also proposed is a problem statement and a solution as well as the different methods and tasks utilized and a schedule with milestones. The Patient Care Pavilion is an addition to the Albany Medical Center Campus, in Albany, New York and is expected to finish construction in June 2013. The 10-story 160ft hospital is comprised of a composite steel structure with braced frames and intermediate moment frames resisting the lateral loads. Due to poor site soils the Patient Pavilion sits on a 36" deep mat foundation with retaining walls surrounding three sides of the site

As designed, the steel structure for the Patient Pavilion is adequate and very economic for it's location. A redesign to concrete would be uneconomical; therefore due to the critical nature of the hospital, a progressive collapse analysis will be performed to reinforce the building against blast. The façade will be changed to a curtain wall system and the panels will meet blast requirements. However, for progressive collapse, it will be assumed that the blast is sufficient enough to completely knock out the column.

Two procedures will be used to analyze progressive collapse for the Patient Pavilion. The first procedure will be the Tie-Forces (TF) method, which takes an indeterminate span and simplifies it into a determinate structure with hinged connections. The second procedure is the Alternate Path (AP) method, which assumes that when a vertical element is removed that the connecting elements can bridge over the vertical support acting as a continuous member.

In addition to the structural depth, two breadth studies will be proposed. The first breadth will be a construction management breadth that will consist of changing the façade from stacked brick to precast panels. Using this type of façade will accelerate the construction process and reduce labor cost as well as produce savings associated with general conditions. The second study will consist of the analysis of the thermal heat exchange rate of the existing façade system. Upon completion of the analysis a precast panel system will then be chosen to reduce the heat loss in the Patient Pavilion. Computer models of the exterior rooms will be generated to help with the analysis of the existing and redesigned façade.

Knowledge obtained in MAE courses will be incorporated in order to successfully design and analyze progressive collapse for the Patient Pavilion. Multiple computer modeling programs learned in AE597A – Computer Modeling will be utilized to create a three-dimensional model of the building. Steel connections will have to be considered when designing for progress collapse and multiple connections will be designed utilizing the knowledge obtained in AE534 – Steel Connections.

Introduction

The Patient Pavilion is located in Albany, NY, at the intersection of New Scotland Avenue and Myrtle Avenue, on the eastern end of the existing Albany Medical Center Hospital (AMCH) campus. Constructed as an expansion to the AMCH, the Patient Pavilion utilizes pedestrian bridges to tie into an existing parking structure across New Scotland Avenue, as well as tying into an existing building on the AMCH campus as shown in *Figure 1.*

The Patient Pavilion will retain the architectural style, forms, and materials of downtown Albany and the AMCH campus, as specified in the City of Albany Zoning Ordinance. The façade primarily consists of brick and stone with punched windows and white stone accenting the upper levels. To add emphasis to the pedestrian walkway over New Scotland Avenue, metal paneling and glazed aluminum curtain-walls added an integrated modern look to the traditional façade.

Figure 1 – Pedestrian Bridges
Image courtesy of Gilbane Construction

The Patient Pavilion consists of two phases; Phase 1, contains the demolition of an existing building on the AMCH campus, and the construction of a six story medical

center see *Figure 2* and Phase 2 is a future four story vertical expansion of the Patient Pavilion see *Figure 3*. The building height of Phase 1 is 75 feet above grade and the vertical expansion of Phase 2 will increase the building height to 145 feet above grade. Due to a small site and large square footage demands, the building cantilevers over the site on the side of New Scotland Avenue, demanding for the design of cantilevered plate girders to support a column load from stories 2-10.

Figure 2 – Phase 1 of Patient Pavilion; Initial Design
Image courtesy of Gilbane Construction

This patient care facility, contributes 229 patient beds, 20 operating rooms, and 1000 new permanent jobs to the AMCH campus. The 348,000 square foot expansion consists of six stories above grade with a four story vertical expansion in the future. Phase 1 construction on the Patient Pavilion began in September of 2010 and projects to finish in June of 2013.

To better understand the terminology used for referring to designated levels, an architectural elevation is provided on the next page.

Figure 3 – Phase 2 of the Patient Pavilion; Vertical Expansion
Image courtesy of Gilbane Construction

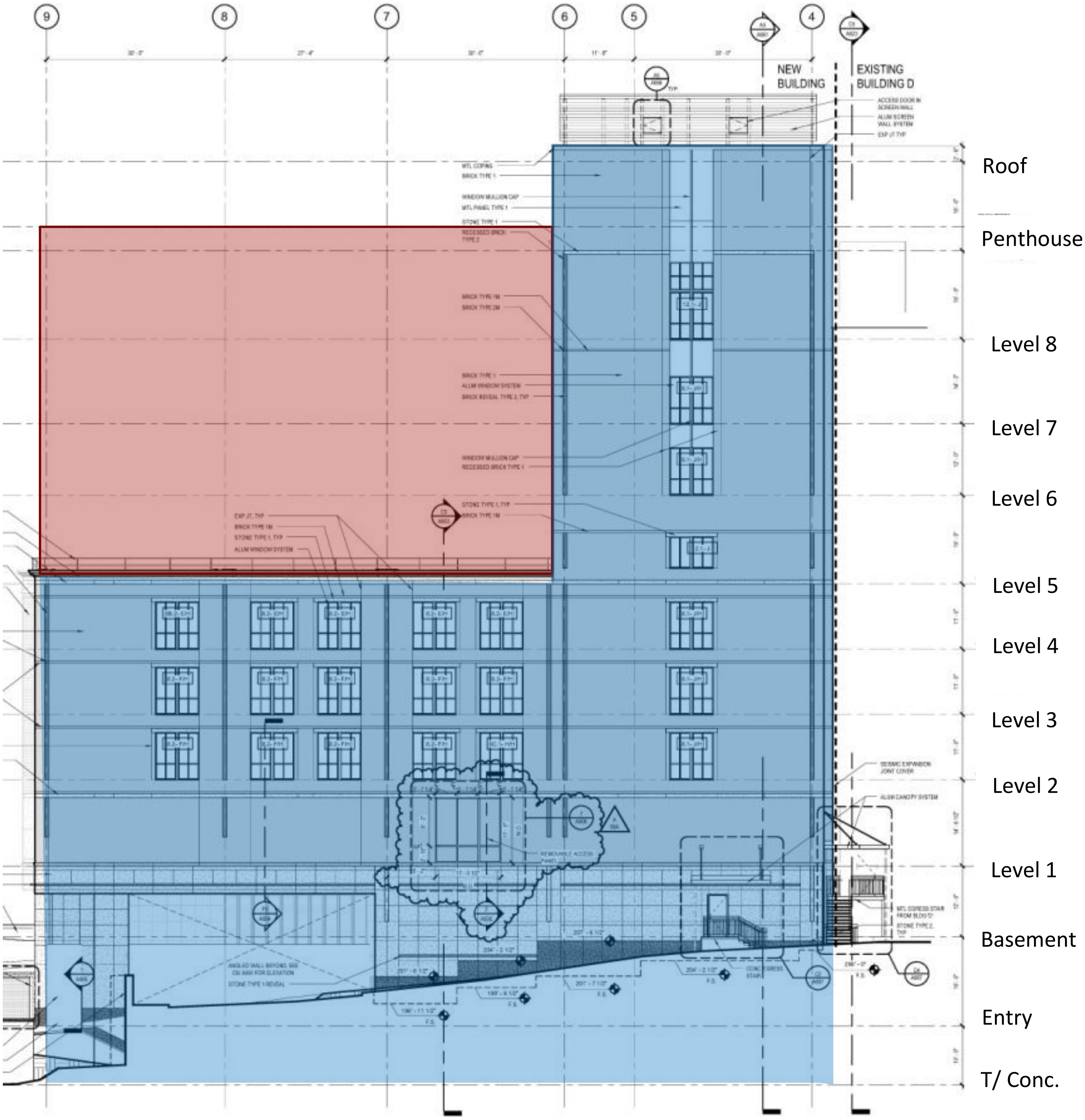


Figure 4 – South Elevation **Image Courtesy of Ryan-Biggs Associates**

Phase 1

Phase 2

Figure 5 – Site Plan **Image courtesy of Gilbane Construction**

New Scotland Avenue

Myrtle Avenue

Structural Overview

The majority of the Patient Pavilion rests on a 36" thick mat foundation, and some piles located near existing buildings. The floor system utilizes composite beams, girders, and slabs to carry the loads derived from ASCE07-02. The lateral forces are collected on the brick non-bearing façade, transfers into the slab and is distributed to the foundation/grade by the integration of braced and moment frames. On the southern end of the site, 62" deep plate girders are utilized to cantilever nine stories over the edge of the site. Multi-story trusses are utilized to carry multiple levels with a large clear span, these are located over the emergency access ramp and at the pedestrian bridge that ties into an existing AMCH building see *Figure 6.*

Figure 6 - Span over Emergency Access Ramp and Street Labels
Image courtesy of Gilbane Construction

Foundation

Vernon Hoffman PE Soil and Foundation Engineering supplied the geotechnical report for the Patient Pavilion site. Procedures used were site boring, vane shear testing, pressure testing, and cone testing. Soil testing concluded that foundations must be designed to a net bearing pressure of 3000psf. Design ground water level was reported to be between 4' and 10' throughout the site. After a full analysis of the site, the geotechnical report recommended the building to sit on a mat foundation resting on a controlled fill.

Because of the relatively low allowable soil bearing pressure, the majority of the Patient Pavilion sits on a 36" mat foundation resting on a 4" mud slab with a 12" compacted aggregate base. Alternatively, 20'-0" deep piles are utilized in order to prevent unwanted settlement of the existing buildings. Piles are utilized in place of shallow foundations because piles will control settlements and provide uplift resistance more effectively than shallow foundations.

Foundation walls are utilized along existing building C and along New Scotland Avenue to lessen the demand on the excavation shoring; these walls also serve the purpose of shear walls in the lateral system. Backfilling behind these walls was needed to provide construction access for equipment and materials to build the pile caps and grade beams.

Floor System

The Patient Pavilion utilizes 3"x20ga galvanized composite steel deck with 3 1/2" lightweight topping, reinforced with #4's at 16" O.C. for shrinkage and temperature, this floor system is typical throughout the levels, unless otherwise noted. On level 2, the floor slab is thickened with a 3" lightweight concrete topping in order to reduce floor vibrations in the operating rooms. The entry level utilizes an 8" lightweight concrete slab on 3 1/2"x16ga composite metal deck because of longer deck spans and larger live loads. In areas where radiation is prevalent, the slabs above and below that level are stiffened with a steel plate anchored to the slab with angles. These plates are located on levels 2 and 3 and their function is to provide a shield from the radiation for adjacent areas, refer to *Figure 7* for radiation slab details.

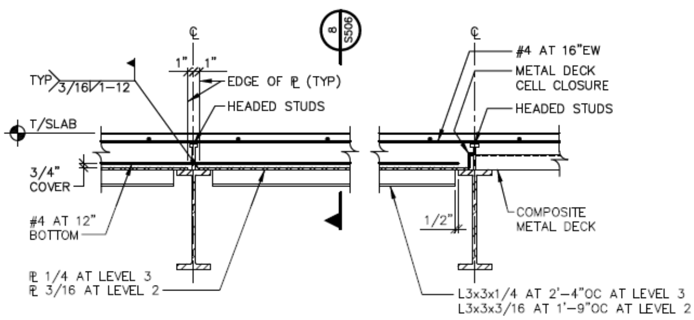


Figure 7 – Slab Detail; Radiation Shielding Plate
Image courtesy of Ryan-Biggs Associates

Typical beam spacing throughout is 10'-0" O.C., creating a 10'-0" deck span requirement, all beams are composite beams, typically W12's. However, on the Basement Level and Level 2, typical beams range from W16's to W18's. Reasons for deeper beams are that the live load requirements on the Entry Level through Level 2 are greater than the other floors. However, the Basement Level and Level 2 utilize deeper beams than the Entry Level and Level 1 due to greater floor-to-floor heights.

Typical beams span 27'-4", these beams sit on girders that typically span 30'-0". Girder sizes range from W14's to W18's; however, on the Basement Level and Level 2 girder sizes fluctuate from W18's to W24's, refer to *Figure 8* for a typical bay on Level 3.

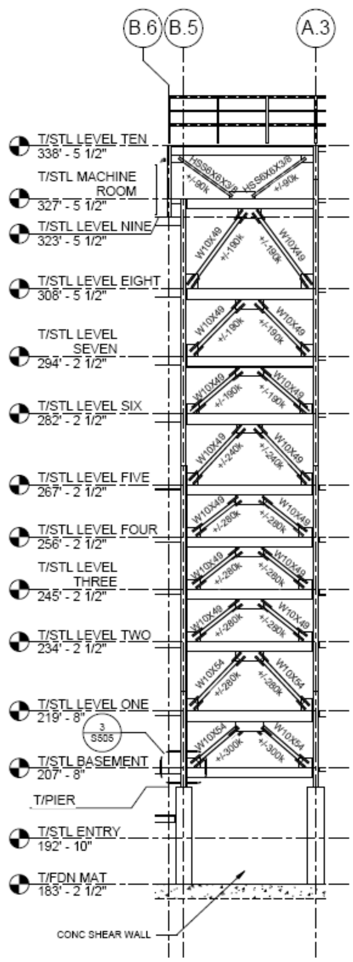
A demand for specialty framing is needed in certain areas in this project; on the southern end of the site, a column is cantilevered 18' over the edge of the site resting on a 62" plate girder. The pedestrian bridge on the tying into the existing AMCH building spans 83' over another existing AMCH building. A two-story truss was designed on bottom two levels of this pedestrian bridge, consisting of W10x77's and W10x100's.

Figure 8 – Typical Floor Plan **Image courtesy of Ryan-Biggs Associates**

Lateral System

The lateral system for the Patient Pavilion predominantly consists of braced frames, with some moment frames. Within the structure, there are 14 braced frames and 5 moment frames, because of the locations of the braced frames, Chevron bracing is utilized to allow openings for doorways and corridors. See *Figure 8* for a typical braced frame. Figure *7* shows the locations of the braced and moment frames, the location of some braced frames fluctuate from level to level. For instance, braced frame 13 is braced between the Basement Level through Level 2 and above Level 2 is a moment frame.

The braced frames along the western side of the site sit on retaining walls in the basement, which also act as concrete shear walls. A strong connection is required to transfer the shear load from the column into the concrete shear wall, for these connections a 30”x30”x3½” baseplate with a 2” diameter anchor bold anchored 42” into the wall is specified. Diagonal bracing on the lower levels range from W10’s to W12’s and HSS8x6’s to HSS8x8’s on the upper levels. Heavier bracing on the lower levels provides a greater resistance to shear, which increases as the force moves down the frame. Columns used in these lateral resisting frames range from W14x43 to W 14x233.



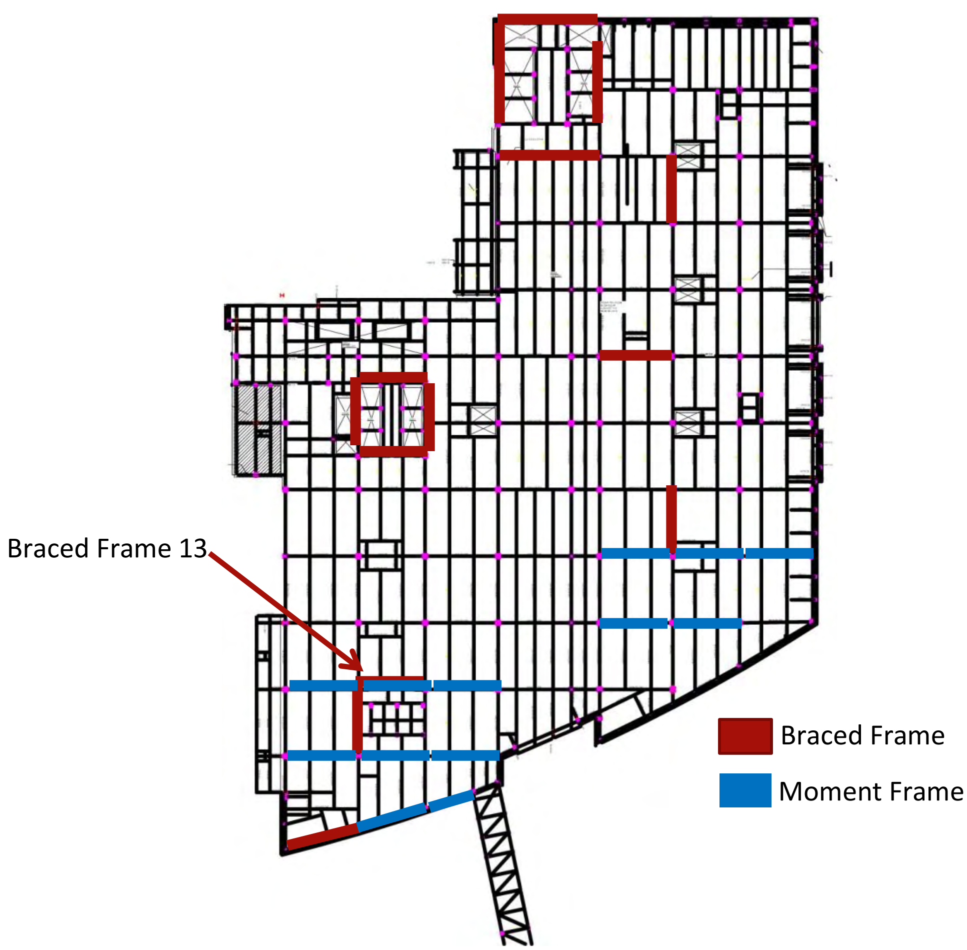


Figure 9 – Typical Layout of Lateral System
Image courtesy of Ryan-Biggs Associates

Figure 10 - Typical Braced Frame
Image courtesy of Ryan-Biggs Associates

Design Codes and Standards

Ryan-Biggs Associates abided by these standards and codes when developing the design of the Patient Pavilion:

- AISC 13th Edition Manual
- AISC Specification 360-05
- 2007 Building Code of New York State (BCNYS)
- Minimum Design Loads for Buildings and Other Structures (ASCE7-02)
- AISC Manual of Steel Construction, Load Resistance Factor Design (LRFD)

Standards and codes utilized for this report:

- AISC 14th Edition Manual
- AISC Specification 360-10
- 2006 International Building Code (IBC 2006)
- Minimum Design Loads for Buildings and Other Structures (ASCE7-05)
- AISC Manual of Steel Construction, Load Resistance Factor Design (LRFD)

Materials

The structural materials designated by the AISC 13th Ed. were used in the design of the Patient Pavilion by Ryan-Biggs; see *Table 1* for the capacities of the large variety of structural elements. The materials were specified on the General Notes page, S001, on the Construction Documents provided via Gilbane Building Company. All steel materials below are according to ASTM standards.

Table 1 – Material Properties

Material Properties		
Material		**Strength**
Rolled Steel	**Grade**	**f_y = ksi**
W Shapes	A 992	50
C, S, M, MC, and HP Shapes	A 36	36
Plates, bars, and angles	A 36	36
HSS pipe	A53 type E or S Grade B	35
Reinforcing Steel	A 615	60
Concrete	**Weight (lb/ft^3)**	**f'_c = psi**
Footings/mat foundation	145	3,000
Interior S.O.G or Slab on Deck	145	3,500
Foundation Walls, Shear walls, Piers, Pile caps, and Grade beams	145	4,000
Exterior S.O.G.	145	4,500
Masonry	**Grade**	**f'_m = psi**
Concrete Block	C 90	2,800
Mortar	C 270 Type S	n/a
Unit Masonry	n/a	2,000
Grout	C 476	2,500
Brick	C 216 type FBS Grade SW	3,000
Welding Electrodes	E70 XX	70 ksi

Loads

In the following tables, dead and live loads that were used to analyze and design the Patient Pavilion are listed as well as the loads used for this thesis. Live loads interpreted by the designer were derived from ASCE7-02, live loads used in this thesis were derived from ASCE 7-05; dead loads were assumed or calculated and verified with specified dead loads on the structural general notes.

Dead Loads

The dead loads listed on the general notes of the structural drawings are listed below in *Table 2.* Upon further analysis shown in *Table 3* and *Table 4*, the assumptions of these loads were verified to be accurate and conservative in some cases. The MEP is larger than typical because in a hospital the MEP weight is to be assumed larger than typical.

Table 2 – Superimposed Dead Loads

Dead Loads (As Shown on General Notes S100)	
Description	**Weight (psf)**
Roof Without Conc. Slab	30
Roof With Conc. Slab	95
Roof Garden	325
Floor	95
Level 9 Mechanical Penthouse	125

Table 3 – Roof without Conc. Slab Verification

Roof Without Conc. Slab Verification (ASCE7-05 and Vulcraft)	
Description	**Weight (psf)**
MEP	12
3”x16ga decking	5
Rigid Insulation (tapered starting at 8”)	.75psf per in thickness=(.75x8x.5)= 12
Total	**29**

Table 4 – Roof with Conc. Slab and Floor Verification

Roof With Conc. Slab and Floor Verification (ASCE7-05 and Vulcraft)	
Description	**Weight (psf)**
MEP	12
3”x20ga Composite Decking	48
Steel Framing	13
Finishes and Partitions	15
Fireproofing	2
Miscellaneous	5
Total	**95**

Live Loads

See *Table 5* for the controlling live load description per each level with the exception of elevator lobbies and stairs. The live loads given on the structural general notes were obtained using ASCE7-02, they were rechecked according to ASCE7-05 and were deemed accurate, see *Table 6.*

Table 5 – Live Loads

Live Loads (As Shown on General Notes S100)	
Description	**Weight (psf)**
Entry	100
Basement	100
Level 1	100
Level 2	100
Level 3	80
Level 4	80
Level 5	80
Level 6	80
Level 7	80
Level 8	80
Level 9 (Mechanical Penthouse)	125
Elevator Lobbies and Stairs	100

Table 6 – Verifying Live Loads per ASCE7-05

Level 1 – Level 2; Verification (ASCE7-05)	
Occupancy	**Weight (psf)**
Assembly Areas – Lobby	100
Hospitals – OR Rooms	60 + Partitions
Hospitals – Patient Rooms	40 + Partitions
Hospitals – Corridors above 1st Floor	80

Snow Load

The snow load for the Patient Pavilion was determined per ASCE7-05 section 7.3. Following the procedure described in this section, the flat roof snow load was calculated to be 37 psf, approximately 40psf, which was listed on the structural general notes. Hand calculations cand be found in Appendix A.

Upon finding the density of the snow, and back figuring the density to find the height, it was determined the flat roof snow load height was 2 feet; this eliminates drift along the parapets, which are 2 feet high. Snowdrifts were calculated against the stair towers (See *Figure 9)* where windward drift loads control because of a larger l_u. Due to the windward forces control, the height of the snow load was reduced by using 3/4 of h_d, however after interpretation of the code the full h_d was used to calculate the drift width W. The height and weight of the drift is shown below in *Figure 9*, the location of each drift calculated is shown in *Figure 10.*

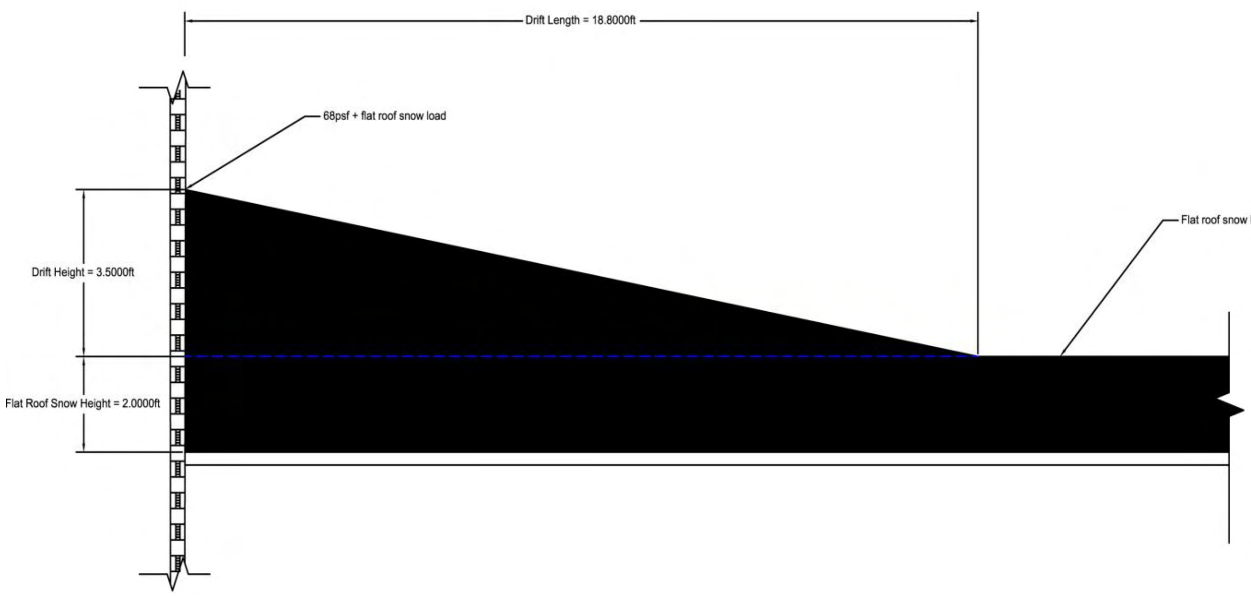


Figure 11 – Snow Drift

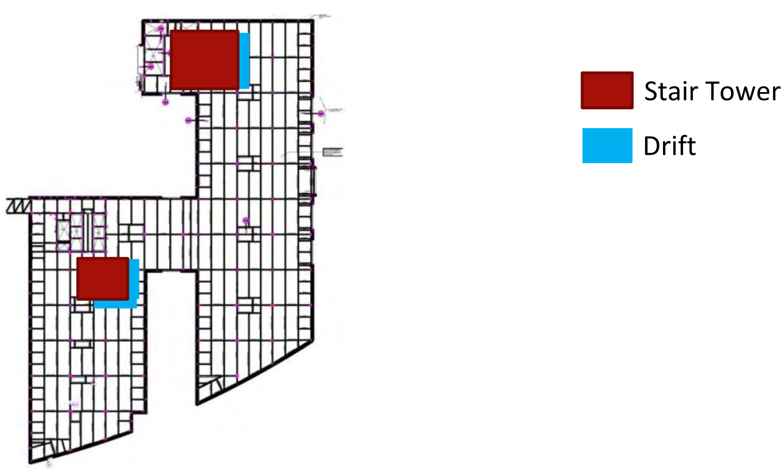


Figure 12 Drift and Stair Tower Locations

Problem Statement

After performing a thorough analysis on the Patient Care Pavilion, it was determined that it meets all code criteria per ASCE7-05 and sufficient to carry all loads per code. The 10-story 160ft hospital is comprised of a composite steel structure with braced frames and intermediate moment frames resisting the lateral loads. Due to poor site soils, the Patient Pavilion sits on a 36" deep mat foundation with retaining walls surrounding three sides of the site.

As designed, the steel structure for the Patient Pavilion is adequate and very economic for it's location. Redesigning the steel structure to concrete would benefit the building because it would be easier to meet the low floor-to-floor height requirements. However, in Albany, New York concrete is much more expensive than steel therefore the redesign would be more costly. Finding improvements for the Patient Pavilion was difficult, and considering the author of this proposal is interested in working on the East coast this rules out seismic considerations. Having the capacity to hospitalize a large amount of people, an in depth progressive collapse analysis will be made in order to prevent the possible catastrophic event of an explosion collapsing the entire building. Additionally the existing façade will be redesigned from hand laid brick to a curtain wall façade to meet blast requirements.

Lining two sides of the Patient Pavilion are vehicle streets, as well as an emergency access ramp that runs under the Northeast corner of the building. These areas can be easily accessed with a vehicle and an explosion could easily destroy the exposed exterior columns. Specific areas of interest are highlighted in green in *Figure 13* below, the area over the emergency access ramp could possibly destroy three columns with one explosion and the exterior columns on the Eastern side of the site are fully exposed to the street.

Figure 13 - Areas of Interest **Courtesy of Gilbane Construction**

Problem Solution

Two design methods will be considered when analyzing the Patient Pavilion for progressive collapse, both of which will be done in steel. Prior to the design for progressive collapse, the façade will be reevaluated for blast utilizing precast panels that will replace the existing façade. Upon completion of the façade design, the spandrel beams and supporting columns will be redesigned to hold the new load from the curtain wall system. Once the building façade is redesigned as well as the perimeter gravity system, two methods of progressive collapse are going to be utilized to analyze the Patient Pavilion:

- Tie-Forces (Indirect Analysis)
- Alternate Path (Direct Analysis)

The Tie-Forces (TF) method is the simpler of the two methods and essentially this method takes an indeterminate span and simplifies it into a determinate structure with hinged connections; see *Figure 14.* Tie-Force method assumes that there is ductility, alternate paths, and continuity within the structure. There are four types of ties that can be utilized by the tie method; they are viz internal, peripheral, ties to columns and walls, as well as vertical ties.

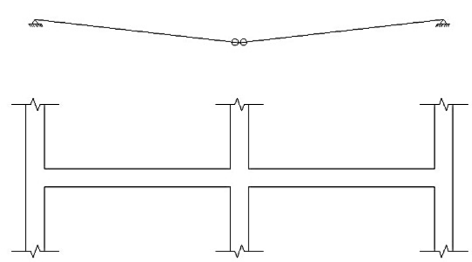


Figure 14 – Tie-Forces Method

The Alternate Path (AP) method is a more complex analysis consisting of three different procedures: linear static, nonlinear static, and nonlinear dynamic. For this report, the linear static procedure will be used. The AP method is applied when a vertical load-bearing member is removed from a structure and the connection elements thus must be able to bridge over the removed element; see *Figure 15* below.

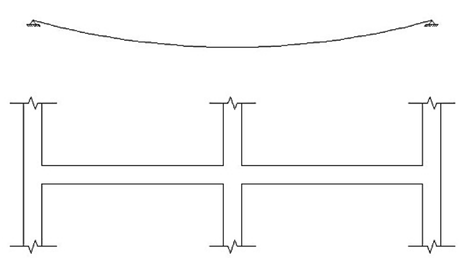


Figure 15 – Alternate Path Method

Note: For progressive collapse, the assumption will be made that the blast is large enough to completely remove a column. The blast analysis will only be taken into consideration for choosing a curtain wall system.

MAE Material Incorporation

Material learned in current and previous MAE courses will be utilized to investigate progressive collapse on the Patient Pavilion. Multiple computer modeling programs, learned in AE597A – Computer Modeling, will be resourced to design the collapse resistant structure. ETABS will be considered to analyze the structure as well as SAP and if time permits, RAM Concept, which was not addressed in the course, will also be utilized.

Removing a column from the structure essentially doubles the span of the beams/girders connecting into it, therefore the connections between the column and beam must be considered carefully. Utilizing knowledge learned in AE534 – Steel Connections as well as knowledge learned from other resources, multiple connections will be designed to resist collapse.

Breadth Topics

Construction Management – Cost and Schedule

The focus of the construction management breadth is to utilize concrete precast panels for the façade rather than the existing façade that is comprised of hand-stacked brick. Cost analysis will be performed for material and labor cost as well as reducing the project timeline that would produce savings associated with general conditions cost.

Cost of the building is not controlled by the cost of the material used; the majority of the cost is associated with the labor hours used to erect the building. Benefits of using precast panels are to reduce the labor needed to install the façade and also minimize installation mistakes made in the field. Spandrel beams will need to be redesigned to hold the weight of the new precast panels, these will also be incorporated into the cost, however the additional cost of steel should be minimal.

Mechanical – Façade Study

The existing façade for the Patient Care Pavilion is hand-stacked brick tied into each floor. A heat transfer analysis will be performed on the existing façade to determine its thermal efficiency. Based on the results of the analysis a new curtain wall façade will be chosen to decrease the heat loss. Computer modeling programs will be utilized to model an exterior room in the Patient Pavilion.

Task and Tools

Structural Depth – Progressive Collapse Redesign

Task 1: Design Building Façade

- Determine possible façade precast panels to resist blast
- Size spandrel beams and supporting columns for the new precast panels

Task 2: Update Computer Model

- Revise seismic forces on the building with new building weight
- Apply updated lateral loads to the building
- Revise perimeter framing members

Task 3: Research and Perform the Tie-Forces Method

- Perform a thorough study of the TF method
- Apply the TF method analysis on critical areas in the building

Task 4: Research and Perform the Alternate Path Method

- Perform a thorough study of the AP method
- Apply the AP method analysis on critical areas in the building

Breadth 1 – Construction Management: Cost and Schedule Analysis

Task 1: Determine Cost and Schedule of Existing Façade

- Contact PM to obtain information for existing façade
- Utilize RS means to determine productivity rates

Task 2: Determine Cost and Schedule of Proposed Façade

- Utilize RS means to determine cost and schedule
- Create a schedule using Microsoft Project

Breadth 2 – Mechanical: Façade Redesign

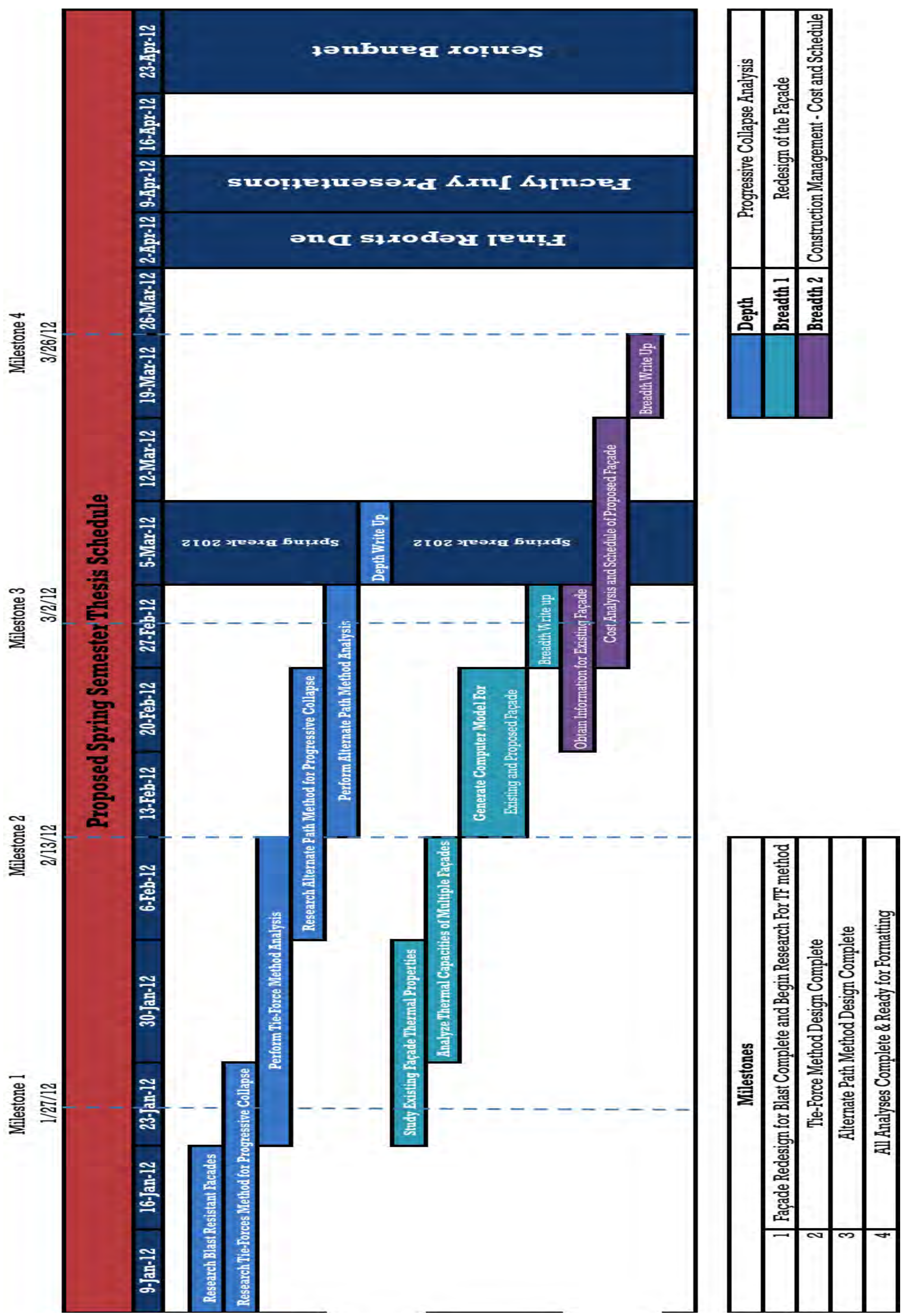
Task 1: Existing Façade Study

- Analysis of existing façade
- Generate a computer model of an exterior room

Task 2: Façade Redesign

- Analyze different curtain wall systems that meet blast requirements
- Generate a computer model of an exterior room

Schedule


Proposed Spring Semester Thesis Schedule
Milestone 1 1/27/12
Milestone 2 2/13/12
Milestone 3 3/2/12
Milestone 4 3/26/12
9-Jan-12
16-Jan-12
23-Jan-12
30-Jan-12
6-Feb-12
13-Feb-12
20-Feb-12
27-Feb-12
5-Mar-12
12-Mar-12
19-Mar-12
26-Mar-12
2-Apr-12
9-Apr-12
16-Apr-12
23-Apr-12
Research Blast Resistant Facades
Research Tie-Forces Method for Progressive Collapse
Perform Tie-Force Method Analysis
Research Alternate Path Method for Progressive Collapse
Perform Alternate Path Method Analysis
Depth Write Up
Study Existing Façade Thermal Properties
Analyze Thermal Capacities of Multiple Façades
Generate Computer Model For Existing and Proposed Façade
Breadth Write up
Obtain Information for Existing Façade
Cost Analysis and Schedule of Proposed Façade
Breadth Write Up
Spring Break 2012
Spring Break 2012
Final Reports Due
Faculty Jury Presentations
Senior Banquet
Milestones
1 Façade Redesign for Blast Complete and Begin Research For TF method
2 Tie-Force Method Design Complete
3 Alternate Path Method Design Complete
4 All Analyses Complete & Ready for Formatting
Depth Progressive Collapse Analysis
Breadth 1 Redesign of the Façade
Breadth 2 Construction Management - Cost and Schedule

Conclusion

The redesign for the Patient Pavilion focuses on resisting the building against progressive collapse and blast. The façade will be redesigned to resist blast requirements, however when performing the progressive collapse analysis it will be assumed that the blast is large enough to remove a column. The gravity system will have to be redesigned around the perimeter of the building for the spandrel beams and the columns that support the new curtain wall system. Two different methods will be considered when analyzing progressive collapse, Tie-Forces method and the Alternate Path method. Areas deemed to be crucial to designing for progressive collapse will be considered, and will be reinforced as need.

A mechanical breath will be performed to analyze the existing façade and to redesign the façade using a curtain wall system. Areas of focus for the façade are: heat transfer, its efficiency, and blast requirements. Generating a computer model for both façades will supplement the hand calculations for the façade.

Finally, a construction management breadth will be incorporated to analyze the cost and schedule of the existing façade. Once a new curtain wall system is designed a cost and schedule will be created utilizing RS means and Microsoft Project. A comparison of the two buildings will be made to determine the cost difference for a blast and progressive collapse resistant structure to the existing structure.