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Technical Proposal Revision 1
Bed Tower Addition at Appleton Medical Center
Appleton, WI

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Senior Thesis Studio

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Executive Summary

The design of the existing structure for the Bedtower Addition at Appleton Medical Center is being used as an addition to a hospital in San Francisco, California. Currently located in Appleton, WI, the existing design will have to be modified to comply with seismic requirements for the new San Francisco location. Two different options are being considered so the structure will be able to withstand seismic loads.

One of the two options is to modify the existing braced frames. This includes checking the connections and sizes of the beams so that they comply with ASCE7-10. There will be a quick check on the gravity system for change in snow loads and the lateral system will also be affected. A computer modeling program and hand calculations will then be used to compare the results of the modified braced frame system with the existing one.

The other option is to install a base isolation system. A base isolation system simply requires the structure being separated from the foundation by base isolators. This will ultimately reduce seismic loads acting on the structure. The base isolation system will then use the existing structure to check if modifications are to be corrected again. Comparisons will then be made with a computer modeling program and hand calculations. The purpose is to see the impact which the base isolation does to the lateral loads on the structure. It is assumed that the system will greatly reduce the forces thus ensuring safety to the occupants inside the building.

In addition to the structural depth, two breadths will be analyzed. One will be architectural impact and the other will be a construction and cost analysis.

Because modifications will be made to the structure, increase in beam or column sizes could reduce the total area that the hospital uses. Modifications could also affect the exterior. Drawings and sketches will be used to show the differences.

A construction and cost analysis will be performed because the modifications and addition of the base isolation system will greatly impact the schedule and costs of the building. The purpose of this breadth is to create a new schedule which will be efficient and keep additional costs to a minimum.

Once all of the analysis is compared to the existing structure, it will then be determined if a redesign is more efficient for the new location of the hospital.

Introduction

Bed Tower Addition at Appleton Medical Center, owned by ThedaCare is located in Appleton, Wisconsin approximately two hours (~106 miles) northeast from Madison, Wisconsin. The building was measured at a height of 107 ft and 3 in. above grade to the highest occupied floor, which entails 9 stories including a basement. The total size of the addition is 152,330 sq ft. This includes renovation done to the existing hospital plus the new addition itself.

Bedtower Addition

Picture 1: *Bird's eye view of Appleton Medical Center*

The bedtower addition is to accommodate more patients for the hospital. Because of its size, it stands out amongst the rest of the complex. It has a unique triangular shape layout which is carried throughout all the floors of the building. The horizontal streaks of CMU along the exterior make the addition look sleek and long. Accommodating the long streaks are large areas of glass. Both materials work together to show floor separation and this gives the perception that the addition is taller than it actually is.

The first floor is the lobby area which consists of the registration and waiting area along with a mini coffee shop. Offices are located on the second floor area which is a very large space and has movable partitions. Third through eighth floors consist of patient rooms, waiting rooms, and floor manager offices. The second to fourth floors connect to the

Picture 2: *Perspective view of Bed Tower Addition entrance*

original hospital with the fourth floor extended into the original building, which is the emergency and surgery center.

On the exterior of the building, the façade consisted of two essential components which are a stone façade and large areas of glazing. Limestone and Cast Stone, architectural concrete building unit used to simulate natural cut stone, make up the entire exterior. Limestone makes up the crown running along the bottom of building. Cast stone is what is seen throughout the rest of the exterior which makes up the vertical façade.

Glazing makes up the other half of the exterior. There are three kinds of glazing. They are: 1) Clear Vision Glass; 2) Tinted Vision Glass; and 3) Spandrel Glass. The clear vision glass is used on the first floor where the lobby is located to allow the most daylight and energy. The tinted vision glass and spandrel glass work together to shade the patient rooms and stairwells and they don't transmit as much sunlight or energy as the clear vision glass.

Picture 3: *Bed Tower Addition*

Structurally, the addition is made up of a system of steel framing and composite deck. The foundation is a mat padding. On top of the roof, there is a large penthouse which holds the mechanical equipment. This is all supported by the steel framing of the building. For lateral loads, cross bracing is integrated within the frame.

Picture 4: *Construction of the addition*

Code

International Code

- 2006 International Building Code
  - Live load reduction used for typical floor loads and corridors above the first floor.

Design Codes

- ASTM International 2008
  - Concrete and testing of masonry
- ACI 318-08
  - Reinforced concrete design and construction
- AISC 360-05
  - Structural steel - Designed for "in place" loads
- SDI - Vulcraft Steel Deck 2008
  - Steel roof decking
  - Steel composite floor deck - Designed as unshored
- OSHA Safety Standards 2008
  - Steel erection
  - Steel joist erection
  - Metal decking erection
- ASCE 7-05
  - Wind loads

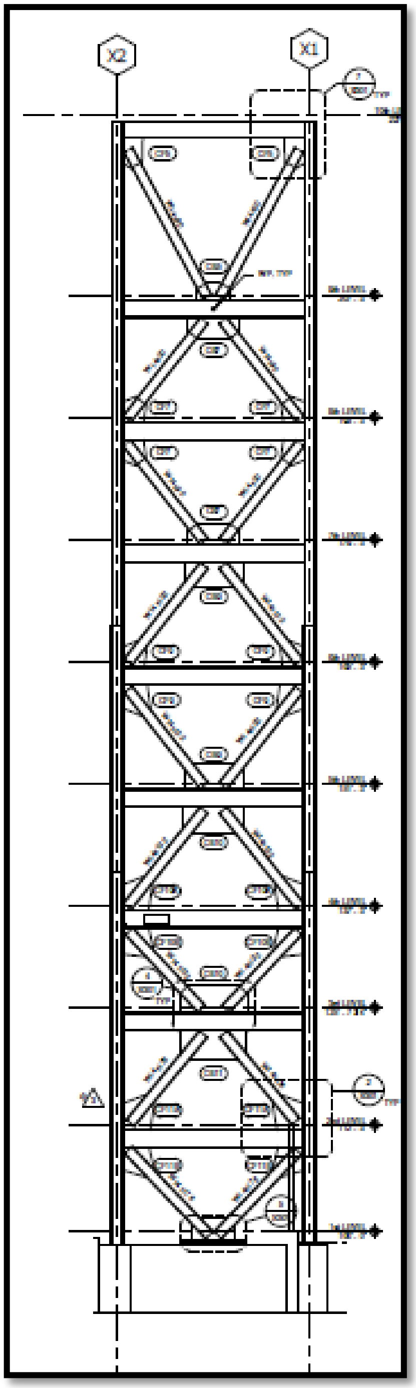


Figure 1: *Elevation of a braced frame system*

Courtesy of HGA

Structural System

The overall lateral system is a rigid frame with cross bracing. Rigid frames are commonly used when there is a need to provide unobstructed interior space with total adaptability. For the case of the Appleton Medical Center, a rigid frame was the best decision. It allowed the architects to create large spaces without being hindered by the structural system.

Bracing

Concentrically steel braced frames in each direction resist the lateral loads while the concrete slabs on metal deck act as the diaphragm which transfers the loads to the braced frames. There are 8 sections where the braced frames run vertically throughout the building. The typical frame runs from the top of the foundation to the top of the 9th level penthouse roof. Two others run to the top of the 9th level and the last one runs just between the 9th and 10th level. Shown on the previous page is a typical braced frame in Figure 1.

Connection to the mat foundation, explained later in the foundation section, helps transfer the lateral loads to the base. The braced beams are connected to the columns and floor beams by gusset plates for ease of construction and transfer of loads. Close-up of the braced frames are pictured on the left in Figure 2.

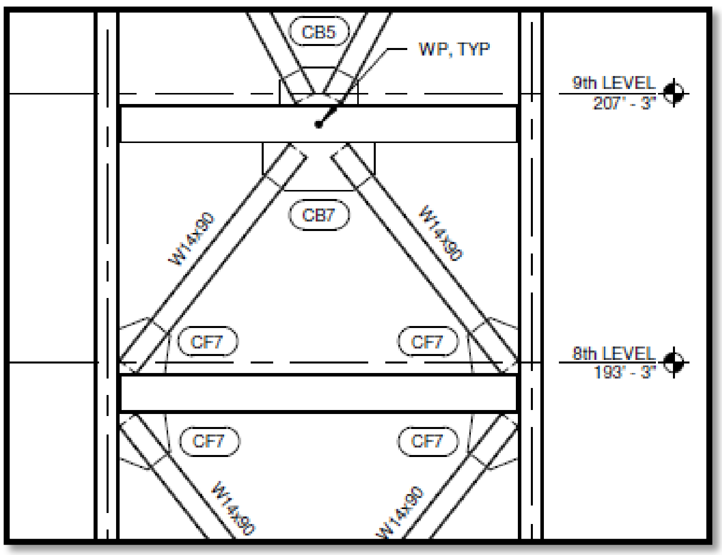


Figure 2: *Close-up of the braced frame system*

To the right are construction photos of the gusset plates used and connection to the foundation for the braced frames in Figures 3 and 4, respectively.

Figure 3: *Close-up of gusset plate construction for the braced frame*

All 3 Figures Courtesy of HGA

Figure 4: *Picture of a typical column connection to the foundation using a base plate*

Foundation

The geotechnical report was completed by (RVT) River Valley Testing Corporation. Originally, the foundation was designed with spread footings in mind, but after investigation by RVT they recommended three alternatives, which included the currently used mat foundation. Tests indicated that the natural soils on the site were able to hold bearing pressures ranging from 1,500 psf to more than 6,000 psf. The footings were then designed for a maximum soil bearing pressure of 3500 psf for just gravity loads and 4200 psf for gravity plus lateral loads. Spread footings range from 6 ft x 6 ft to 9 ft x 9 ft with depths being 1 to 2 ft. Maximum allowable interior column loads were to be 1,500 kips and the maximum allowable perimeter wall load was 3 kips per lineal foot.

Typical reinforcement for the mat slab includes the use of #7, #9, and #11 bars. The thickness of the mat slab is 3 ft 6 in. throughout the entire foundation under the triangular side of the addition. The area where the addition connects to the original part of the building has various thicknesses with 12 in. being the typical.

Most importantly, the braced frames are connected to the foundation to resist overturning moment. Typical thicknesses of these are 4 ft and run as long as the column spacing. Columns are connected to the bases by steel plates that are connected to the top of the concrete by 6 #6 hooks. The bases are reinforced by 5 #5 bars running horizontally and #5 bars running vertically spaced at 12 in. O.C. Pictured below in Figure 5 is a section and elevation of the braced frame to foundation connection with reinforcement.

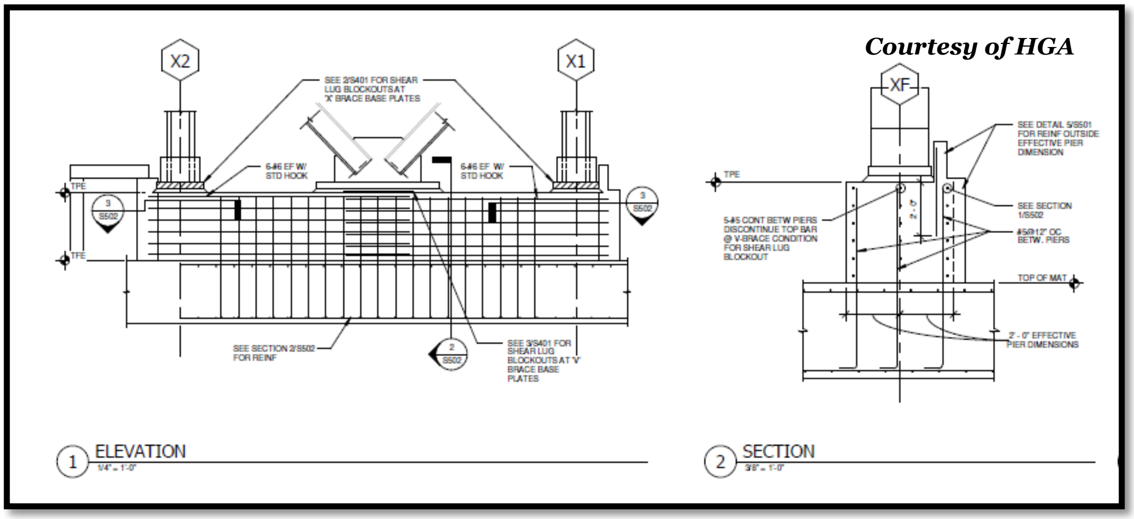


Figure 5: *Detail of Typical Foundation Connection for the Braced Frames*

Figure 6 shows where the braced frames are connected at the foundation level in green. There is one more braced frame, but as stated earlier in the bracing section, this one is located on the top level.

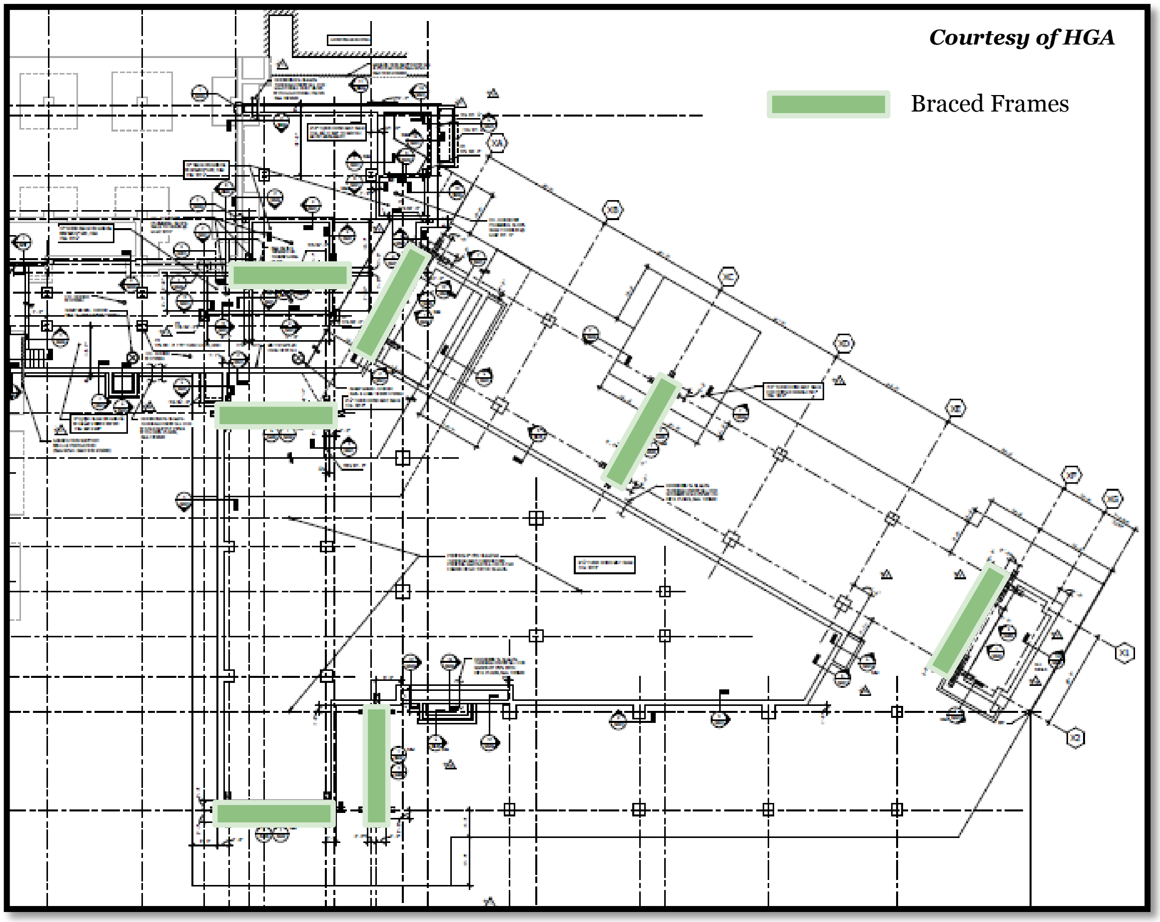


Figure 6: *Location of braced frames*

Floor Construction

Typical floor construction for the addition included the use of 4 types of "deck." Most floors were constructed of 3 in., 18 gage galvanized steel deck with a 4-½ in. normal weight concrete topping, making it a total thickness of 7-½ in. reinforced with 6x6 WWF. One floor was a combination of two decks. One "deck" was a 10 in. light weight concrete slab which was reinforced with #4 @ 18 in. O.C. running longitudinally. The other deck was a 2 in., 18 gage galvanized steel deck with a 3-½ in. light weight concrete topping making it a total thickness of 5-½ in. and reinforced with 6x6 WWF. Both the galvanized decks are composite and require a stud length of 5 in. for the

7-½ in. deck and 4 in. for the 5-½ in. deck. The roof deck was just a 1-½ in. 20 gage galvanized steel decking.

Bay sizes were typically set at 30 ft, especially on the outer spans of the building where the patient rooms are located. But, due to the irregular shape of the addition and use of the interior space, column lines were placed where columns were to not interfere with the working space of the interior. Bays of the interior ranged in various lengths. Decking typically spanned 10 ft and was supported by beams ranging from W14's to W21's with the typical being W16's. Lengths of the beams were typically 22 ft and were supported by girders ranging from W18's to W24's, but some exterior girders were W30's. Below in Figure 7 is a typical floor plan.

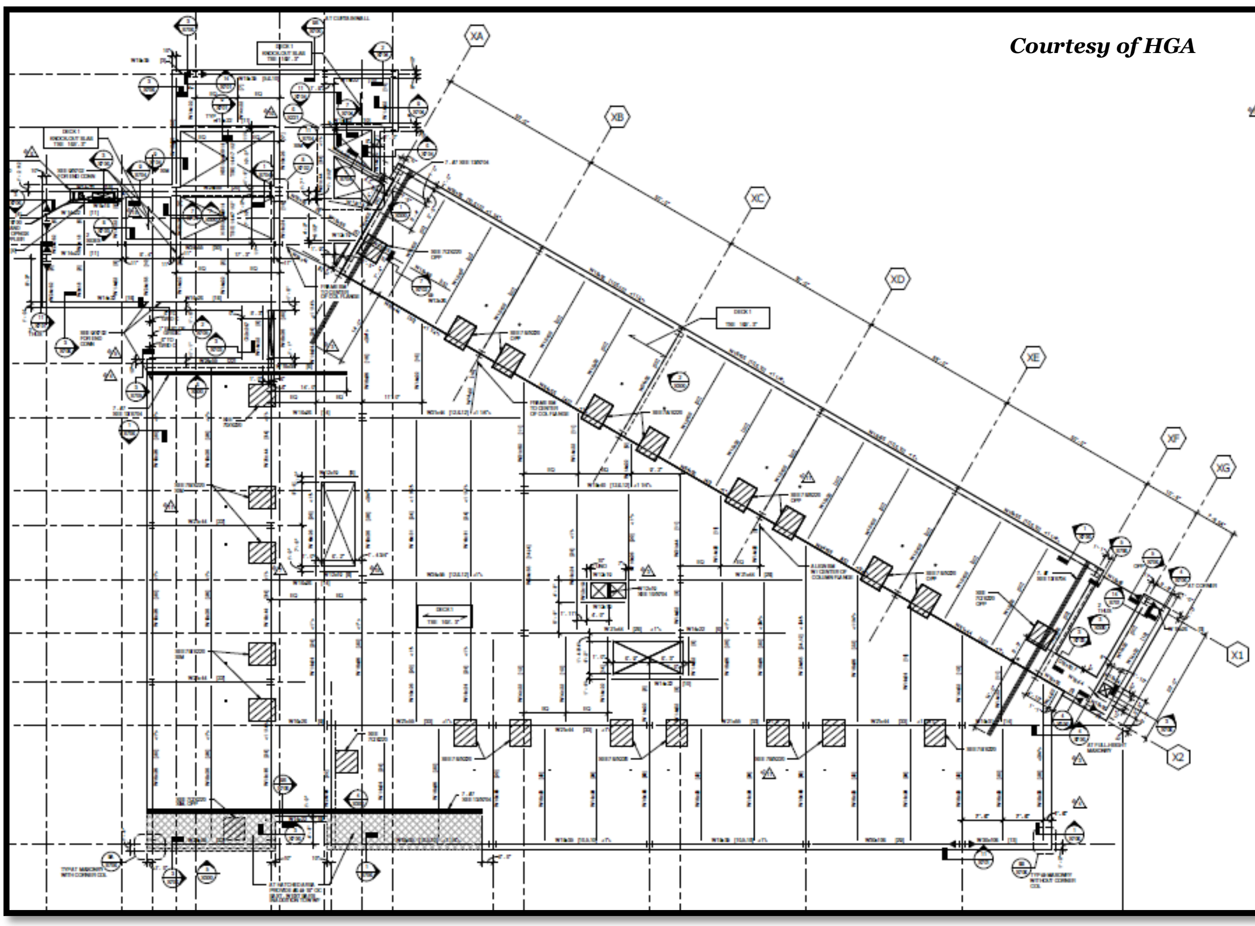


Figure 7: *Typical Floor Plan*

Construction Materials and Building Loads

Materials used in construction were specified in the general structural notes on Sheet S001. More information on the materials was found on the floor plans and detailed sections and elevations as well.

Dead Loads	
Material	Load (psf)
Superimposed	30
Composite Deck	
7.5" Thick 3" Steel	75
5.5" Thick 2" Steel	57
Roof	2.14
10" Slab	120 pcf

Figure 8: *Dead Loads*

Properties of Materials		
Material		*Strength*
Concrete	**Weight**	**f'c (psi)**
Composite Deck	145	3500
All other concrete	115	4000
Steel	**Grade**	**fy (ksi)**
Reinforcing Bars	A615	60
W Shapes	A992	50
Other Shapes	A36	36
Rectangular HSS	A500 - B	46
Round HSS	A500 - B	42
Bolts	A325/A490	60
Studs	A108	50

Figure 9: *Properties of Materials*

Dead loads used for calculations were found in various ways. The composite deck and roof deck were found using the Vulcraft Roof and Steel Deck manual. The weight of the 10 in. light weight concrete slab was known and it was then assumed a superimposed dead load of 30 psf was used.

Live Loads		
Occupancy	Design (psf)	Thesis (psf)
Typ. Hosp. Floor	80	80
Corridors (Above 1st Floor)	80	80
Corridors (1st Floor)	100	100
Lobby Floor	100	100
Stair and Exits	100	100
Storage	125	125
Mechanical Room	125	125
Snow Load	34	34

Figure 10: *Live Loads*

Live loads were found using ASCE 7-05. However when doing research, typical hospital floors for patient rooms were found to be 40 psf, but it is believed that 80 psf was used because corridors (above 1st floor) with a load of 80 psf controlled. Because the patient rooms were found above the 1st floor, 80 psf was used for ease of calculations, although it is a conservative approach to this design.

Problem Statement

After the conclusion of technical report 3, the bed tower addition was proven to be adequate in strength for lateral loads. From the analysis, it was determined that wind was the controlling force. However, the author this proposal wanted to learn more about seismic design. In order to do this, seismic forces need to control analysis. To accomplish this, a scenario had to be created where seismic design controlled.

The Scenario

A hospital in San Francisco, California wants to build a bed tower addition to comfortably accommodate more patients. They decide to build the addition similar to the one located in Wisconsin, because of its architectural similarities and unique triangular design which would fit perfectly on a plot of land already own.

With an idea in mind, design started, but problems quickly arose. The existing structural system was believed to not hold the adequate strength. Therefore, a new lateral structural system would have been designed.

Problem Solution

Two designs are being considered for the new bed tower addition. One design solution is to modify the existing braced frames to fit the seismic requirements of ASCE7-10. Additional braced frames might also be designed to further ensure adequate strength. If this were to occur, these new braced frames will be designed by hand and properly placed within the structural system so as to not disturb the existing architectural layout. Dampers are also being considered into the design of the new braced frames to see if vibration throughout the building could be reduced. This could be helpful for the hospital since less vibration would be less disturbing to the patients and staff inside. Once the above is completed, the new lateral system will then be compared to the existing one to check differences in strength and flexural capacities.

The other design being considered would be using base isolation. This is when the superstructure (the structural skeleton itself) is separated from the substructure (the foundation) by base isolators during an earthquake. During this process, the superstructure will move slower because of the base isolators absorbing a majority of the shock inflicted upon the building. For the purpose of this proposal, thorough research of this subject will have to be done. Such research includes, seeing if there are any hospitals in the San Francisco area which utilize base isolation and looking at various types of base isolation. A thorough cost analysis of the base isolation will also be considered.

Breadth Study I: Architectural Impact

Both design solutions can make an architectural impact on the building. In the event that additional braced frames are designed, they will need to be located so the entire building layout is not affected. This was also a problem during the design process of the actual structure. Braced frame locations were selected after the layout of the hospital was created. As a result, the structural engineers had difficulty in selecting the placement of the frames. Utilizing the base isolation method will also make a big impact. In order to design a base isolation system, a moat (cavity) space needs to surround the building to account for the large displacements created during an earthquake.

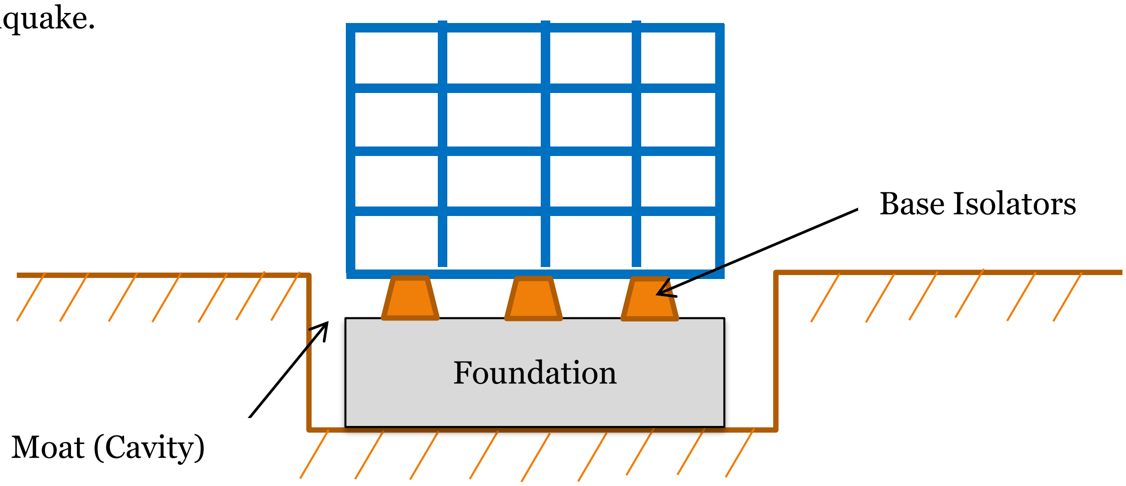


Figure 11: *Picture of a building with base isolation*

Breadth Study II: Construction and Cost Analysis

Redesign of the braced frames would impact construction and create additional costs. Construction impacts will include change in schedule to modify the braced frames. In addition, the length of the schedule could increase if more braced frames are designed. Implementing the base isolation system will also impact construction. Changes to the schedule and site layout will need to be reconsidered for the addition of the moat around the building and change in foundation design to support the base isolation system. Costs due to these changes will result in additional labor, formwork, and material costs.

Tasks and Tools

Structural Depth Analysis

1) Modification of Existing Braced Frames
    a) Use ASCE7-10 to see what needs to be checked
    b) Modify braced frames to comply with the code
    c) Use computer modeling program to determine both the effectiveness of the modifications and change in any member sizes
    d) Do hand calculations to check strength capacities
    e) Add any new braced frames in the event the existing modified braced frames were to fail
        i) Design new braced frames and input them into a computer modeling program
        ii) Do hand calculations to check if the new braced frames were able to reduce stress on other existing lateral members and check for adequate strength
2) Base Isolation Design with Existing Structure
    a) Research and select type of base isolation system
    b) Design base isolation system
    c) Input it into a computer modeling program together with the existing structure
    d) Do hand calculations to determine strength capacities
3) Base Isolation Design with Modified Structure
    a) Input base isolation design into a computer modeling program together with the modified structure
    b) Do hand calculations to determine strength capacities
4) Compare and Contrast
    a) Compare results of all 3 options to determine the best design for new location
    b) Check cost ramifications of using the base isolation

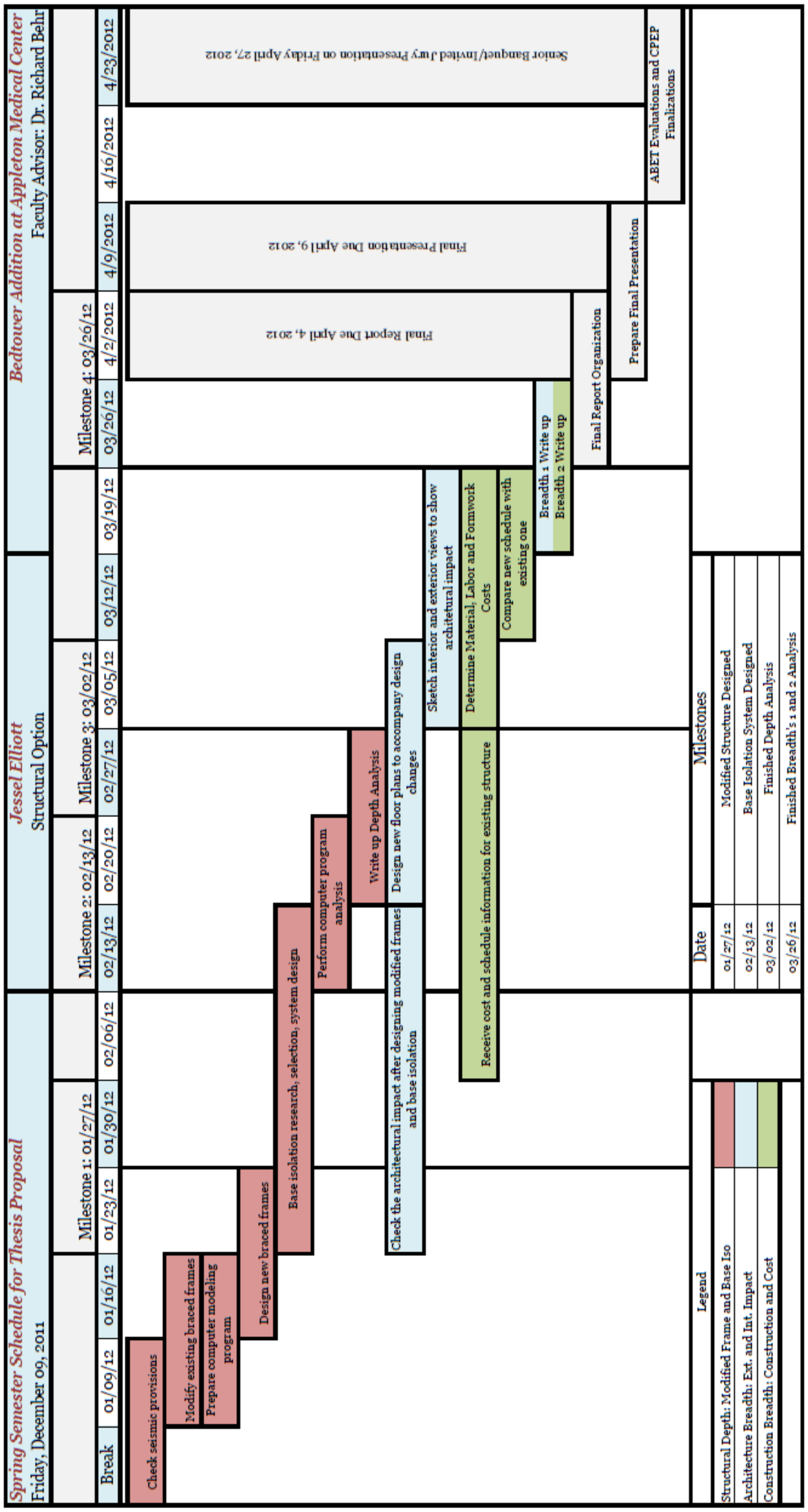
Breadth Study 1: Architectural Impact Analysis

1) Interior Layout
   a) Check floor layout after modification of braced frames. Ex. – Bigger members could reduce total floor area or hinder certain passages such as doors and hallways
   b) Check selection of new braced frames, if added, and impact on the existing spaces
   c) Design a new layout if needed
   d) Sketch quick interior views of spaces where the braced frames could hinder visual performance or layout.
2) Exterior Changes
   a) Determine how to disguise moat around the building for base isolation
   b) Sketch exterior view

Breadth Study 2: Construction and Cost Analysis

1) Obtain existing structure's cost and schedule information
2) Construction Impact
   a) Design site layout for construction of base isolation system
3) Cost Impact (Using R.S. Means)
   a) Determine labor costs for both designs
   b) Determine formwork costs for both designs
   c) Determine material costs for both designs
4) Schedule Impact
   a) Choose 3 vendors who specialize in base isolation
   b) Compare costs between all three
   c) Determine most efficient schedule
5) Compare new cost and schedule information with existing information

Proposed Schedule



Conclusion

The intent of this proposal is to explore redesign options for the Bedtower Addition at Appleton Medical Center by moving its location from Wisconsin to California. Options include modifying the existing structure to comply with ASCE7-10. A second option is implementing a base isolation system to reduce to the loads inflicted on the building. Once the modified structure has been designed, it will be one of two structures evaluated with the base isolation system. The other structure will be that of the existing building. Through structural analysis using a computer modeling program and hand calculations, comparisons can be made between the existing structure and both redesign options. Comparisons include checking reduction in seismic forces, displacements and story drifts. In addition, there is a possibility of architectural changes such as different floor layouts and reduced area. A construction and cost analysis will also be compared to that of the existing structure. An overall comparison of the structural depth and breadths will determine if redesigning the existing structure can be a more efficient option than the existing one.