St. Elizabeth Hospital Boardman Campus Inpatient Facility

Boardman, Ohio

Josh Behun

Structural Option

Thesis Proposal

January 18, 2007

Faculty Consultant: Dr. Linda Hanagan, P.E.

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Executive Summary

The St. Elizabeth Boardman Inpatient Facility is a 65 million dollar renovation to the already existing hospital located in Boardman, Ohio. The hospital, owned by the Humility of Mary Health Partners, began the renovation project in October of 2005 and has recently finished construction of the new addition in August of 2007, which consists primarily of a seven story, 25,000 square foot tower addition. Structurally, the building has been designed as three distinct sections; the patient tower, the surgical wing, and the diagnostic wing. The patient tower is the majority of the renovation, though the diagnostic wing has also received an addition. The structural system for the patient tower addition consists of structural steel framing with a brick façade and an aluminum panel curtain wall system that exists on the north facing elevation of the tower, while the rest of the building is primarily two stories of masonry construction.

The proposed thesis is to investigate the validity of a redesign of the patient tower with a structural concrete system, as apposed to the original steel frame design. From calculations performed throughout the second technical assignment, it was determined that the steel system used would have been the most efficient design for the building. Though, a structural alteration may provide additional improvements throughout other applications of the building's functions and processes, including; construction, operation, overall design efficiency, or any other number of areas of practical usage.

Along with the redesign of the patient tower's main structural system, a few breadth studies will also be conducted. First off, the architectural aluminum panel curtain wall will be evaluated for the validity of its use with a concrete structural system, as well as its ability to withstand weather elements without leakage and resist excessive amounts of heat loss from within the building. Secondly, as the design of the building undergoes a variety of modifications, the overall cost and scheduling for the building are likely to change as well. Thus, to make an adequate comparison of the differing structural systems, an updated estimate and schedule will be prepared for the concrete system and the construction processes that are involved.

Once all of the final components of the hospital are considered, the effect the building places on the environment and the degree of sustainable practices used throughout the construction phase and its life cycle will also be evaluated. With this information, it can then be determined how close the hospital would be to obtaining a LEED ranking and becoming acknowledged as a certified "green" building. Also, with an evaluation of the amount of earnable LEED points, the necessary steps to improve efficiency can be established and the goal to achieve this recognition, or possibly raise it to a higher level. Along with sustainable effects, the mechanical systems within the building will also require an in depth evaluation in order to analyze and understand the hospitals indoor air quality demands.

Building Description

The St. Elizabeth Hospital Boardman Campus Inpatient Facility is a 65 million dollar renovation to an already existing two story building located in Boardman, Ohio that consists primarily of a seven story, 25,000 square foot tower addition. The patient tower is constructed utilizing a steel framing system, which includes a façade system that is constructed using a brick veneer with a curvilinear aluminum panel curtain wall system that exists on the north facing elevation of the hospital. The remainder of the building, including the preexisting areas, is primarily masonry construction. The total height of the new building tops off at around 104 feet, plus a penthouse that contains a stairway for access to the rooftop HVAC equipment. The hospital began the construction for the new patient tower addition during October of 2005, and has recently finished in August of 2007.

Introduction to Structural System

Foundation

The foundation for the St. Elizabeth Hospital Inpatient Facility consists of 16" diameter auger cast grout injected piles with a capacity of 50 tons and an f'c of 4000 psi, including (4) #6 vertical bars for the top 20' of the piles and #3 ties spaced at 16" on center. The vertical reinforcement from each pile is to extend 18" into its corresponding pile cap or grade beam with a 90° hook of 2'-0" in length. Several of the column piers have been constructed on existing footings, subsequent reinforcement bars are to be drilled and grouted into the existing footing with Hilti epoxy adhesives, providing a minimum embedment of 8".

Super Structure

The framing for the patient tower's structural system consists primarily of wide flange structural steel members. The typical column size for the building is within the range of W12x40 to W12x136, while there are a minimal number of W10 and W14 columns throughout the atypical areas of the new addition. The girders for the building are on average W30x90 where the façade is brick and W18x40 where the outer façade is the aluminum panel curtain wall system. The floor to floor height of each story two through seven is 14'-8" tall while the floor to floor height for the first floor is 15'-4" in height. The remainder of the building, including the preexisting areas, is mainly two stories of masonry construction with a glass curtain wall storefront entrance. The design engineer for the hospital had conducted the initial design by separating the building into three distinct sections; the diagnostic wing, the surgical wing, and the patient tower. The first two wings are the preexisting masonry structure, while the patient tower is the steel framing that makes up the bulk of the renovation project. The connections between the tower addition and the preexisting two story building contain expansion joints that include Teflon slide bearings, allowing the hospital's different sections to react to lateral loading as separate identities.

Floor System

The floor system of the St. Elizabeth Hospital Inpatient Facility is a concrete slab system comprised of a 4" light weight concrete topping slab on 2" – 20 gage galvanized composite decking with 5" long ¾" diameter shear studs and a 6x6-W2.1xW2.1 welded wire fabric reinforcement system. The majority of the beams for the floor framing are 21" in depth with a typical span of 34'. On the first two floors, the new addition's floor systems are connected to the existing floor slabs as well as the masonry walls by ½" diameter Hilti adhesive anchors spaced at 24" on center, with a minimum embedment of 4½".

Lateral Bracing System

The lateral resisting system in place at the St. Elizabeth Boardman Hospital consists of a number of braced frames strategically placed throughout the superstructure. The majority of the bracing frames used along the exterior of the building contain chevron type bracings, or K braces, and are located against the eastern most side of the building, where the aluminum panel curtain wall system meets the brick façade. There is also a large section of bracings amongst the elevator shafts that consist primarily of chevron style bracings as well, except for a two column section along the western most side of the elevators that is constructed using a set of singular cross bracings. Aside from the typical bracings throughout the building, there are also a small number of interior framed sections that contain knee bracings for added lateral support. All of the bracing members used throughout the framing system are square HSS members ranging in size from 5x5x3/8" to 9x9x1/2".

Roofing

The roofing system is a flat roof which consists of structural steel members similar to that of the floor system. The area where the HVAC units rest has a slab of 4½" light weight concrete on 2"- 20 gage galvanized composite decking with 6x6-W2.1xW2.1 welded wire fabric reinforcement. While the remainder of the roof area, including the penthouse roof, is constructed of 1½"-20 gage galvanized wide ribbed steel roof deck.

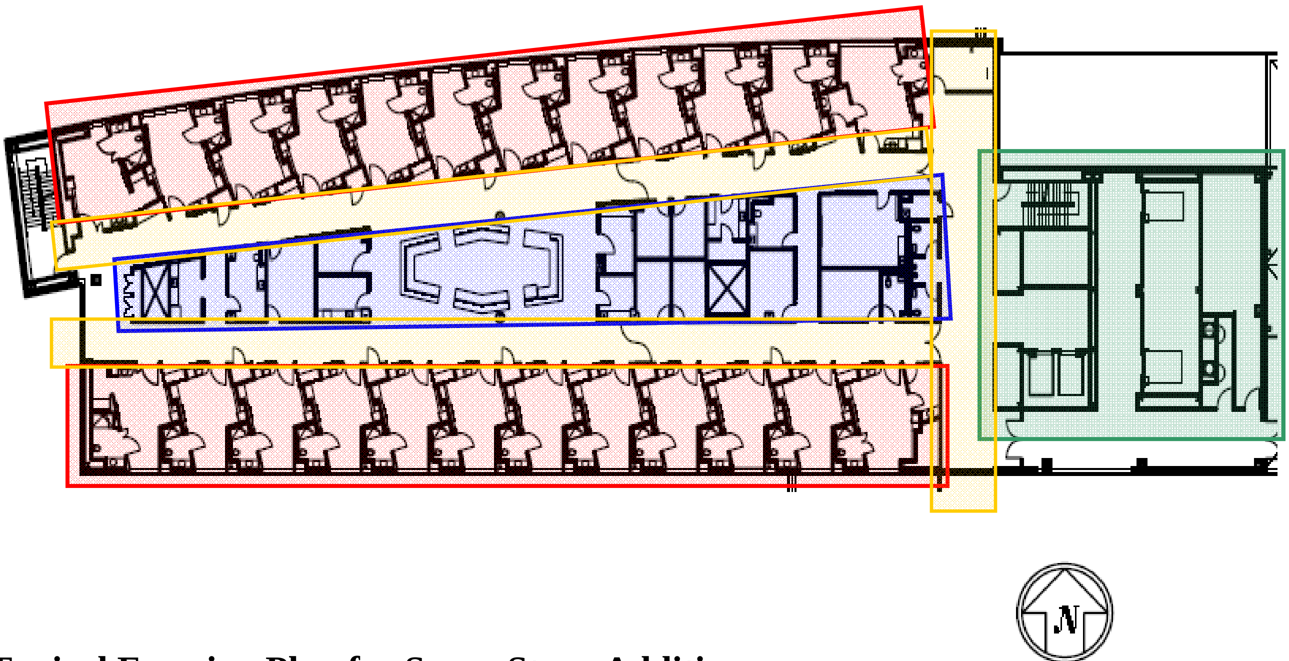
Mechanical System

The mechanical system of the new hospital is comprised of three local systems contained within different areas of the building for handling the building's indoor environment. The most noticeable system is a set of railing enclosed roof top units that control the heating and air conditioning for the seven story addition. There are also two mechanical rooms housed within the building for more localized air quality control. The first of which is located on the second floor and consists of three air handling units for controlling air quality throughout the entire building, while the other mechanical room is housed on the third floor and contains one air handling unit as well as two large chillers and 6 boilers to provide comfortable heating and cooling environments for their patients through all seasons. All air quality is controlled in each room by VAV boxes to meet minimum air quality standards by code.

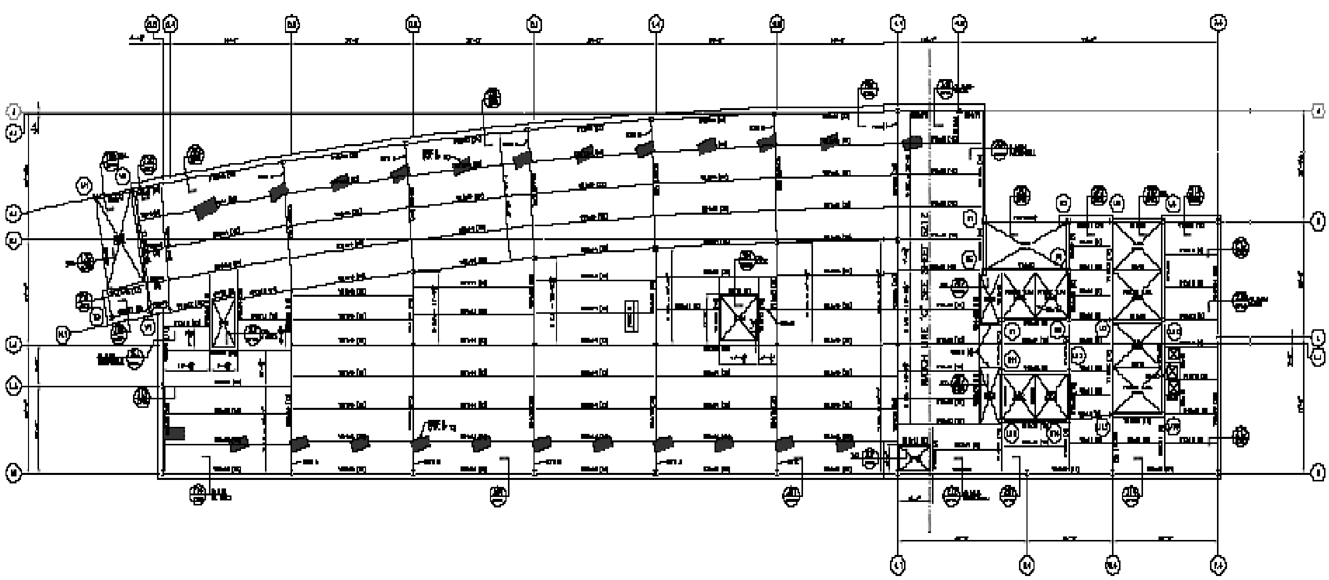
Typical Framing Plans for new Inpatient Facility

Typical Floor Plan for Seven Story Addition

- Showing **patient rooms**, **nurse's station**, **elevator core**, and **corridors**.



Typical Framing Plan for Seven Story Addition



Problem Statement

Based on all of the analysis performed for the building, the structural system for the St. Elizabeth Hospital Inpatient Facility as it currently stands has been designed adequately enough to resist all of the loading combinations that it would receive in the northern Ohio region. Though, in order to evaluate the possibility of improvements that could be made to the building, the structure will be redesigned using a cast in place concrete structural system. In the essence of designing a building that is meant to provide assistance for maintaining public health, it is only natural that the building itself should be made to reduce the strain it places upon the environment it occupies. With that, the hospital must be evaluated to meet the standards of a LEED certified "green" building, which practices sustainable methods and ideals while promoting a healthier and more efficient existence.

Problem Solution

The hospital's new patient tower addition was originally designed using steel framing members. The focus of this study will be to redesign the building's structure in order to investigate the validity of using a concrete structural system instead of the original steel framing system that is currently in place at the hospital. Though, since the use of a concrete system stands to impose any number of implications upon the current building, the constraints it then creates upon the hospital will be inspected and evaluated as well. Plus, with the use of structural concrete, the current steel lateral bracing system will no longer be valid, thus the necessity to construct shear walls for resisting lateral forces will be investigated. While physical changes are underway, the building will be evaluated for its environmental impact and utilization of sustainable practices, in order to obtain a clear vision for the path to be taken to progress the hospital into a LEED certifiable status, while also conducting a more in depth evaluation of the demands of indoor air quality placed upon the hospital's mechanical systems.

Breadth Topics

Construction Management

In conjunction with redesigning the building using a concrete structure as apposed to the current steel framing method, the project's construction schedule will be evaluated and revised as needed to allow for the amount of time required to construct and finish a cast in place concrete structure. Aside from the project's scheduling demands, the cost differential between the structural steel and concrete systems will also be analyzed and assessed. In these ways it can be determined which procedure allows for the most efficient way to complete the project based on cost and time constraints.

Building Envelope

The building exterior, aside from the brick façade, contains an aluminum panel curtain wall system on the north facing elevation of the new tower addition. A building's envelope is an area that may pose considerable amounts of concern with subjects such as water penetration and heat loss. While conducting a site visit of the hospital, it was brought to my attention that there had been a few leakage problems and that water damage is currently a concern of the hospital's maintenance personnel. The processes used to install the system, as well as testing methods performed and alternative solutions, will be investigated to determine if the current façade system was the best choice, or if it could have been constructed in a more efficient manner.

Sustainability / Mechanical Systems Analysis

Once all of the final components of the hospital are considered, and it has been determined which system will be declared the more functional structural design method for the hospital, the building can be evaluated for the effects it places upon the environment and its application of sustainable practices throughout the building's construction phases and life cycle. From there, it can be determined what steps will need to take place in order for the hospital to become recognized as a LEED certified "green" building, or if there are any steps that can help it to achieve a higher ranking. By evaluating the amount of LEED points the building would earn in its current condition and the amount of points that are easily within reach, it can be determined what the costs of upgrading the building's environmental status may amount to. Since the building functions as an establishment for healing the sick, indoor air quality will remain an important issue throughout the building's entire life cycle. With that stated, an in depth analysis of the mechanical systems in place within the hospital and their efficiency with meeting indoor air quality demands would be a pertinent issue for a more comprehensive sustainable design inspection.

Being that there are three breadth ideas listed above, as further evaluation of the latter two topics are investigated and it is determined which one poses to be a more significant concern, the third option will be neglected within the final thesis or only briefly mentioned with a minor degree of significant detail.

Tasks and Tools

I. Structural Concrete Design

Task 1 - Design Concrete Framing System

a) Design the floor slabs with ACI.
b) Design the columns with ACI.

Task 2 - Determine New Loads

a) Determine the weight of the new building.
b) Recalculate the lateral forces imposed upon the building using ASCE-05.

Task 3 - Evaluate Lateral Resisting System

a) Calculate the effects of the new lateral loads on the concrete framing system.
b) Design shear walls if necessary.

II. Breadth Research

Task 1 - Begin Construction Management Estimations

a) Evaluate the scheduling process for concrete buildings.
b) Conduct take-offs for concrete system and compare construction costs of each.

Task 2 - Research Building Enclosures

a) Research water penetration.
b) Research heat loss.
c) Evaluate the aluminum curtain wall and the validity of using this façade system with a concrete framing structure.

Task 3 - Consider Effects of Sustainability

a) Evaluate the building's environmental impact; from the beginning of construction on through the entire life cycle.
b) Determine the necessary steps for achieving LEED certification.

Task 4 – Investigate Hospital's Mechanical Systems Indoor Air quality

a) Determine requirements of indoor air quality for hospitals.
b) Investigate the actual output of the hospital's mechanical systems and determine its efficiency with indoor air quality demands.

Time Table

Tasks	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Research Hospital Structures	C L								**S P**
Design Concrete Floor Slabs	A S								**R I**
Design Concrete Columns	S E								**N G**
Determine New Loading	S								
Evaluate Lateral System - Design Shear walls	B E								**B R**
Begin Take-offs and Estimate	G I								**E A**
Research LEED Points	N								**K**

Tasks	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
Research Building Enclosures					**P R**			**F I**
Research Mechanical System / Indoor Air Quality					**E S**			**N A**
Prepare Construction Schedule and Estimate					**E N**			**L S**
Determine LEED Status					**T A**			
Prepare Presentation					**T I**			**W E**
Complete Thesis Report					**O N**			**E K**