PROPOSAL

Daniel Goff
Structural Option

Faculty Advisor
Linda M. Hanagan

Executive Summary

The Primary Health Networks Medical Office Building is located in Sharon, Pa in between Pitt and E Silver streets next to the Shenango River. It will be a 5 story structure rising 85 feet, having four elevated floors and a roof. The building offers 78,000 square feet of occupant space and will cost approximately $10 million.

Concrete spread and mat footings to serve as a foundation for the building. The building is primarily a steel framed structure with steel columns supporting wide flange steel girders and steel bar joists. Typical sizes for floor joists and girders range from 10 inch to a maximum depth of 24 inches. The floor structure is concrete on metal deck for all four elevated floors, whereas the first floor is concrete slab on grade. Typical bay sizes range from 30'x26' to 33'-10"x30'. The building's lateral force resisting system is comprised of three Ivany block shear walls. The shear walls are located around stairwells throughout the building.

The proposed thesis will investigate the value of an alternative concrete framing system. Two-way flat plate slab systems with drop panels will be designed for both floor and roof structures; these floors will be supported by concrete columns located along the same gridlines as the existing system. Concrete shear walls will be designed as a lateral force resisting system and then compared to the existing lateral system to determine efficiency.

The impact of this change on constructability will be evaluated by comparing construction schedules for both structural systems as a proposed construction management breadth.

The current building façade will be redesigned to better integrate with the surrounding structures while remaining modern and aesthetically pleasing through the combined use of brick veneer and glazing systems. The feasibility of this redesign will be investigated through a cost comparison with the existing façade.

Table of Contents

Figure 1 – Elevation
Image courtesy of Taylor Structural Engineers

Building Summary

The Primary Health Network's Medical Office Building, as shown in Figure 1, will be located between Pitt and E Silver streets near the Shenango River in Sharon, Pa as denoted in red on Figure 2. The building will be 5 stories above grade, four elevated floors and a roof comprising a total building height of 85 feet. The tentative construction period is November 2014-August 2016, the demolition of existing structures on the site is included in this timeframe. The approximate building cost of $10 million will provide 78,000 square feet of occupant space. The building façade is an exterior insulation finishing system in combination with a glazing system. The E.I.F.S. was chosen for its economic efficiency while the glazing serves the purpose of giving the building modern aesthetics.

Figure 2 – Site Map

Image courtesy of Taylor Structural Engineers

Structural System Overview

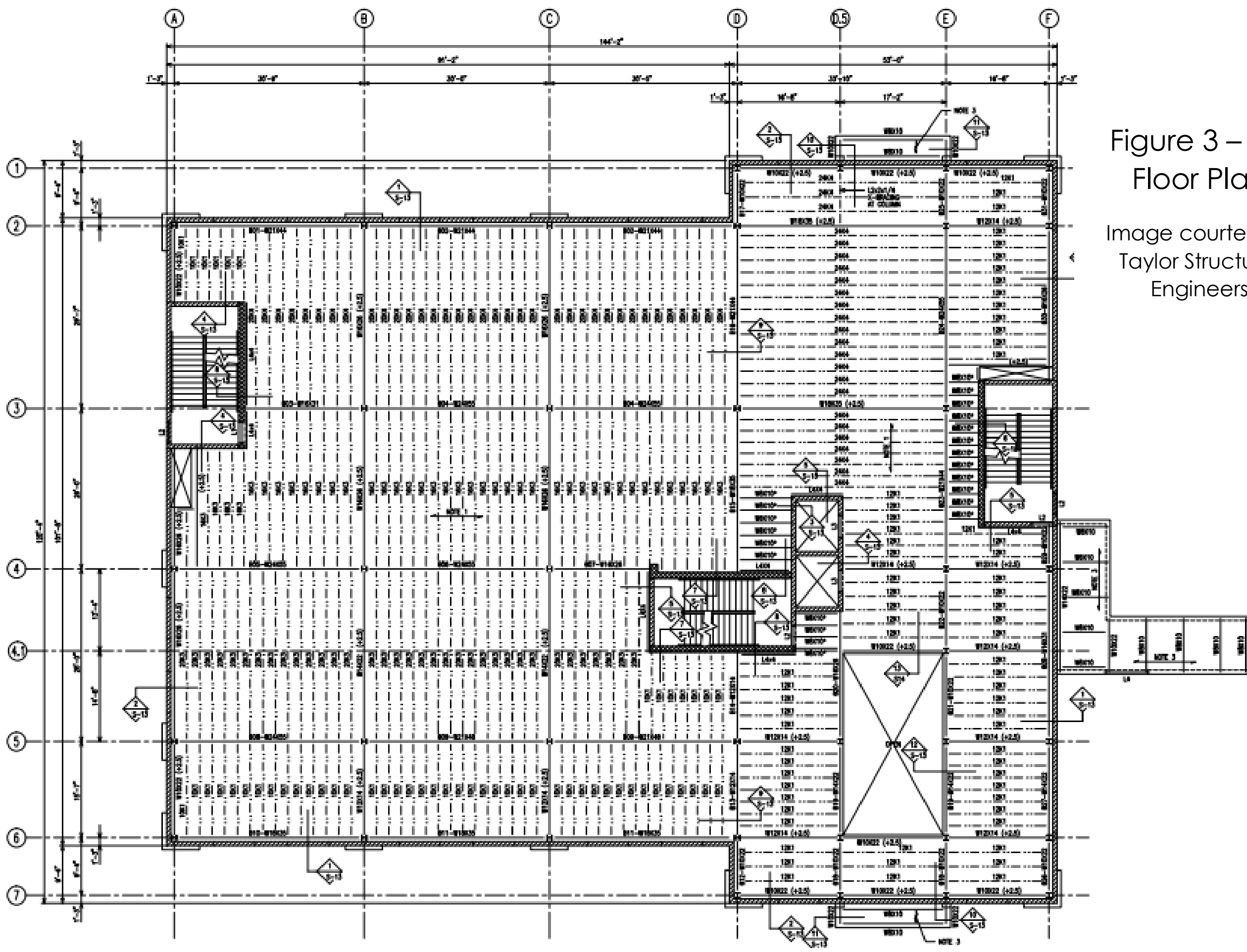


Figure 3 – 2nd Floor Plan

Image courtesy of Taylor Structural Engineers

The Primary Health Network's Medical Office Building in Sharon, Pa is primarily a steel framed structure. Steel columns and rolled steel girders comprise the gravity support system as seen in Figure 3 above. The four elevated floors consist of concrete on metal deck supported by steel bar joists. The roof structure is comprised of an adhered membrane on rigid insulation supported by metal deck. Fully grouted Ivany block masonry walls encasing the three main stairs comprise the lateral force resisting system for the building. The building first floor is supported by a reinforced concrete slab-on-grade while the remaining building load is transferred through the columns to reinforced concrete footings.

Design Codes and Standards

Below is a list of all applicable building codes and standards used in design.

- International Building Code 2009
  - NOTE: IBC 2012 selected for wind load calculations
- American National Standards Institute 2006
- American Society of Civil Engineers 7-05
  - ASCE 7-10 for wind calculations
- American Concrete Institute 318-08
- American Institute of Steel Construction
  - Structural Steel Buildings 2005

Materials

The following tables give the material properties of all major structural components used in the building design.

Table 1.1 – Steel Properties

Shape	ASTM	Grade	Fy(ksi)
Beams and Girders	A992	50	50
Plates and Bars	A36	-	36
Steel HSS	A500	B	46
Pipe	A53	B	30
Columns	A992	50	50
Bolts	A325	-	-

Table 1.2 – Concrete Properties

	Minimum Strength(ksi)	Weight (pcf)	Max Water/Cement Ratio
Mat Footings	4	144	0.50
All Other Foundation	3	144	0.50
Interior Slabs	4	144	0.45
Exterior Slabs	4	144	0.40

Table 1.3 – Masonry Properties

	Minimum Strength(ksi)	ASTM
Hollow Units	1.5	C90
Solid Units	1.5	C90
Ivany Block	3	-
Standard Mortar Above Grade	3	C270 Type S
Standard Mortar Below Grade	3	C270 Type M
Mortar for Ivany Block	3	C270 Type M

Typical Bay

A typical bay in this building is roughly 30'x30' with the joists spanning north to south on the western half of the building and east to west on the eastern half. A typical bay is shown in Figure 7 below, a typical floor plan can be seen in Figure 8 on the next page. Steel columns support the floor and roof structures. Figure 6 – Details the typical spliced connection at the third floor level where column sizes are reduced. All columns are W10's with weights ranging from 33 to 60 plf. At the third floor level the columns are spliced with the majority being decreased to W10x33's.

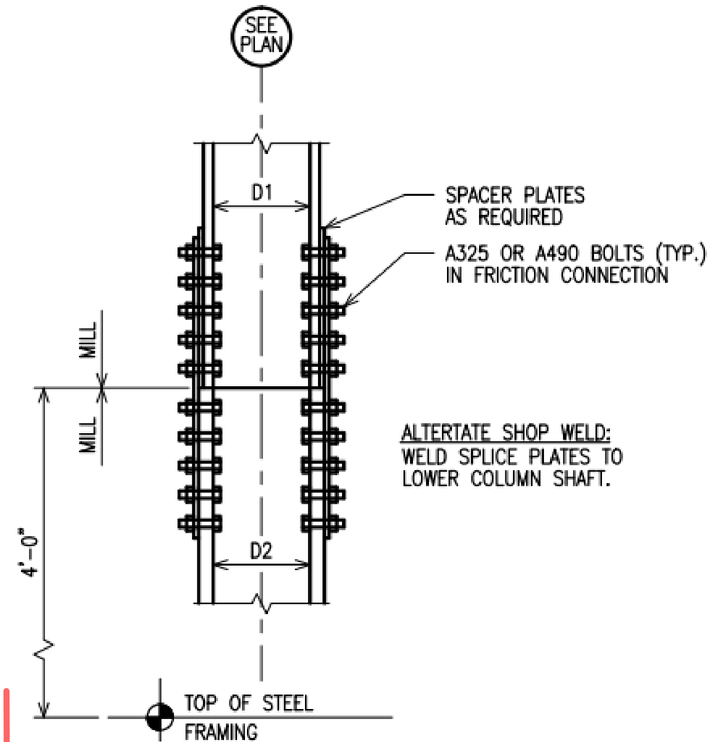


Figure 6 – Typical Column Splice

S-10 Typical Bolted Column Splice

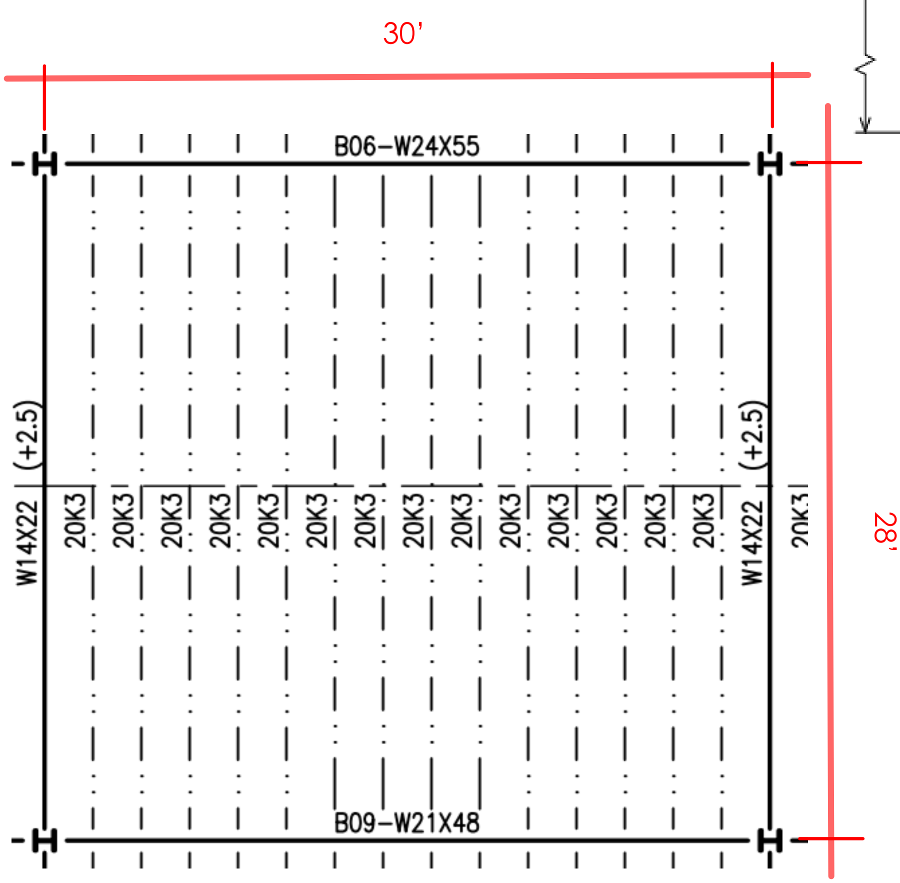


Figure 7 – Typical Bay

S-2 Second Floor Plan

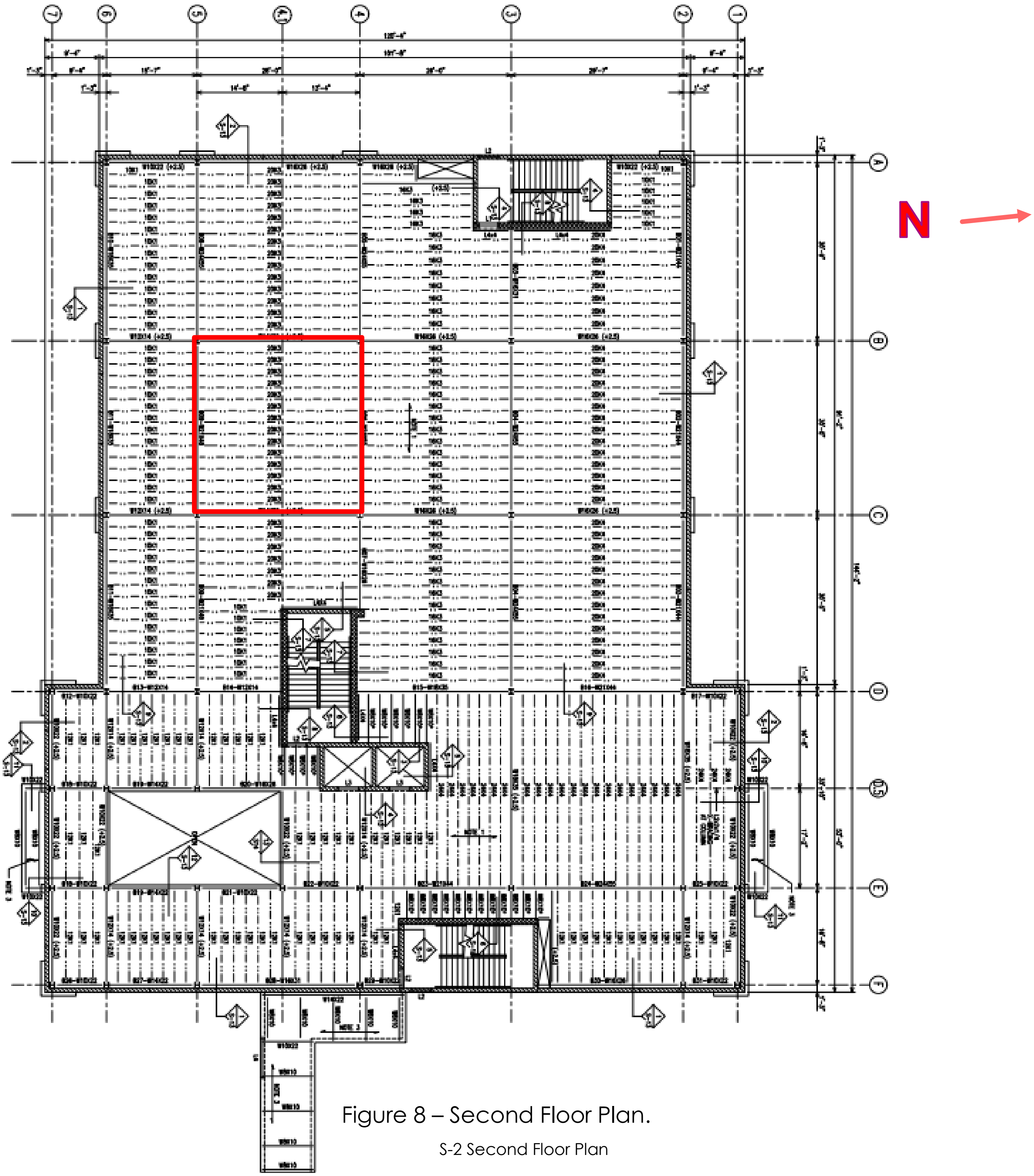


Figure 8 – Second Floor Plan.

S-2 Second Floor Plan

Floor System

The Medical Office Building's floor system consists of normal weight concrete on 19/32" 26 gage galvanized form deck. K series steel bar joists of various sizes ranging from 10 inch to 24 inch depth support the floor deck. These joist are in turn supported by wide flange sections with similar variances in depth. In areas where joist span direction changes HSS sections are used to maintain deck elevation consistent with joist seat height as noted in Figure 5 below.

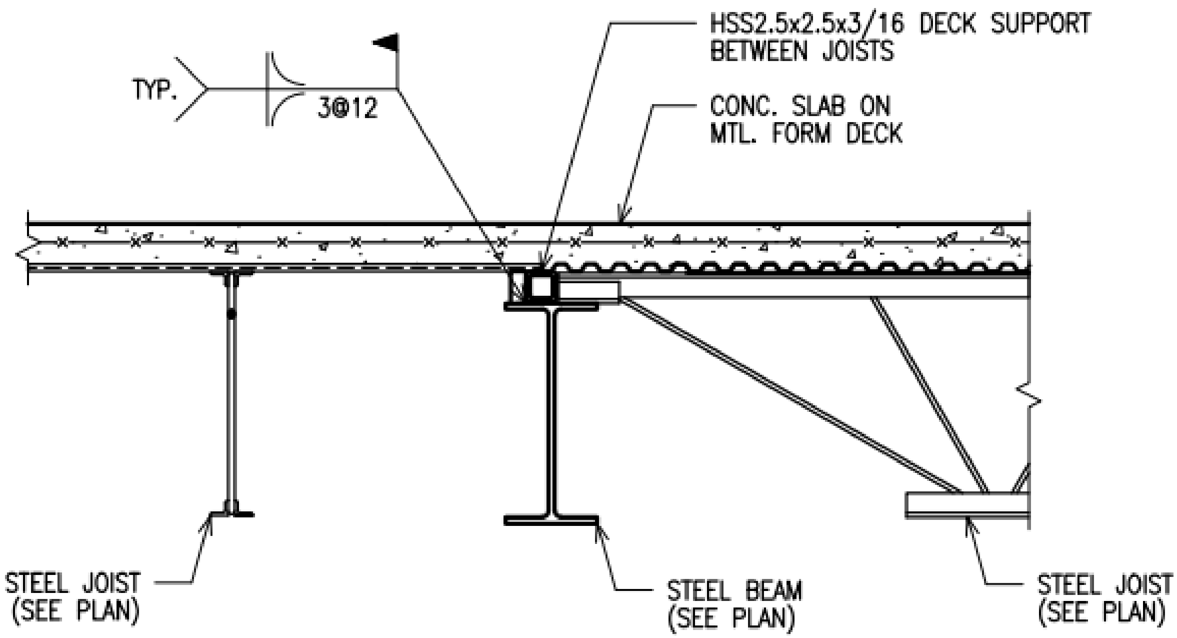


Figure 5 – Typical Framing Detail
S-13 Section 9

Building Lateral System

The main lateral force resisting system in the Primary Health Networks Medical Office Building is Ivany block shear walls. Ivany block is a concrete masonry unit which, when fully grouted, provides similar performance as an f'c=3ksi cast in place concrete shear wall system with significant cost savings. Ivany block gains another advantage over typical CMU blocks in the placement of reinforcement; Ivany block has slots for rebar allowing for a consistent "d" value to be used in flexural calculations, as shown in Figure 9. Ivany block shear walls partially encase the three stair towers as shown in red on Figure 10 below.

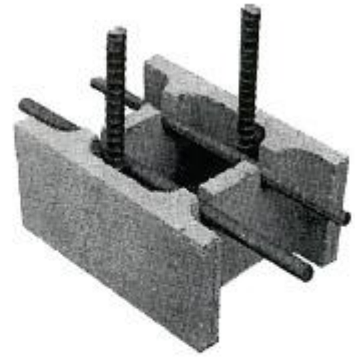


Figure 9 – (Source: koltcz.com)
Ivany Block with Reinforcing

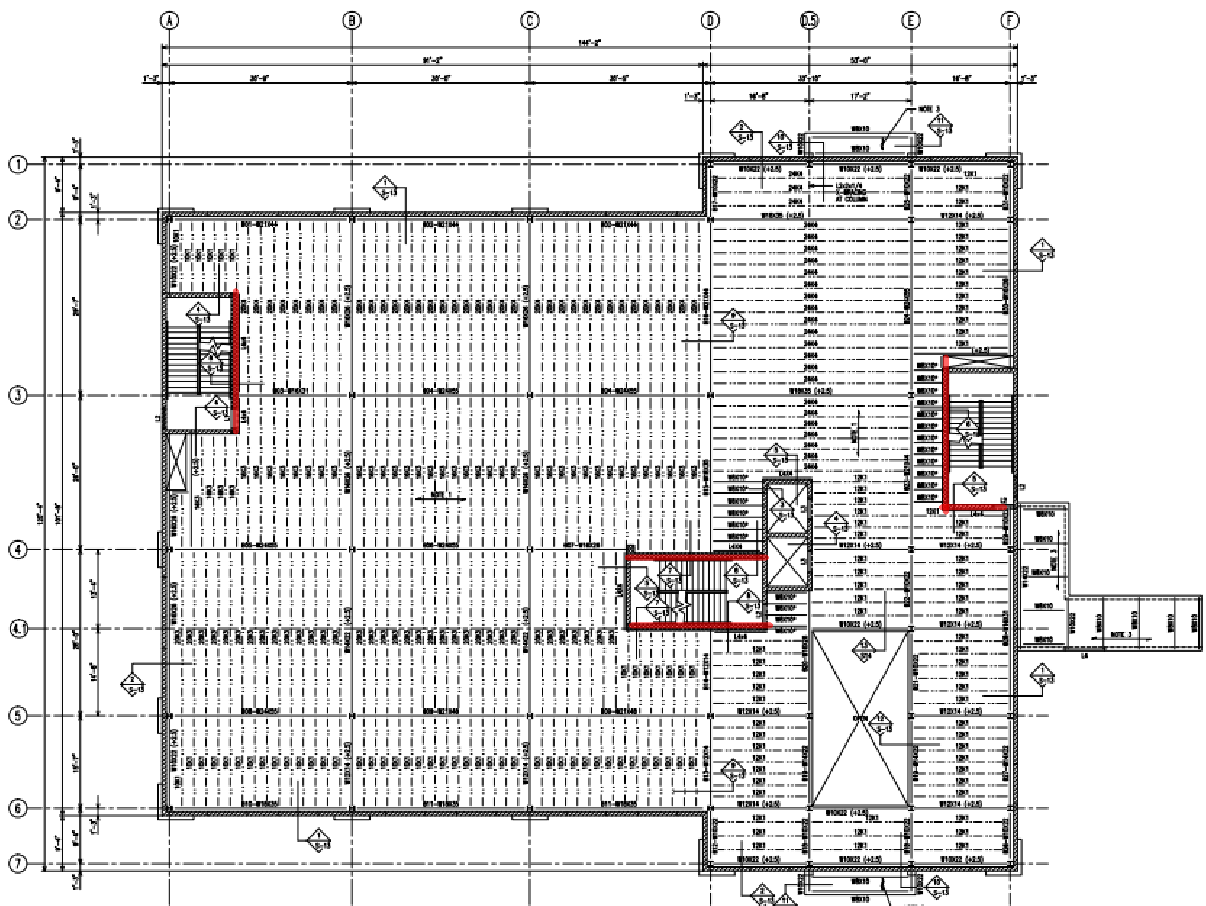


Figure 10
S-2 Second Floor Plan

Shearwall considerations

Lateral loads enter the building through the façade and transfer through girders and tie-beams to ultimately be taken by the Ivany Shear walls. These shear walls which rest on mat footings extend vertically to the roof level. The shear wall located on the western side of the building has openings in the wall at each floor level, this restricted the flexural capacity of the wall by decreasing its depth by 4 feet. The vertical and horizontal bars are #4 spaced at 16" on center. The flexural reinforcing consists of twelve #6 bars spaced at 8" on center up to the third floor where a 28" overlap splices into twelve #5 bars at the same spacing.

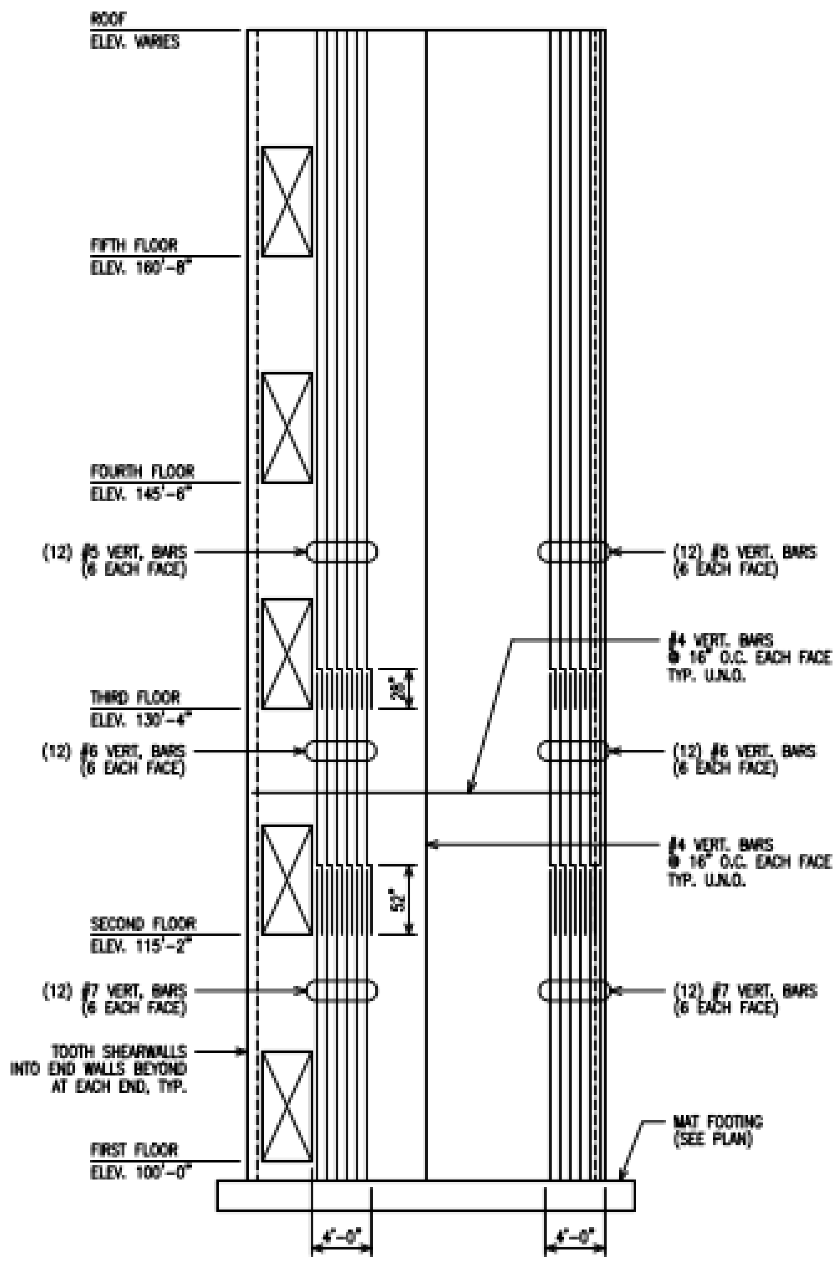


Figure 11
S-11 Shearwall notes

Foundation Design

Greenleaf development services conducted a site survey. Their geotechnical report showed that the soil had a bearing capacity of 2500 psf. This was the basis for the design of the buildings footings. The overall design ideology for the foundation was to keep a shallow profile of individual and spread footings resting on the soil.

All interior columns rest on individual concrete spread footings, a section of which is shown in Figure 3. Exterior columns rest on a continuous concrete wall footing. The ivany block walls sit on mat footings as can be seen in Figure 4.

Figure 3 – Spread Footing
S-12 Section 2

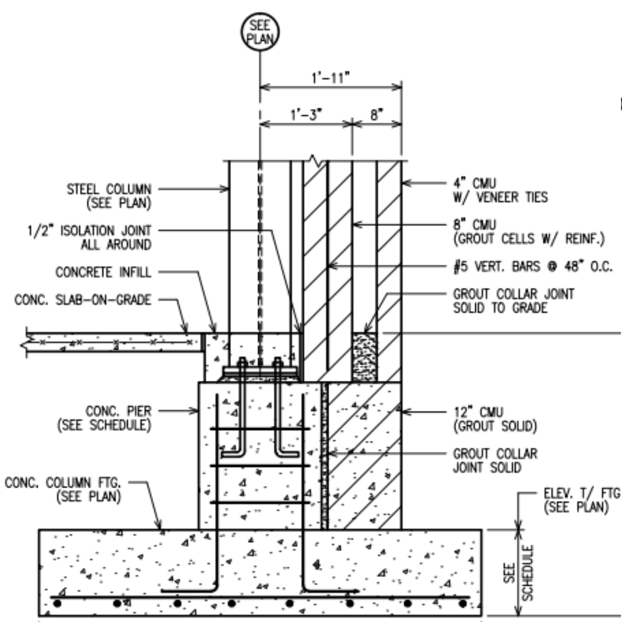
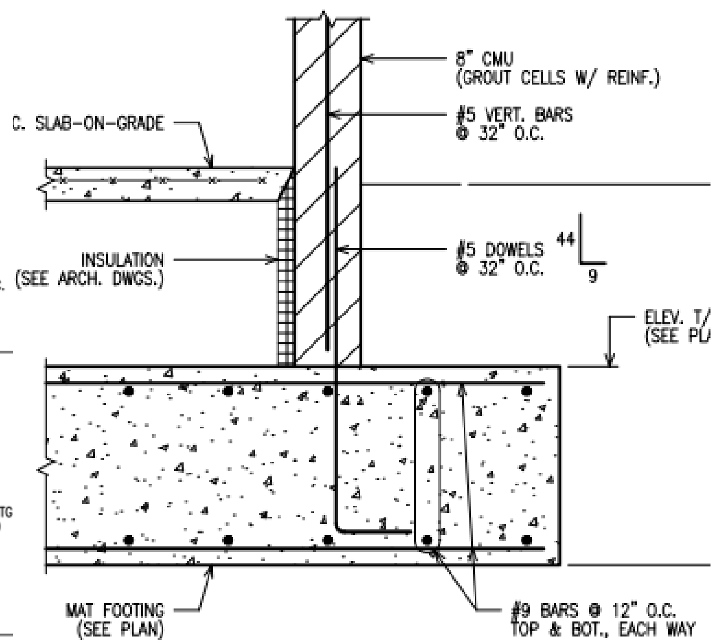


Figure 4 – Mat Footing
S-12 Section 4



Load Path

This section discusses the manner in which forces are transferred and distributed through the building structure ultimately leading to their dissipation.

Gravity

Gravity Loads in The Primary Health Networks Medical Office Building are received by the concrete floor deck which transfers the load to the steel bar joists. The bar joists transfer the load into the wide flange steel girders which bring the load to steel columns. From there the load is transferred down into spread footings which ultimately dissipate the force into the soil.

Lateral Loads

Wind forces are received by the building façade and then transferred into exterior girders. The lateral loading continues through the floor diaphragm, comprised of concrete on metal deck, to the Ivany block shear walls. These shear walls transfer the energy into the foundations and ultimately the soil.

Design Loads

In the design of The Primary Health Network's Medical Office Building two different codes were used to determine design loads. All gravity loads were determined using ASCE 7-05, whereas the lateral forces were determined using ASCE 7-10.

Dead Loads

The floor dead load was taken as 50psf to account for the concrete deck, steel joists and girders, MEP and a false ceiling. 20psf was used as the roof dead load, the reduction due to an adhered membrane being used instead of concrete on the roof deck.

Live Loads

All of the floors were designed for a 100psf live load typically used for lobbies or first floor corridors instead of the typical office live load listed in ASCE 7-05. This allows for flexibility in future changes to the floor layout. A roof live load of 35psf controlled over the ground snow load rating of 25 psf. This design choice was likely made to account for additional mechanical equipment as well as snow drift where the roof level changes.

Lateral Loads

Wind loads were calculated using ASCE 7-10 with a building category II, exposure B and a 115mph base wind speed. The building was designed using seismic design category A, site class B and use group 1.

Joint Details

In the Medical Office Building typical connections include joist to girder, girder to column, joist to block wall and deck to block wall. The first of these two connection types are to be detailed by the steel fabricator, as such this section will focus on the remaining two.

Typical joist to block wall connection

Steel bar joists and steel girders transfer loads into the Ivany block walls via ½" Plates with two ½" dia. By 6" headed studs. Figure 12 below shows a joist seat sitting on the plate supporting the joist floor system. The concrete deck is flush to the wall with a ½" isolation joint.

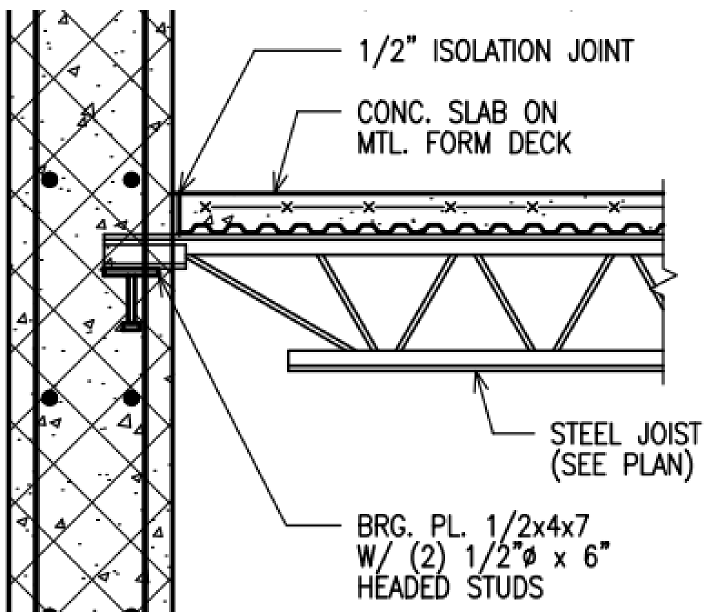


Figure 12 – Typical Joist to block wall connection
S-13 Section 4

Typical concrete deck to block wall connection

Where the concrete on metal deck meets the masonry block walls in an unsupported condition a 4"x4"x1/4" steel angle is fastened to the block wall in order to support the deck via ¾" dia hilti sleeve anchors spaced at 16" on center. This type of fastener has a casing that expands as the connection is tightened. This is shown in Figure 13 below.

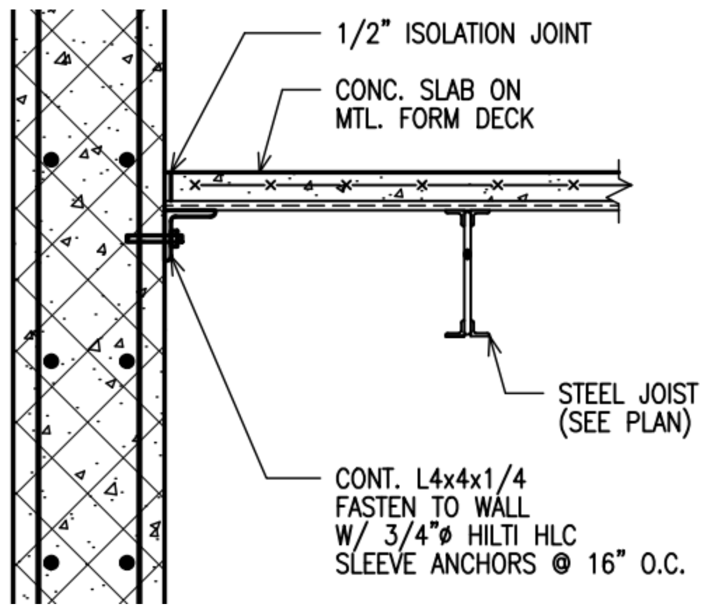


Figure 13
S-13 Section 8

Proposed Alternative Solution

The Primary Health Network's medical office building in Sharon, Pa meets all applicable code standards for strength and serviceability per technical reports I-IV. The current steel framing design consists of wide flange columns and girders supporting a concrete on metal deck with steel bar joist floor system. This system was requested by the building architect. However, alternative framing systems explored in technical report III provided the potential for a more efficient design. The building will be redesigned to demonstrate to the architect the value of an alternate design. The most promising of the three previously explored alternate systems was a two-way flat plate. The average bay size of roughly 30'x30' lends itself perfectly to two-way concrete design. Technical report III concluded that a two-way concrete system would have a shallower structural depth, cost less per square foot, and provide a greater overall fire rating. The main disadvantage of the two-way flat plate slab investigated in technical report III was the increased column size, this can be greatly reduced by the incorporation of drop panels. The floor and roof systems will be redesigned as two-way flat slabs with drop panels. The redesign will tentatively utilize all existing column locations to help maintain the existing building layout. All loading conditions from the original design will be used. The floor and roof designs will be created using programs such as spSlab and spColumn and then spot checked with hand calculations. All structural members will be designed to ACI318-11 specifications.

The existing lateral system is a reinforced type of concrete masonry called ivany block, which when fully grouted claims to have similar performance to concrete with an f'c of 3000psi. The redesigned lateral system will be comprised of concrete shear walls with an f'c of 3000psi located in the same locations as the current lateral system. The redesign will challenge the claim by attempting to achieve similar performance with less material than the original design. The new concrete shear wall system will be modeled in ETABS. The change in material for the buildings superstructure will have a significant effect on construction.

Breadth Topics

Architecture

The current design of the building's façade involves the use of an external insulation finishing system coupled with a glazing system. This provides a stark contrast to the brick façade that has become common place in downtown Sharon. The façade will be redesigned to incorporate common motifs of downtown Sharon such as brick in combination with more modern looks such as glazing systems. The original design focused heavily on cost efficiency, as such all cost implications of the new façade system will be considered and compared. The new façade will then be created and rendered in Revit.

Construction Management

By changing the structure from steel to concrete the construction timeline will change dramatically. The construction of formwork and concrete curing time will need to be taken into account, as well as temperature considerations for pouring concrete. The site is located in an urban center and as such logistics will need special considerations. A detailed construction schedule will be developed for the redesign in order to account for both site existing conditions and new structural demands.

Tasks

I. Task 1 – Research
   a. Acquire cost and scheduling information for existing building design
   b. Investigate new façade styling, costs, and availability

II. Task 2 – Gravity System Design
   a. Design two-way roof slab
   b. Design two-way floor slab
   c. Size roof and floor drop panels
   d. Design columns
   e. Spot check by hand
   f. Create RAM model

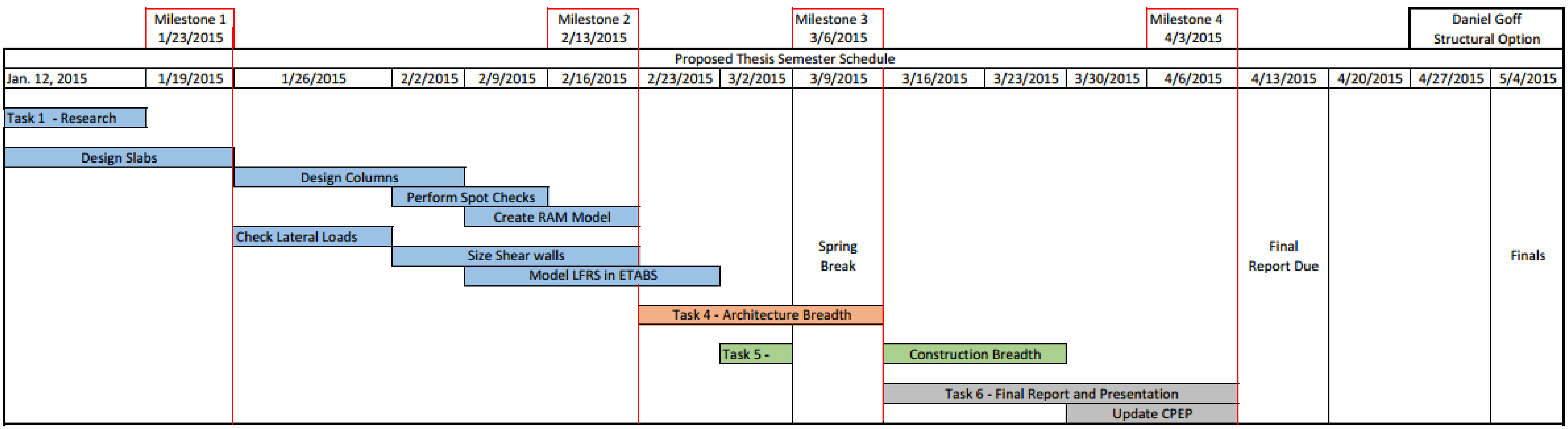
III. Task 3 – Lateral System Design
   a. Estimate new self-weight
   b. Adjust and redistribute lateral loads
   c. Size LFRS elements by hand
   d. Create ETABS model and check results

IV. Task 4 – Architectural Breadth
   a. Determine new façade materials to be used
   b. Discuss cost and availability based on R.S. Means construction data
   c. Create Revit model of new façade design

V. Task 5 – Construction Management Breadth
   a. Discuss staging requirements due to site limitations
   b. Develop construction schedule using Microsoft Project
   c. Compare effects of new façade + structure to existing timeline

VI. Task 6 – Final Report and Presentation
   a. Create final report outline
   b. Write final report
   c. Create presentation outline
   d. Create presentation
   e. Revise final report and presentation
   f. Finalize and practice

Schedule



Structural Depth - Reinforced Concrete Design	
Architectural Breadth	
Construction Management Breadth	
Report and Presentation	

Milestones	
1	Slab Designs Completed
2	Gravity System Design Completed
3	Lateral Design and Architecture Beadth Completed
4	Construction Breadth, Final Report and Presentation Completed

Conclusion

The Primary Health Network's medical office building in Sharon, Pa meets all applicable code standards for strength and serviceability per technical reports I-IV. The current structural system was requested by the building architect. The proposed thesis will redesign the building as a reinforced concrete structure to demonstrate to the architect the value of an alternative design. Two-way flat plate slabs with drop panels will be designed for both floor and roof structures. Concrete columns will be designed in the location of existing columns to retain the existing building layout.

The proposed thesis will redesign the building lateral force resisting system as concrete shear walls in the locations of the existing masonry shear walls. The redesign will test the claim that reinforced Ivany block is as efficient as concrete when fully grouted.

The current building façade will be redesigned to better integrate with the surrounding structures while remaining modern. The feasibility of this redesign will be investigated through a cost comparison with the existing façade.

The impact of this change on constructability will be evaluated by comparing construction schedules for both structural systems as a proposed construction management breadth.