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Final Proposal
Construction Project Management
Apartment Complex
Anytown, USA

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April 14, 2008

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Executive Summary

Through the completion of this thesis report several areas of the Apartment Complex project in Bethesda, MD, as well as some industry issues were analyzed. The report is divided into two main parts.

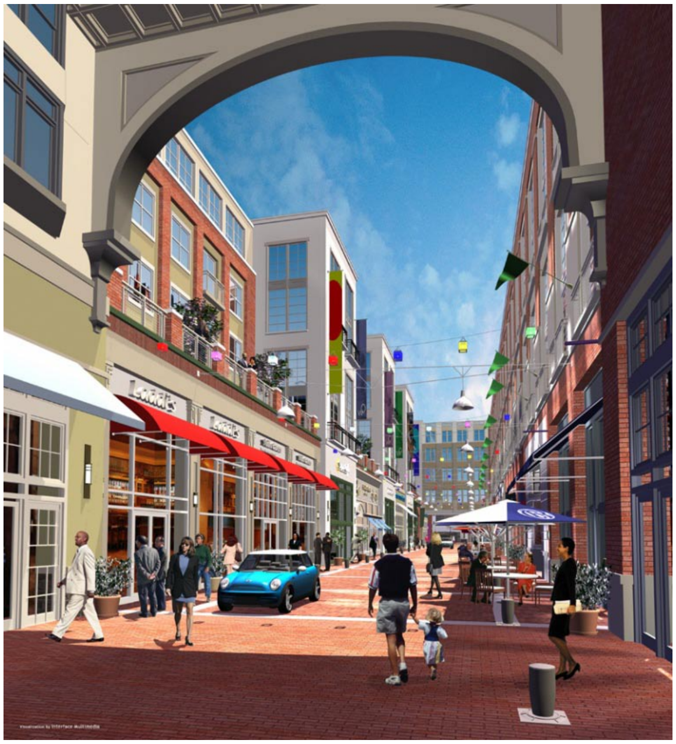
The first part of the report is a project overview. In this section, the project is introduced and information such as project and staffing organization, client information, delivery method, existing conditions, site plans, schedules, and estimates, is provided.

Following, the second section is an in depth analysis of four areas. Four analyses will be conducted and presented in this section. Each analysis will contain several elements. A background of the problem, a problem statement, proposed solutions, methods to be used for each solution, task and tools to be used for each solution, and concluding remarks will be done for each analysis.

The first analysis will be prefabrication. In this analysis I plan to study if prefabrication would have been a better option for the exterior wall assembly. The second analysis is very related to the first. Since the proposed exterior wall will be made out of prefabricated panels, I decided to select the ThermaGuard Slenderwall System which is a 100% thermal-break/air barrier precast system. I plan to study how these prefabricated panels will reduce the Heat transfer through the walls. Moreover, I plan to study if these panels could reduce the heat transfer enough so that the air handling system of the residential area can be reduced.

The third analysis is not related to the other two. This analysis consists on redesigning the interior structure. The current structural system consists on load bearing wood framing. I will redesign the structural system to a metal studs/joist framing system and study the impacts that this design will have during and after construction. The fourth analysis will be dedicated to research a problem that our industry is facing. The fact is that most of the construction workers are Spanish speakers, who do not speak English. On my few years of experience on the construction industry I have notice that the language barrier has become a problem. Therefore this analysis will focus on how this problem is affecting the industry. The goal of this analysis is to determine if this problem is really affecting the industry, and in that case find try to find a solution.

Project Introduction



Type of building:
Mixed-use residential building
(Retail, and residential)

Size (total square feet):
423,469 SF

Number of stories above grade:
Five Floors above ground

Dates of construction (start – finish):
August 21, 2006 – April 11, 2008

Actual cost information:
Contract Amount: $ 50,047,750
General Conditions: $ 2,972,441
4.5% Fee

Project delivery method:
Design-Bid-Built

Having 2 garage levels, retail on the ground level and luxurious apartments on levels two, three, four and five, this Mixed-use project is intended to give something back to the community. The building consists on three rectangles that form a C leaving an open space in the middle of the building where a street with restaurant and stores will be built. There are 180 units on the entire building. The east side has loft apartments while the west side has single apartments. The reason why the apartments are placed that way is so that every apartment can enjoy either a terrace or a balcony. The building façade will be brick almost all the way around, while the interior structure will consist on mostly wood.

Client Information

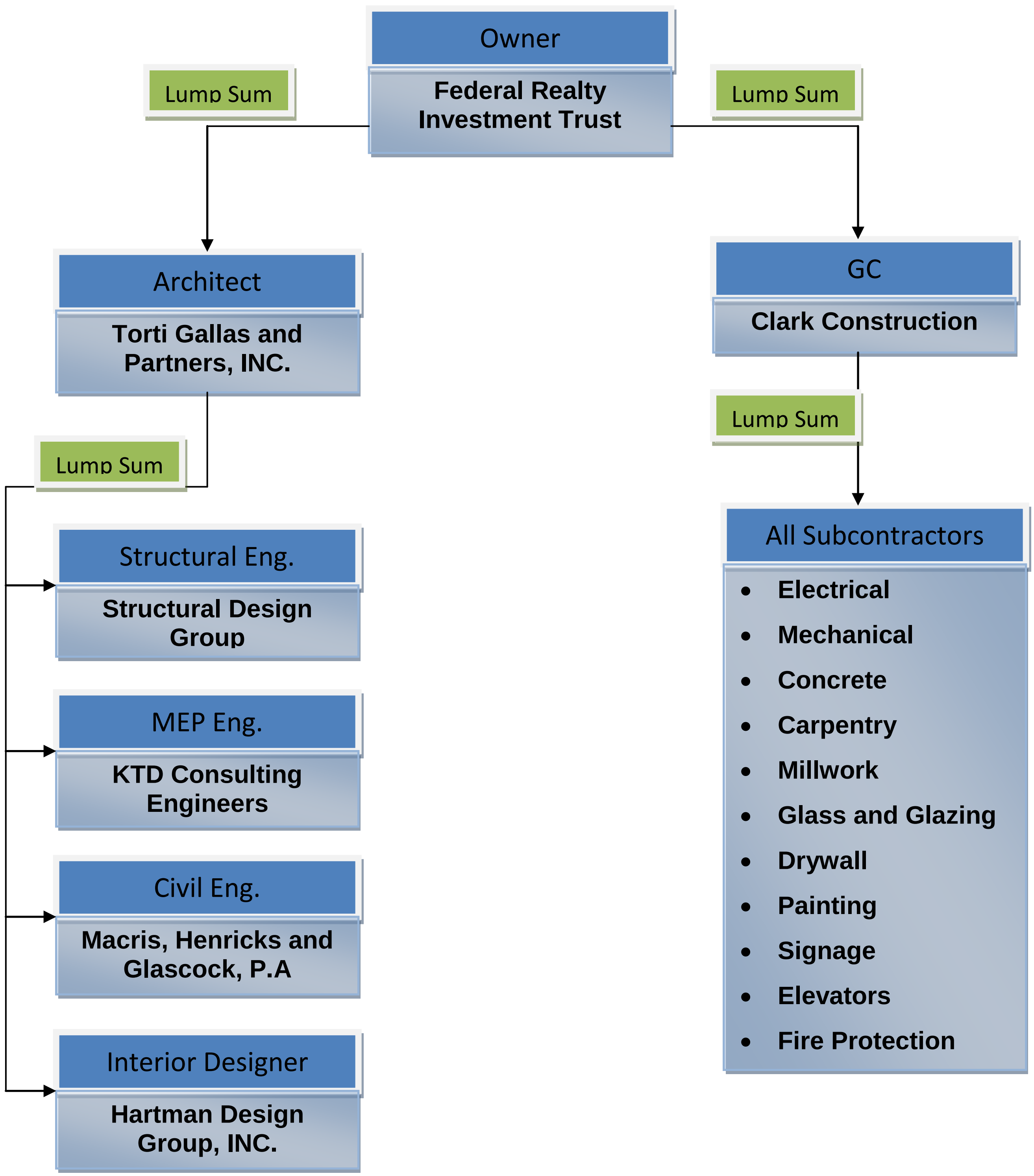
Federal Realty Investment Trust is an equity real estate investment trust specializing in the ownership, management, development, and redevelopment of high quality retail assets. Federal Realty's portfolio contains approximately 19.5 million square feet located primarily in strategic metropolitan markets in the Northeast, Mid-Atlantic, and California. Federal Realty is building the Apartment Complex project in Bethesda because is one of the growing areas in the DC area. Bethesda is actually one of the most expensive places to live in DC. Build in Bethesda is very profitable. The market is very large and the demand in increasing every day. Federal Realty is a very experienced company, and they know that a well done project in Bethesda will certainly be a very profitable project.

Since Federal Realty is a very experienced company and they know how the construction process works, they know that there will always be changes in every project. They know that change orders are part of the construction process. There is a $450,000 contingency that they expect to take care of any unexpected changes. Federal Realty expects the project to be completed in a high quality manner, within budget and on schedule. Construction is scheduled to be 30 months in duration, with a substantial completion on April 11, 2008.

Federal Realty also expects the project to be completed in a safe way. Completing the project without any accident is one of the main goals for this project. Federal Realty as well as Clark construction, who is actually performing the job, think that a project with accidents cannot be considered a successful project. Measures have been taken to ensure the safety for everyone during and after the project is completed. OSHA guidelines are expected to be followed during construction for the safety of every worker. Fencing, traffic control, temporary lighting, access control, security monitoring, and life safety protection such as fire alarms and fire suppression systems, are some of the items that were incorporated during construction to assure the safety of every employee.

Federal Realty gave Clark the responsibility to complete the project. The sequencing of the project is up to Clark. The owner just cares about the final product. If the project is completed on time, within budget and with the expected quality, then the owner will be satisfied.

Project Delivery Method



The delivery method that is being used on this project is design-bid-build. The owner hired design professionals to prepare a complete set of contract document, which includes plans and specifications, for a set price. The owner paid the designers a fixed price, called lump sum, to complete the project plans and specifications. Once the contract documents were complete and given to the owner, then the owner hired a GC. Clark Construction was hired by the owner to manage the project. The owner negotiated with Clark the contract, and they agreed on a lump sum type of contract. The owner will pay Clark $50,047,750 to complete the entire project. However, Clark will have to manage all of the subcontractor's contracts. The owner only has a contract with Clark.

Once Clark was awarded the project, they had to hire every subcontractor for every trade. Clark bid the project, and a different contractor was selected for every trade. As in most of the projects, the lowest bidder was selected. Clark then needed to negotiate the contract with every subcontractor. The contract type used for all the subcontractors was a lump sum contract. The cost of the work for every trade was set before any work began. Moreover, every subcontractor needed insurance and bonds before starting any activity.

When an owner is not very experienced with the construction process, the best thing to do is to hire someone else to manage the entire project. Design-bid-build is a delivery method that allows the owner to allocate responsibilities and risks to others. The GC and the designers have all the responsibilities. Moreover, design-bid- build is the most common and best known delivery method. The down side of this delivery method is that the GC enters the project once the design of the building is completed. The GC has no input on design. Statistics have shown that projects tend to run smoother when the contractor has input on the design of the building.

When selecting design-bid-build, the preferred contract types for designers and subcontractors are lump sum contracts. For the GC was used a lump sum type of contract as well. The lump sum contract motivates the GC to do a better job because if they complete the project for less than the contract amount, then they get to keep the money saved.

Local Conditions

In 1899, Congress passed a law that limited buildings to the height of the Capitol. That law is still effective today. For this reason most buildings in the area are designed as cast-in- place concrete rather than with a structural steel frame. The floor-to-floor height that can be achieved with concrete is lower than the floor-to-floor height that is achieved with steel. That is why concrete is used more in DC than in other cities. Designers can typically get one more floor out of a building when designed by concrete rather than steel. However, Apartment Complex is a hybrid. Cast-in-place concrete was definitely not the preferred method by the builder. This project combines many different materials such as; wood, steel, metal studs, as well as concrete.

The Apartment Complex is located just few blocks away from a metro and bus stop. Most of the workers take the bus or the metro to get to the jobsite. However, there are 5 public parking garages that are located within three blocks from the construction site. Those public garages are somewhat expensive and are not covered by the owner. However, some of the employees park their cars there because it is convenient.

On the jobsite, there are two thirty cubic yard open-top dumpster that are removed constantly. There is a $135 charge per pull, in addition to a $15 fuel surcharge and a $60 disposal charge. Laboratory tests results of soil from 8 test borings that were taken revealed that there were mainly three types of soils; reddish brown clayey sand with gravel, reddish brown sandy lean clay, and reddish brown silty sand with gravel. Groundwater was not encountered in any of the test borings taken.

The weather in Washington DC changes drastically during summer and winter. The positioning of the building as well as the exterior wall types will determine the size of the HVAC system to maintain the building in the optimum temperature on each season. One of my analyses will be to examine the exterior wall to determine if the addition of insulation material could reduce the size of the HVAC system. If this is true, then a large amount of energy could be saved.

Building Systems Summary

Cast in Place Concrete

The Apartment Complex has a structural systems that combines many materials. Concrete is only used up to the second floor slab. Cast in place concrete is used in this project for the foundations, perimeter wall up to the second floor, and beams and columns that extend from G2 level until the first floor slab. Sheeting panels with formwork in the form of walers were used for foundation formwork. For the concrete perimeter wall, vertically arranged upright timbers were used. Timbers were diagonally braced at both sides. Beams and columns formwork where prefabricated depending on the size of each member. Most of the concrete was placed with crane and bucket or by direct chute.

Precast Concrete

Precast concrete members were used only for decorative purposes. Those concrete parts that were hard to build with formwork were ordered as precast concrete and then installed. Two tower Cranes were used to mobilize precast members. Crane #1 was a Pecco SK 400, with radius of 220 feet and a capacity of 10,100 lbs at the tip. Tower Crane #2 was a Peiner SK 315 with radius of 180 feet and a capacity of 11,900 lbs at the tip. The location of both cranes are shown on the site plan on page 13.

Mechanical System

The mechanical system consists on three rooftop units, and two air-handling units located on the first floor that serves the retail stores, restaurants, and the parking garage. The HVAC system for the residential area consists on individual HVAC units for each apartment. The mechanical system contains thirteen different types of pumps. It has two 400 ton chillers and two 1200 GPM 400 ton cooling towers. The air is distributed through galvanizes steel ducts that run all throughout the building. The building has a wet pipe sprinkler system. Smoke detectors as well as sprinklers are located all throughout the building.

Electrical System

There are two 480/277V, three phase, 2500A main breakers that control the residential area, and two 120/208V, three phase, 2000A main breakers that control the retail and restaurant service. Lighting consists of fluorescent and halide fixtures, ranging from 120-277V, which are common throughout the building. The electrical room is located on the northwest corner of garage G1.

Masonry

Both load bearing and veneer masonry was used in this project. Load bearing masonry was only used on interior space. CMU and brick was used as load bearing masonry. CMU's were installed with lintels, rebar, and stirrups. Brick was installed with steel angles. Veneer masonry was used on most of the façade of the building for aesthetic purposes. Most of the veneer masonry was 4" face brick tied with masonry ties.

Excavation Support

Since there are two underground parking garages, excavation support for a deep excavation was needed. Tiebacks and anchors were used for the support system. This support system avoids having a congested site. The absence of interior obstructions makes the excavation process much easier. This support system is mainly used in projects where space is limited and congestion needs to be avoided.

Project Cost Evaluation

Total Project Cost

Total Cost: $50,047,750

Square Foot Cost: $118.19/SF

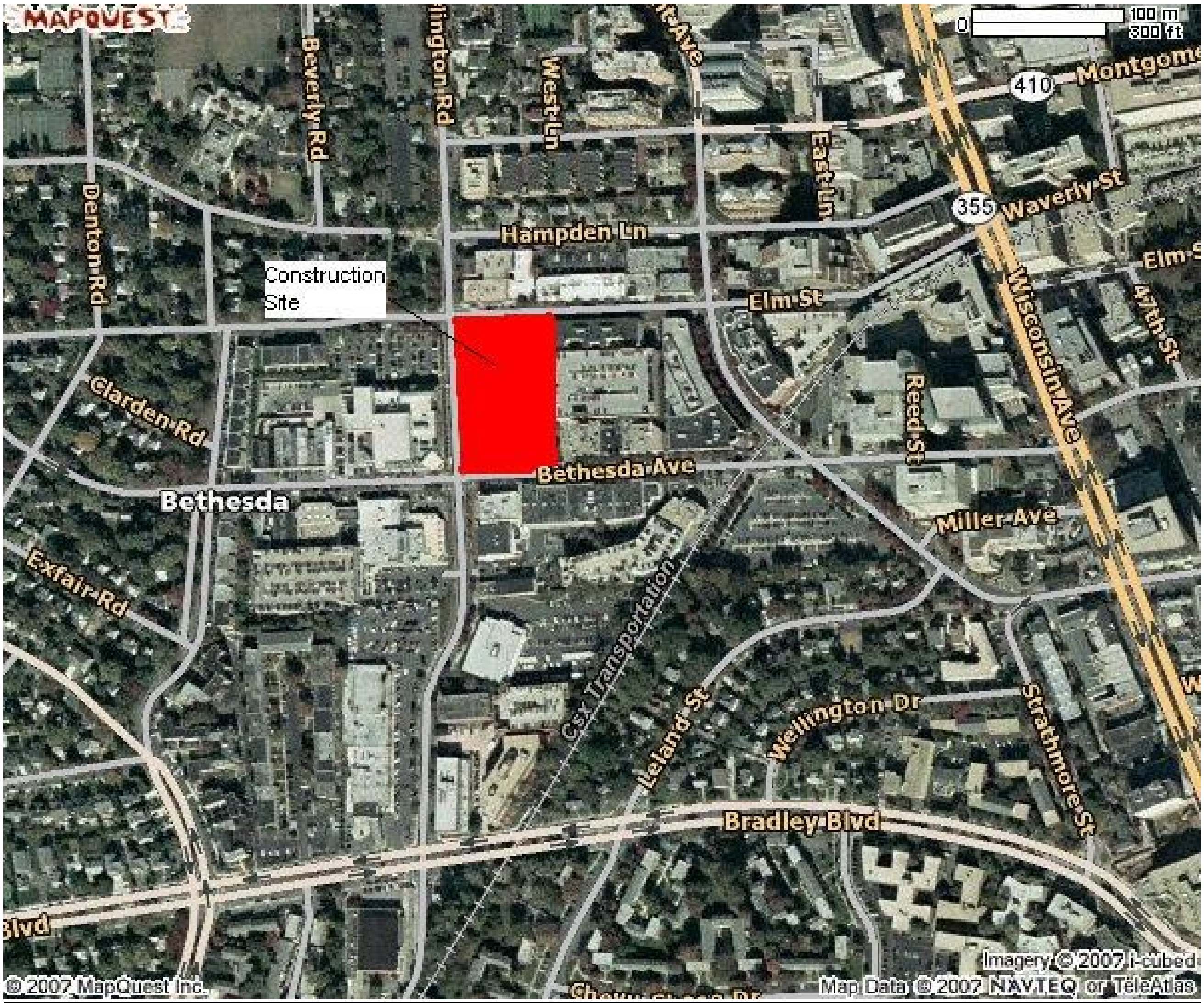
Actual Project Cost

Total Cost: $42,584,209

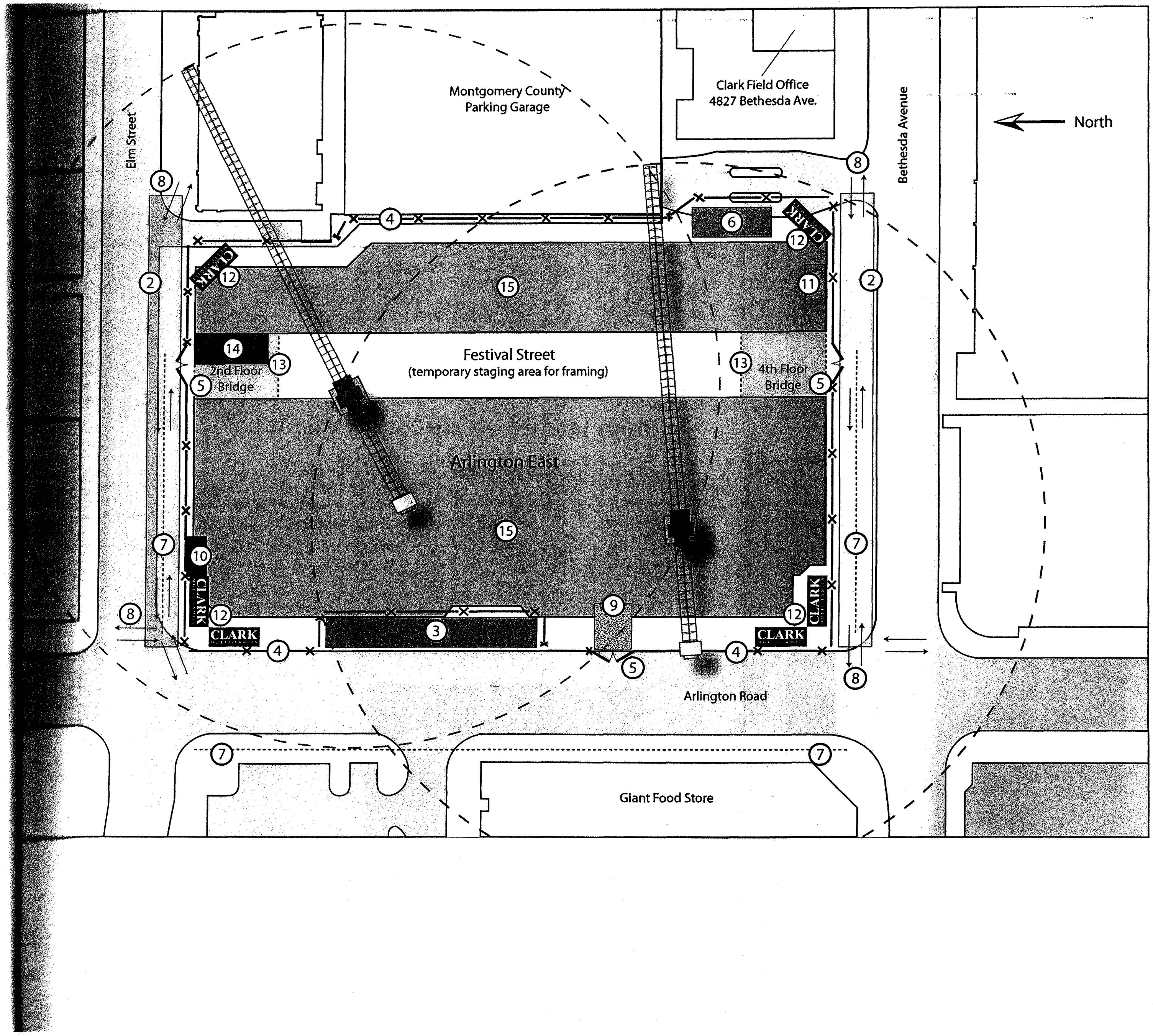
Square Foot Cost: $100.56/SF

	Total Cost of System	Square Foot Cost	% of Total Project Cost
Structural System	$11,661,204	$27.54	27.38%
Mechanical System	$4,304,705	$10.17	10.11%
Electrical System	$3,470,420	$8.20	8.15%
Roofing System	$1,709,289	$4.04	4.01%
Fire Protection	$1,491,035	$3.52	3.50%
Masonry	$2,367,829	$5.59	5.56%

E. Site Plan of existing condition



Above is an aerial picture of Bethesda, Maryland. The red portion is where the Apartment Complex project is located. The project is located close to Wisconsin Ave which is shown in yellow. On the following page, pictures of a 3D model of the building, as well as a site plan of the project showing all temporary facilities are shown.



Arlington East

Bethesda, MD

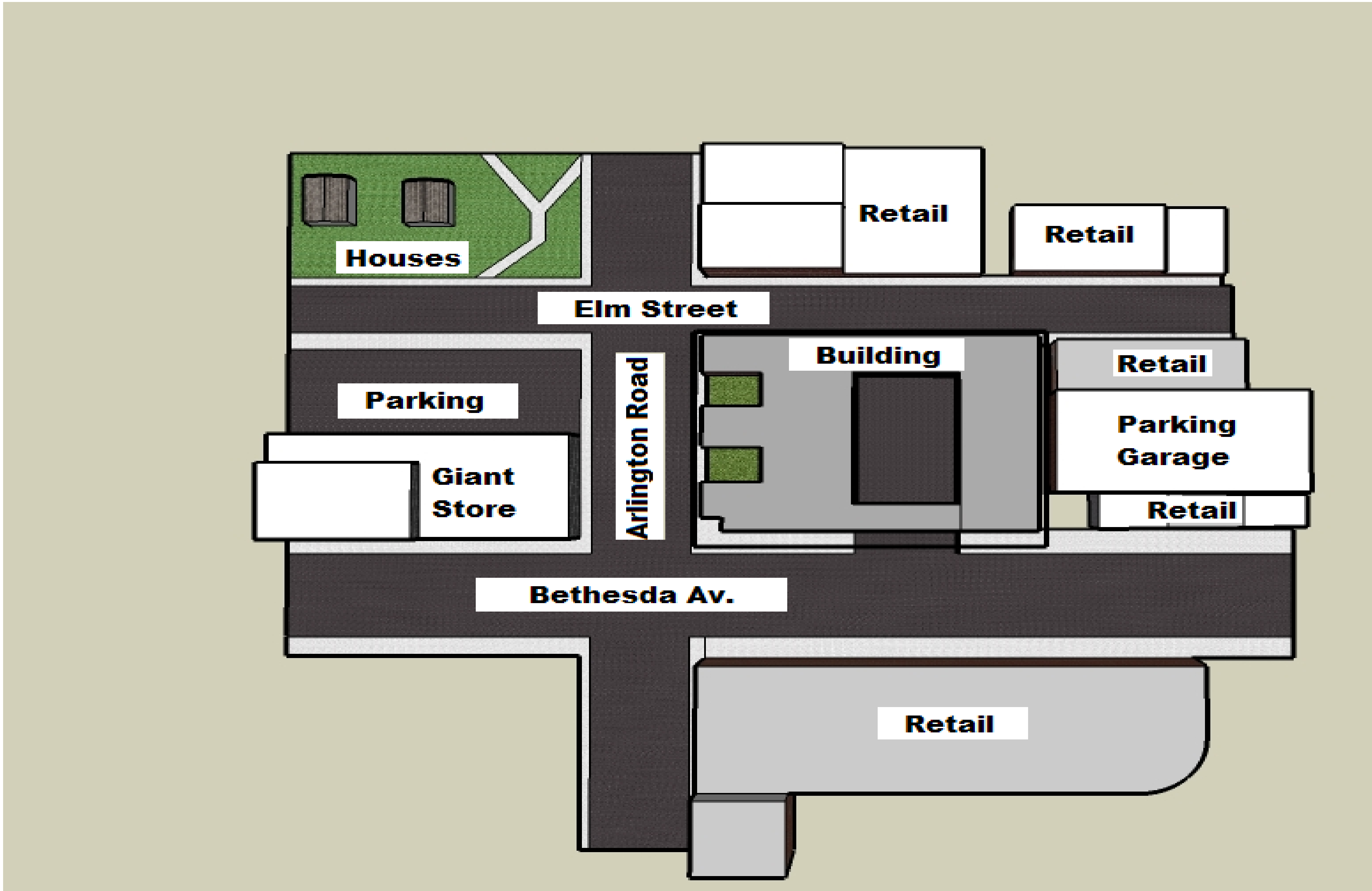
Site Utilization Plan

Legend

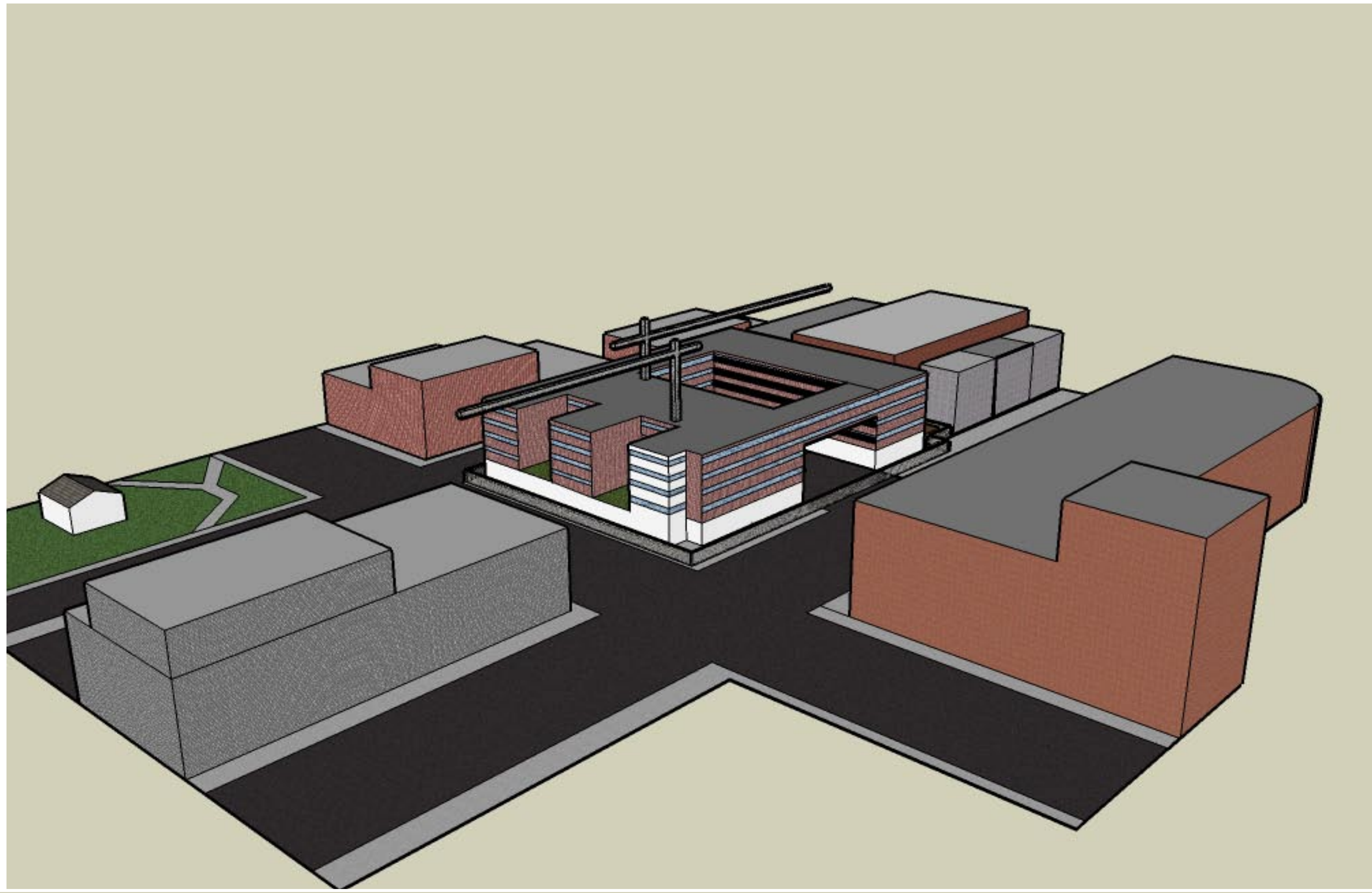
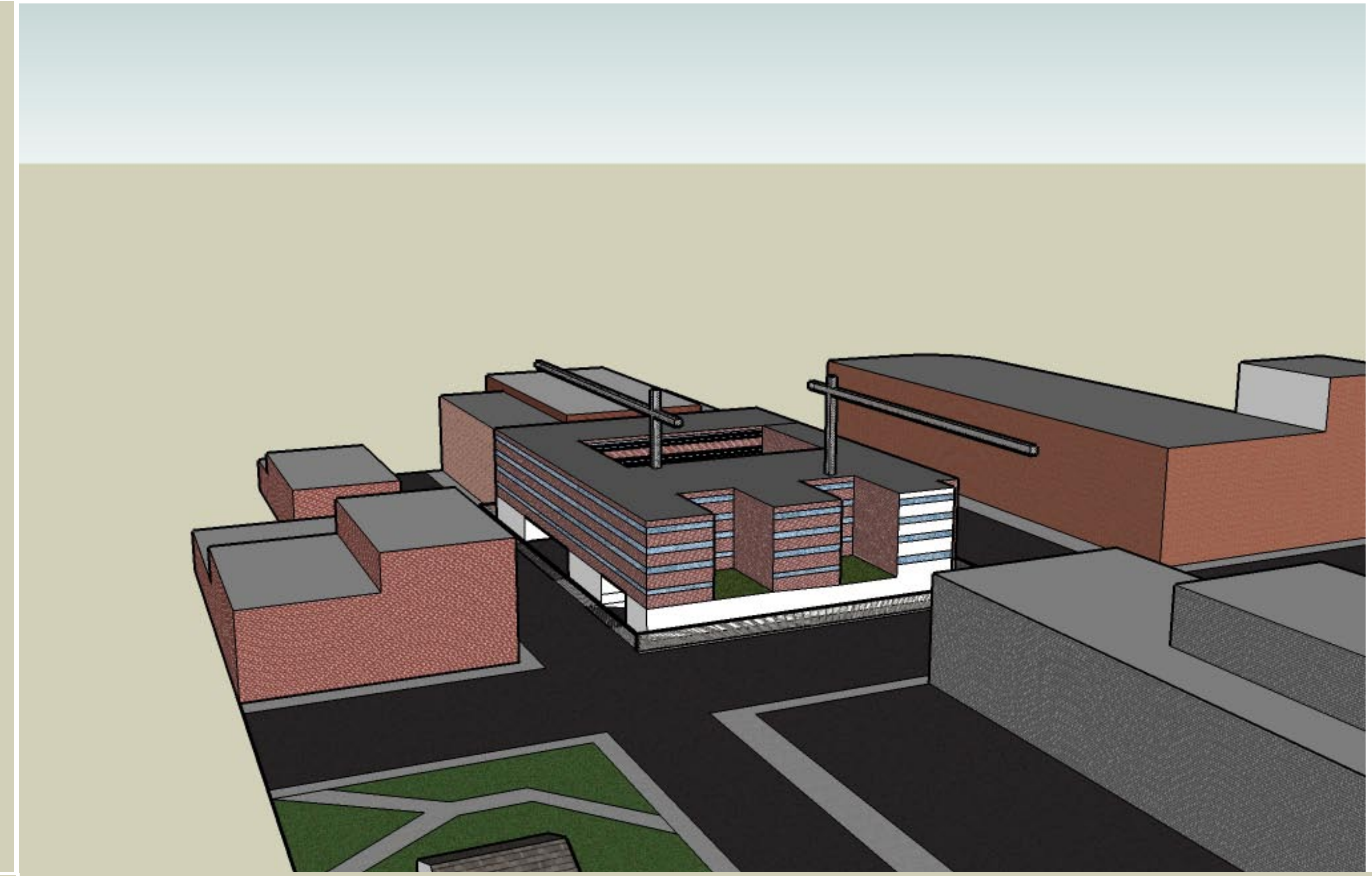
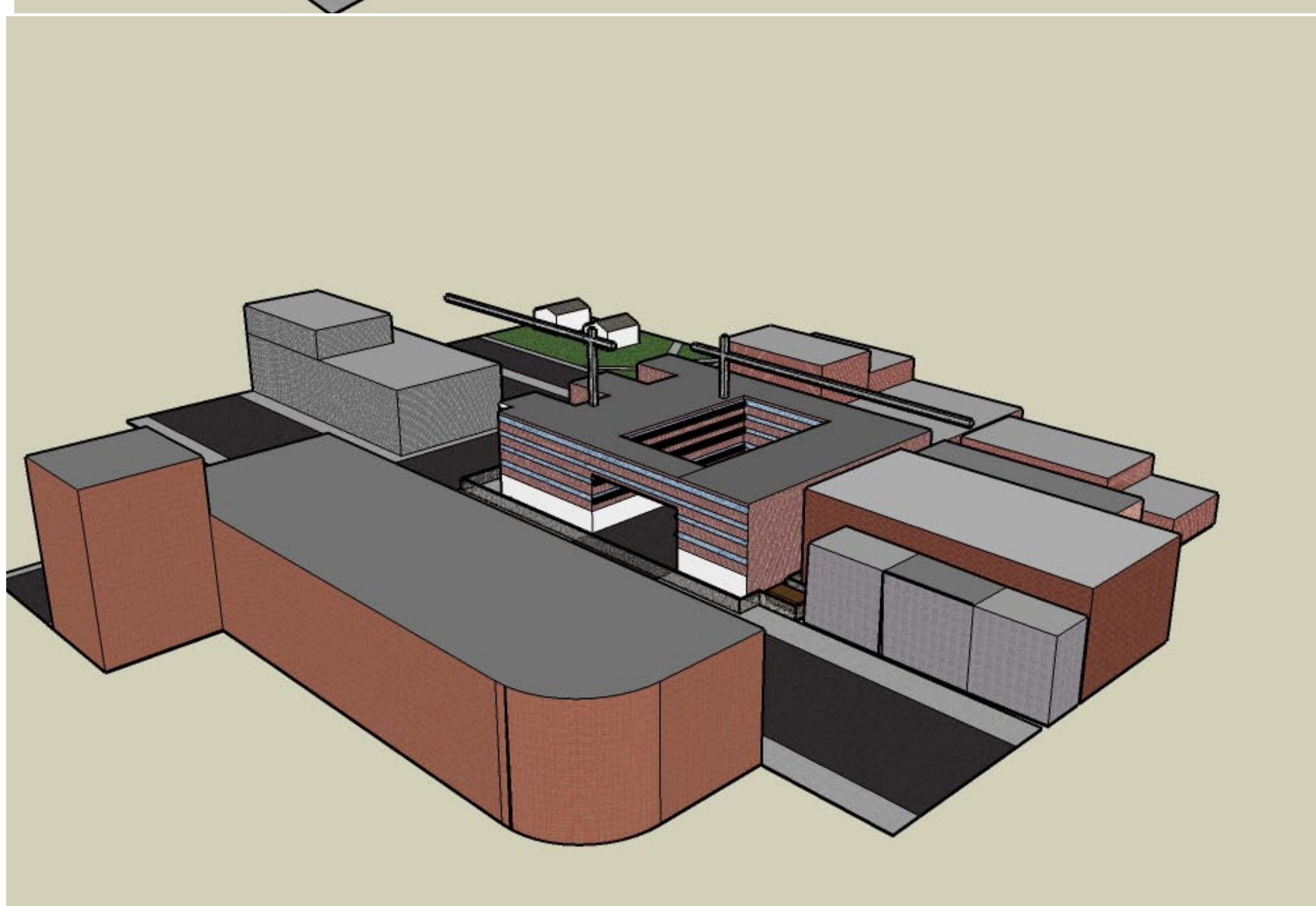
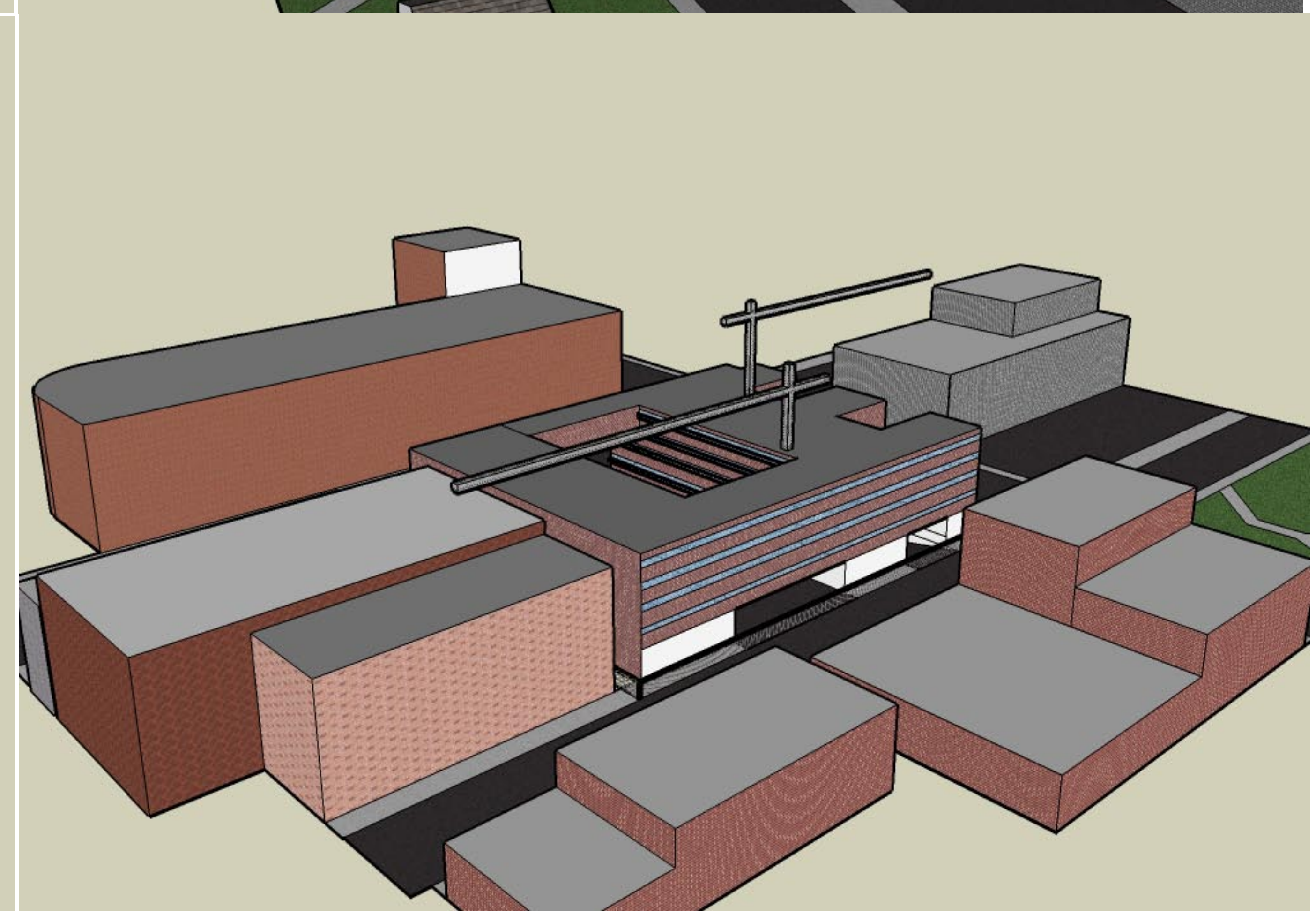
1. Existing Building
2. Covered Walkway
3. Concrete Staging Area
4. Construction Fence
5. Construction Entrance & Gate
6. M & L Field Office
7. Overhead Power Line
8. Pedestrian Traffic
9. Proposed Construction Enterance
10. Temporary Power
11. Temporary Water
12. Clark Sign
13. Bridge
14. Trash Chute w/ Dumpster Below
15. New Building

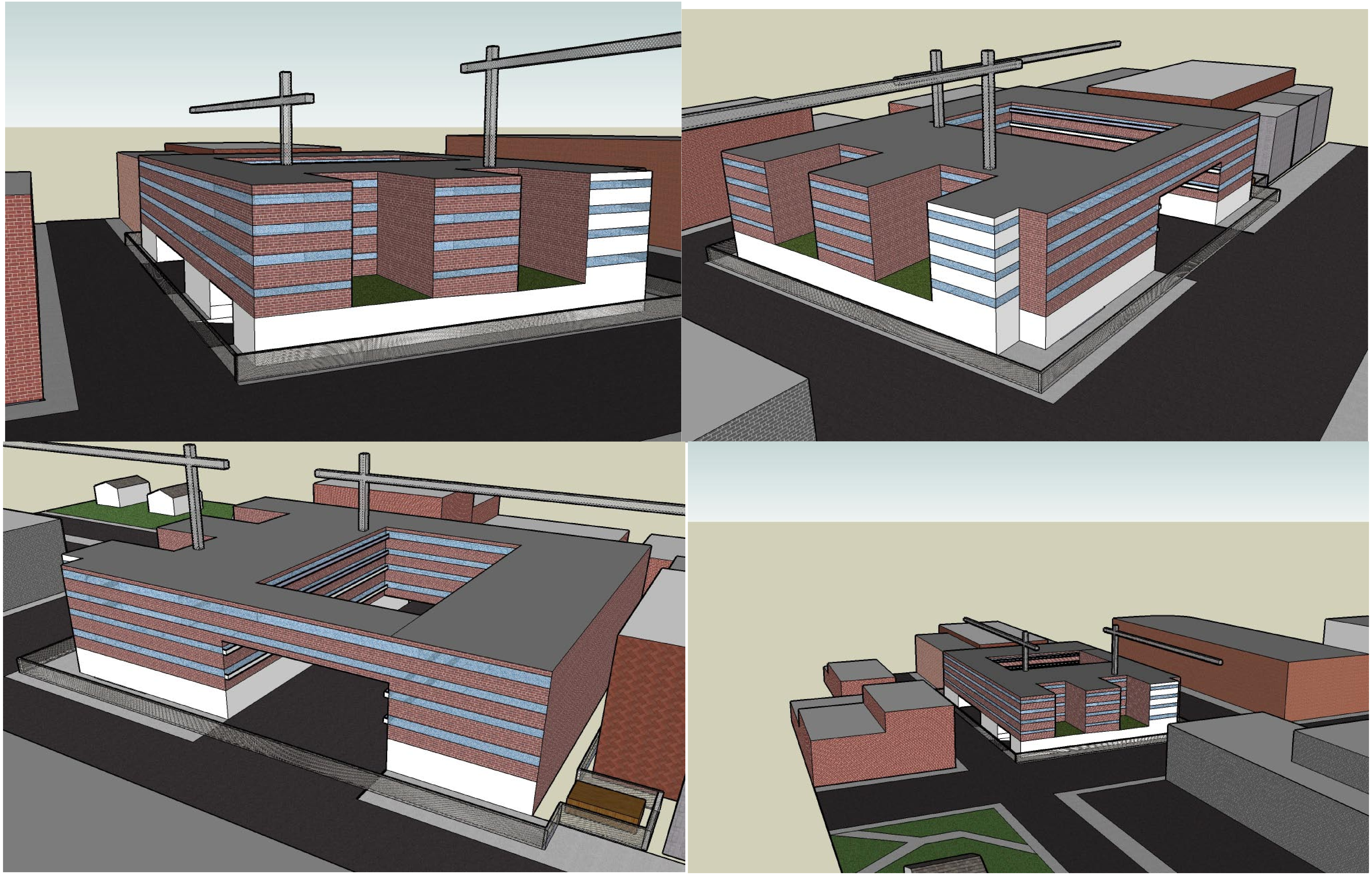
June 28, 2006

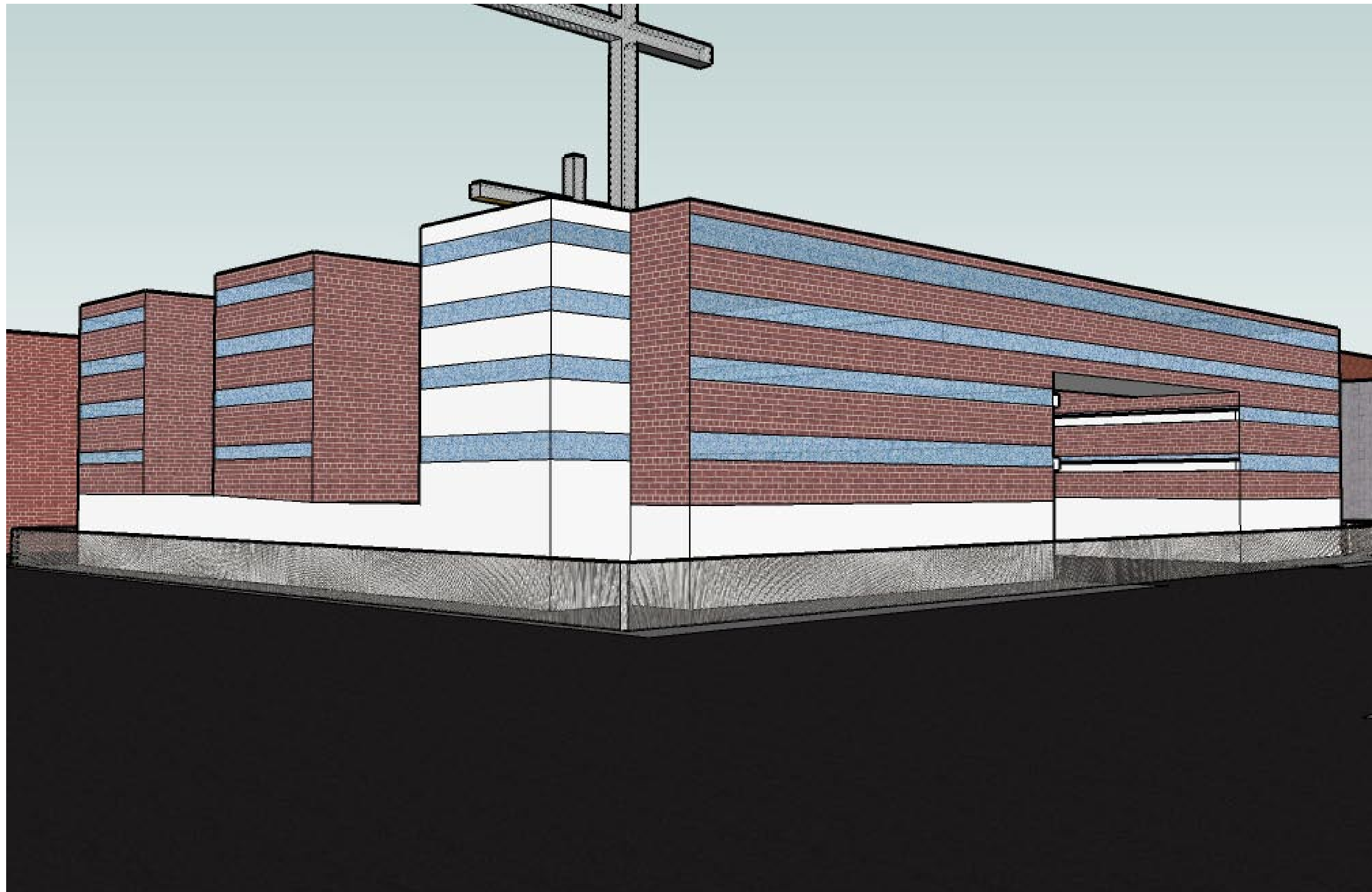
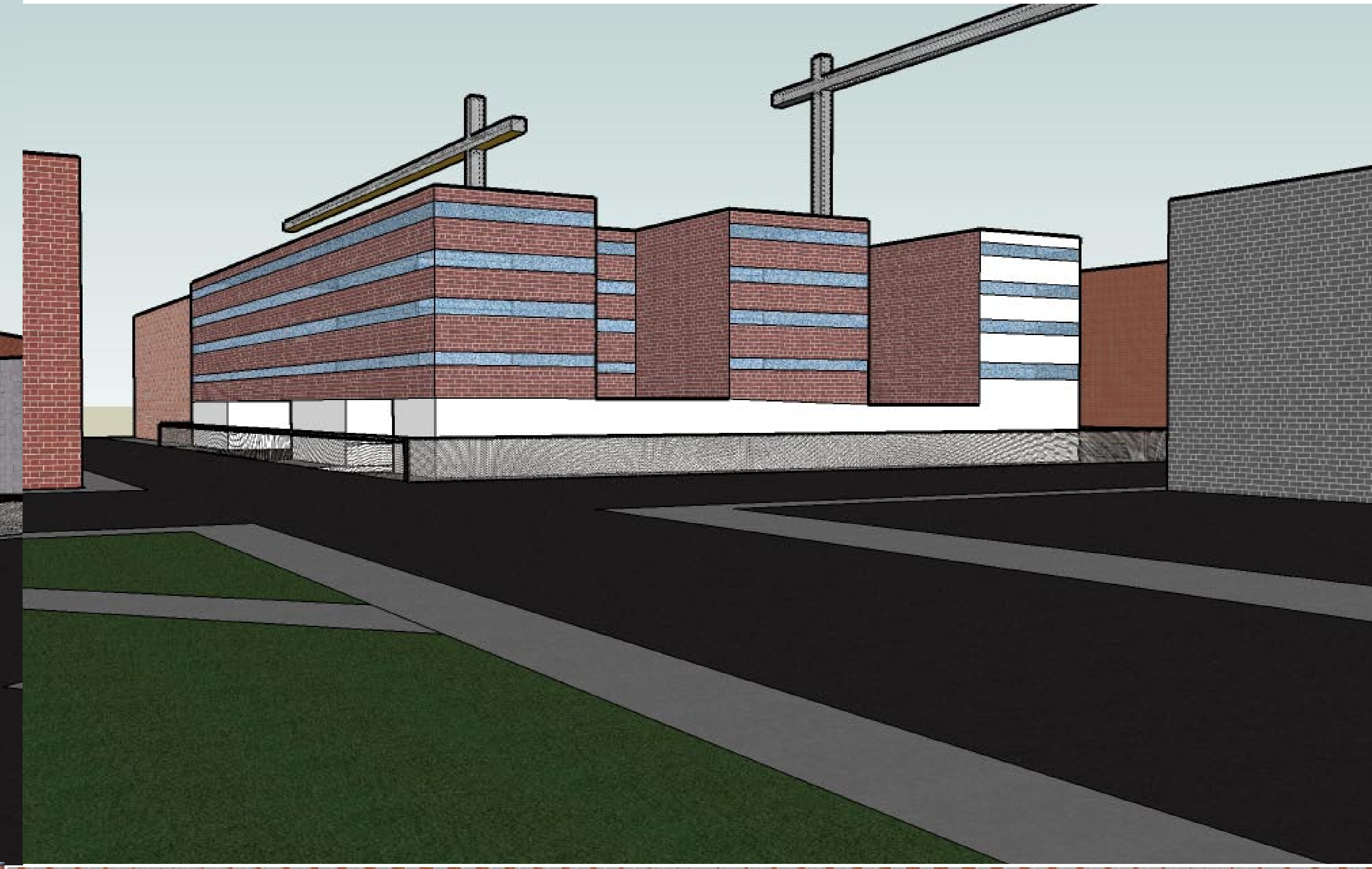
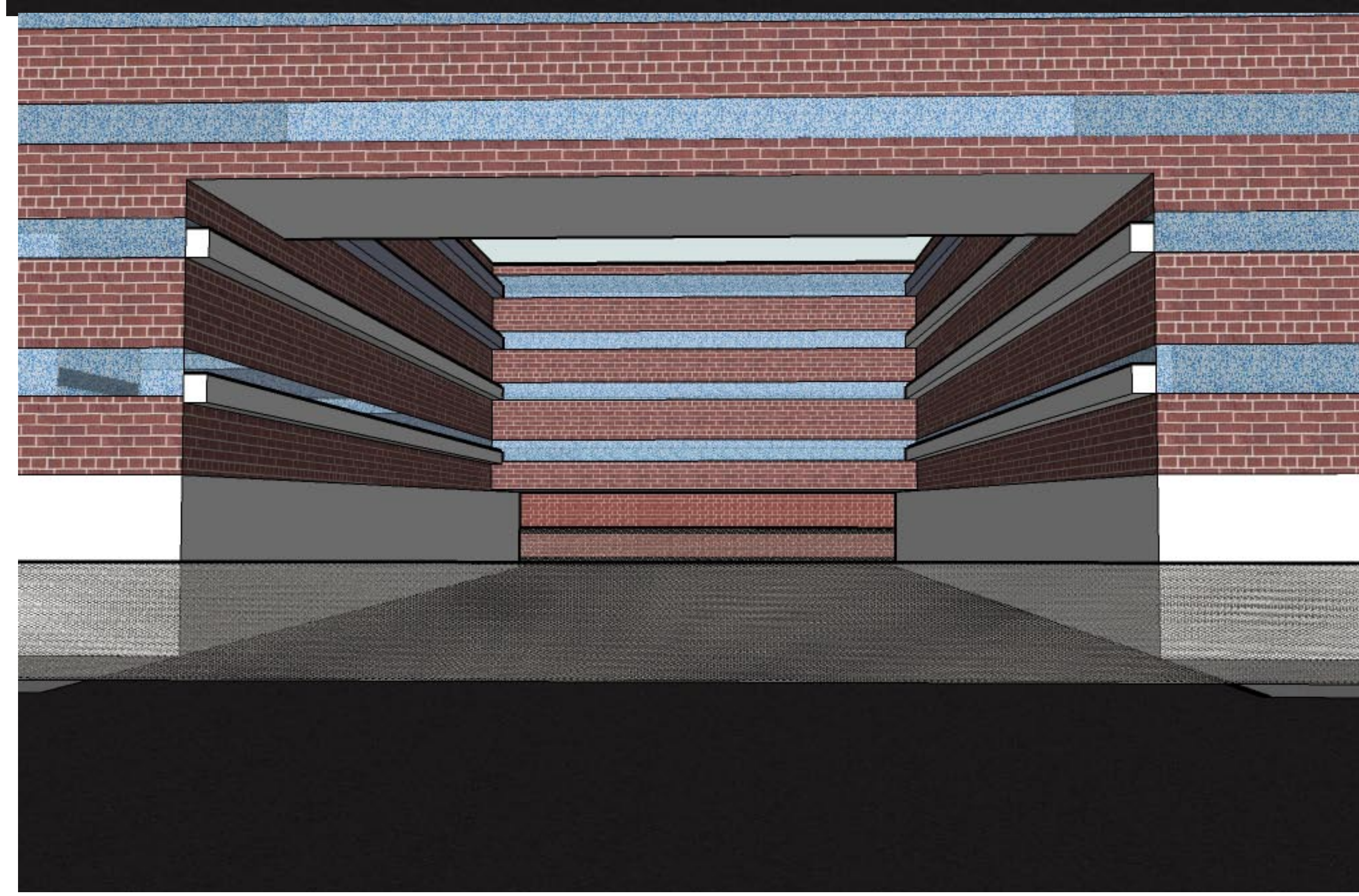
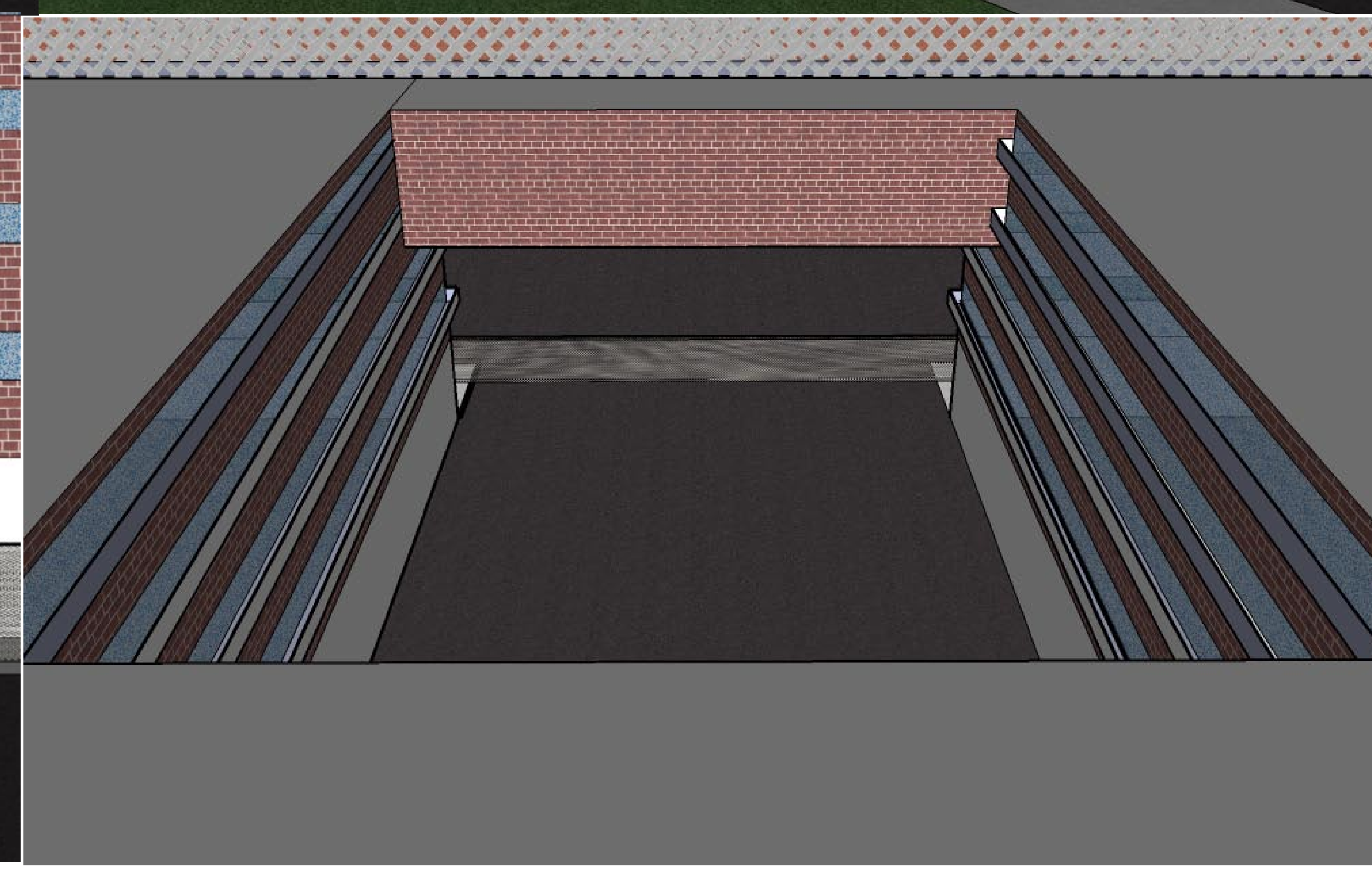
CLARK
MULTI-FAMILY



Houses
Retail
Retail
Elm Street
Building
Retail
Parking
Arlington Road
Parking
Garage
Giant
Store
Retail
Bethesda Av.
Retail



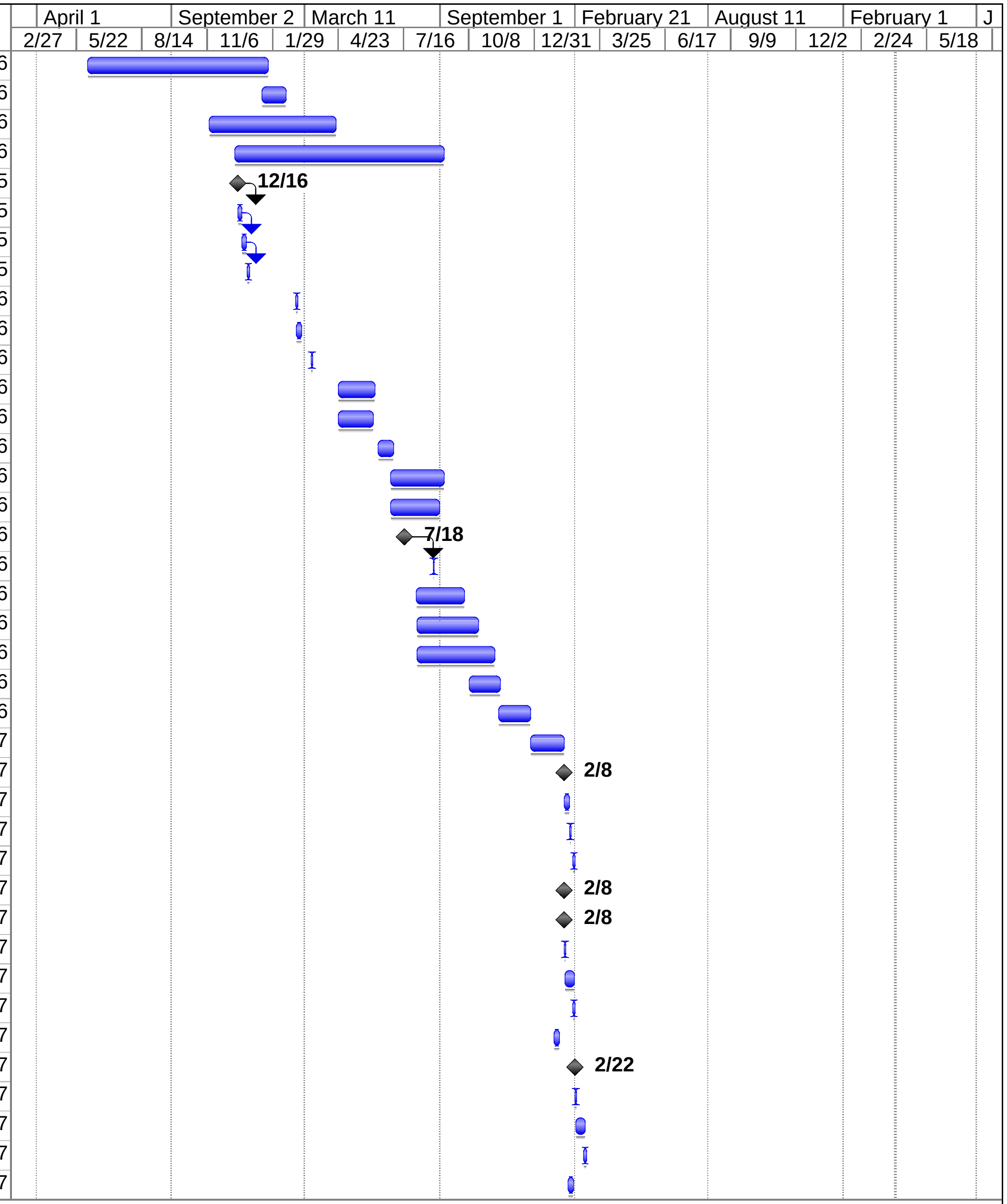
Project Schedule Summary

Foundations are the most critical activity for maintaining the project on schedule. Once the foundations are set in place, the rest of the activities should be done within schedule. That is why many CM/GC subcontract all of the activities besides foundations. They know that by self performing the foundations, they will have more control of the schedule.

Since the Apartment Complex structural system is mainly wood, the delivery of wood to the site was very important to the schedule. A delay on wood delivery would delay the entire project. Once the foundations were in place, and the wood was delivered to the project, finishing the structure became just another everyday activity.

The project summary schedule for the Apartment Complex project is shown on the next page.

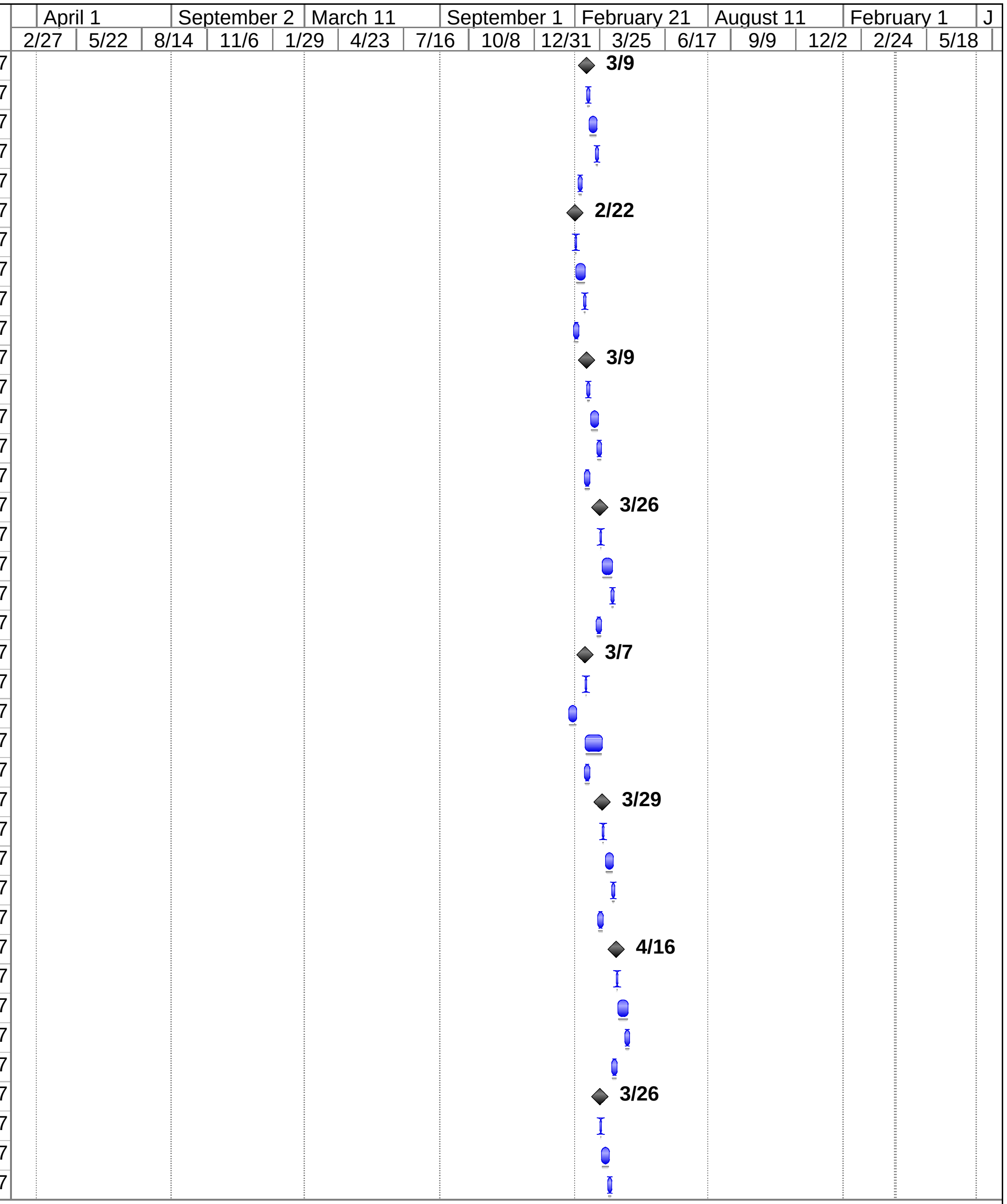
ID		Task Name	Duration	Start	Finish
1		Design/Preconstruction	166 days	Mon 6/6/05	Mon 1/23/06
2		Purchase Subs	23 days	Mon 1/16/06	Wed 2/15/06
3		Permitting	117 days	Wed 11/9/05	Thu 4/20/06
4		Excavation	193 days	Mon 12/12/05	Wed 9/6/06
5		Foundations	0 days	Fri 12/16/05	Fri 12/16/05
6		Install Piles - Section A	3 days	Fri 12/16/05	Tue 12/20/05
7		Install Piles - Section B	4 days	Wed 12/21/05	Mon 12/26/05
8		Install Piles - Section C	3 days	Wed 12/28/05	Fri 12/30/05
9		Excavate for strap beams	3 days	Tue 2/28/06	Thu 3/2/06
10		Pour strap beams	5 days	Wed 3/1/06	Tue 3/7/06
11		Backfill at strap beams	2 days	Mon 3/20/06	Tue 3/21/06
12		Complete Perimeter Piles	35 days	Mon 4/24/06	Fri 6/9/06
13		Excavate to tiebacks	33 days	Mon 4/24/06	Wed 6/7/06
14		Install tiebacks	14 days	Wed 6/14/06	Mon 7/3/06
15		Complete Excavation	49 days	Fri 6/30/06	Wed 9/6/06
16		Install Ave utilities	45 days	Fri 6/30/06	Thu 8/31/06
17		Concrete	0 days	Tue 7/18/06	Tue 7/18/06
18		Exc/Pour tower crane bases	1 day	Thu 8/24/06	Thu 8/24/06
19		Pour Footings	44 days	Wed 8/2/06	Mon 10/2/06
20		Pour foundation walls	57 days	Thu 8/3/06	Fri 10/20/06
21		Pour slab on grade	72 days	Thu 8/3/06	Fri 11/10/06
22		Pour G-1 deck	30 days	Mon 10/9/06	Fri 11/17/06
23		Pour first floor deck	29 days	Thu 11/16/06	Tue 12/26/06
24		Pour second floor deck	31 days	Wed 12/27/06	Wed 2/7/07
25		Structural Steel	0 days	Thu 2/8/07	Thu 2/8/07
26		Install str. Steel at bridges	5 days	Thu 2/8/07	Wed 2/14/07
27		Inspect Steel	2 days	Thu 2/15/07	Fri 2/16/07
28		Pour bridge	3 days	Mon 2/19/07	Wed 2/21/07
29		Wood Framing	0 days	Thu 2/8/07	Thu 2/8/07
30		2nd Floor section 1	0 days	Thu 2/8/07	Thu 2/8/07
31		Layout interior walls	2 days	Thu 2/8/07	Fri 2/9/07
32		Frame interior walls	8 days	Fri 2/9/07	Tue 2/20/07
33		floor trusses and deck	3 days	Mon 2/19/07	Wed 2/21/07
34		Frame exterior walls	5 days	Fri 1/26/07	Thu 2/1/07
35		2nd Floor section 2	0 days	Thu 2/22/07	Thu 2/22/07
36		Layout interior walls	2 days	Thu 2/22/07	Fri 2/23/07
37		Frame interior walls	8 days	Fri 2/23/07	Tue 3/6/07
38		floor trusses and deck	4 days	Mon 3/5/07	Thu 3/8/07
39		Frame exterior walls	5 days	Tue 2/13/07	Mon 2/19/07



Project: tech 2 schedule
Date: Mon 4/7/08

Task | Milestone | External Tasks
Split | Summary | External Milestone
Progress | Project Summary | Deadline

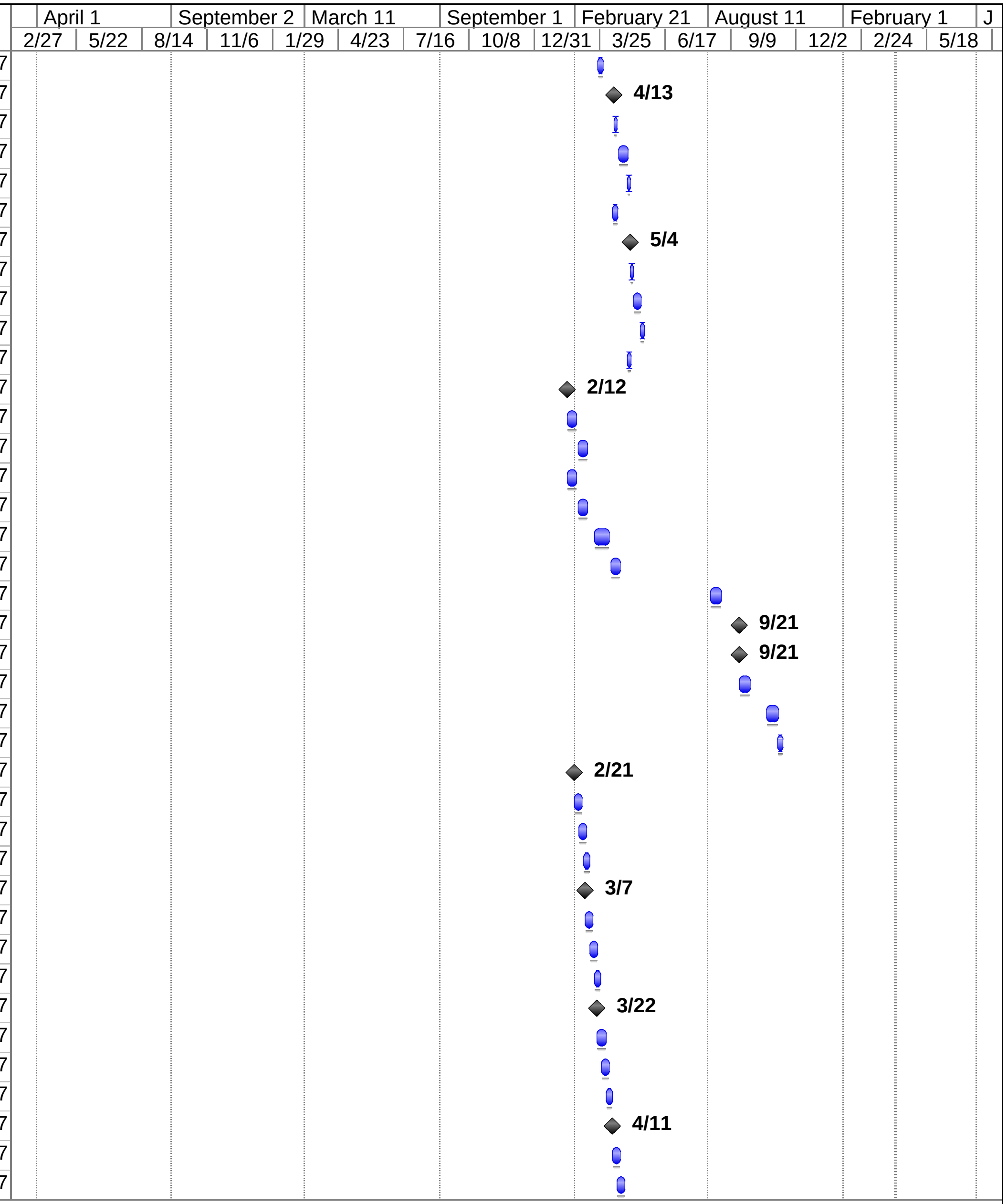
ID	Task Name	Duration	Start	Finish
40	2nd Floor section 3	0 days	Fri 3/9/07	Fri 3/9/07
41	Layout interior walls	2 days	Fri 3/9/07	Mon 3/12/07
42	Frame interior walls	8 days	Mon 3/12/07	Wed 3/21/07
43	floor trusses and deck	4 days	Tue 3/20/07	Fri 3/23/07
44	Frame exterior walls	5 days	Mon 2/26/07	Fri 3/2/07
45	3rd Floor section 1	0 days	Thu 2/22/07	Thu 2/22/07
46	Layout interior walls	2 days	Thu 2/22/07	Fri 2/23/07
47	Frame interior walls	8 days	Fri 2/23/07	Tue 3/6/07
48	floor trusses and deck	3 days	Mon 3/5/07	Wed 3/7/07
49	Frame exterior walls	5 days	Tue 2/20/07	Mon 2/26/07
50	3rd Floor section 2	0 days	Fri 3/9/07	Fri 3/9/07
51	Layout interior walls	2 days	Fri 3/9/07	Mon 3/12/07
52	Frame interior walls	8 days	Wed 3/14/07	Fri 3/23/07
53	floor trusses and deck	4 days	Thu 3/22/07	Tue 3/27/07
54	Frame exterior walls	5 days	Tue 3/6/07	Mon 3/12/07
55	3rd Floor section 3	0 days	Mon 3/26/07	Mon 3/26/07
56	Layout interior walls	2 days	Mon 3/26/07	Tue 3/27/07
57	Frame interior walls	9 days	Thu 3/29/07	Tue 4/10/07
58	floor trusses and deck	4 days	Mon 4/9/07	Thu 4/12/07
59	Frame exterior walls	5 days	Wed 3/21/07	Tue 3/27/07
60	4th Floor section 1	0 days	Wed 3/7/07	Wed 3/7/07
61	Layout interior walls	2 days	Wed 3/7/07	Thu 3/8/07
62	Frame interior walls	8 days	Wed 2/14/07	Fri 2/23/07
63	floor trusses and deck	16 days	Wed 3/7/07	Wed 3/28/07
64	Frame exterior walls	5 days	Tue 3/6/07	Mon 3/12/07
65	4th Floor section 2	0 days	Thu 3/29/07	Thu 3/29/07
66	Layout interior walls	2 days	Thu 3/29/07	Fri 3/30/07
67	Frame interior walls	8 days	Mon 4/2/07	Wed 4/11/07
68	floor trusses and deck	4 days	Tue 4/10/07	Fri 4/13/07
69	Frame exterior walls	5 days	Fri 3/23/07	Thu 3/29/07
70	4th Floor section 3	0 days	Mon 4/16/07	Mon 4/16/07
71	Layout interior walls	2 days	Mon 4/16/07	Tue 4/17/07
72	Frame interior walls	9 days	Wed 4/18/07	Mon 4/30/07
73	floor trusses and deck	4 days	Fri 4/27/07	Wed 5/2/07
74	Frame exterior walls	5 days	Tue 4/10/07	Mon 4/16/07
75	5th Floor section 1	0 days	Mon 3/26/07	Mon 3/26/07
76	Layout interior walls	2 days	Mon 3/26/07	Tue 3/27/07
77	Frame interior walls	8 days	Wed 3/28/07	Fri 4/6/07
78	floor trusses and deck	3 days	Thu 4/5/07	Mon 4/9/07



Project: tech 2 schedule
Date: Mon 4/7/08

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

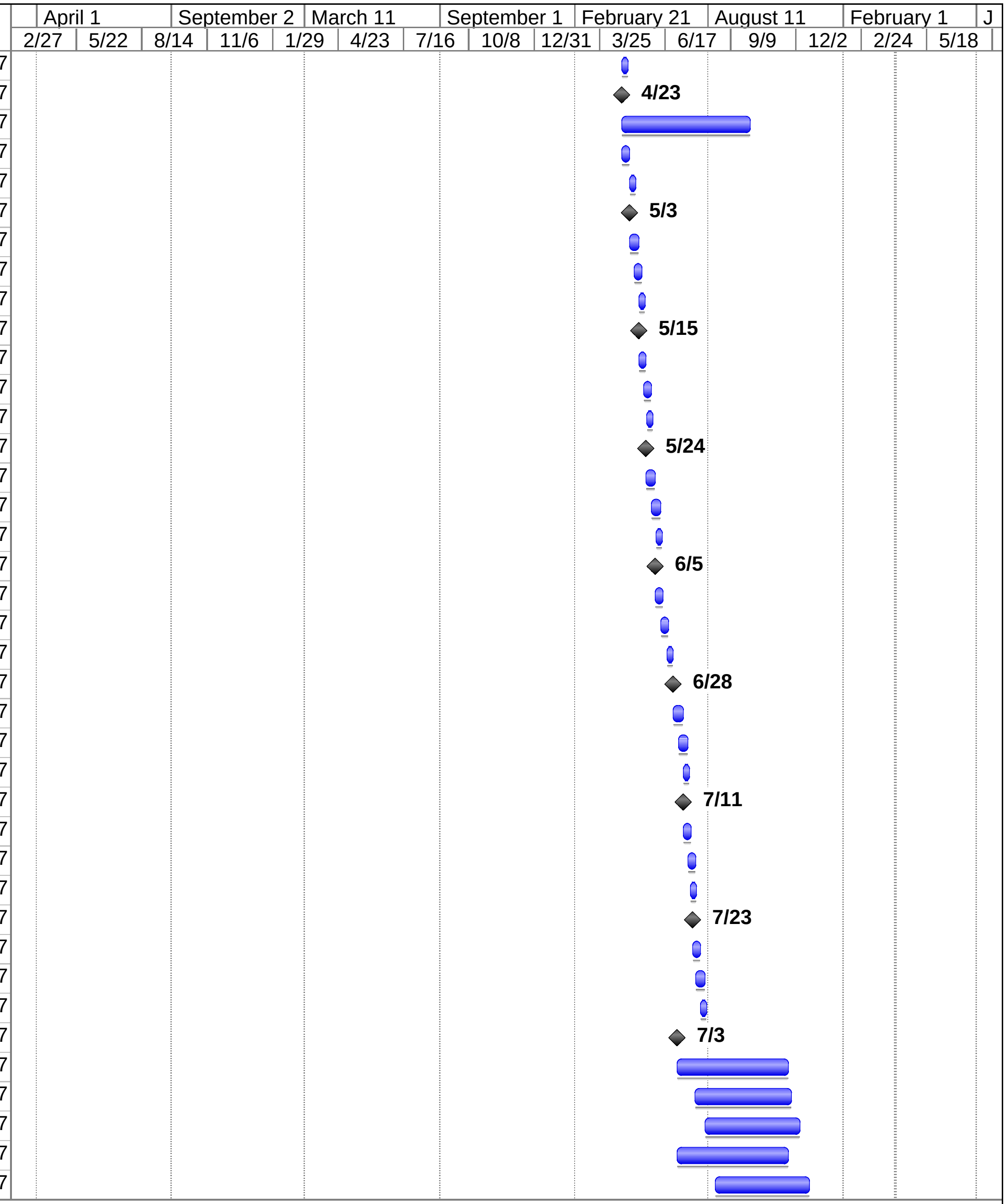
ID		Task Name	Duration	Start	Finish
79		Frame exterior walls	5 days	Fri 3/23/07	Thu 3/29/07
80		5th Floor section 2	0 days	Fri 4/13/07	Fri 4/13/07
81		Layout interior walls	2 days	Fri 4/13/07	Mon 4/16/07
82		Frame interior walls	8 days	Thu 4/19/07	Mon 4/30/07
83		floor trusses and deck	4 days	Mon 4/30/07	Thu 5/3/07
84		Frame exterior walls	5 days	Wed 4/11/07	Tue 4/17/07
85		5th Floor section 3	0 days	Fri 5/4/07	Fri 5/4/07
86		Layout interior walls	2 days	Fri 5/4/07	Mon 5/7/07
87		Frame interior walls	8 days	Tue 5/8/07	Thu 5/17/07
88		floor trusses and deck	3 days	Thu 5/17/07	Mon 5/21/07
89		Frame exterior walls	5 days	Mon 4/30/07	Fri 5/4/07
90		Parking Garage	0 days	Mon 2/12/07	Mon 2/12/07
91		G-2 sprinkler piping	10 days	Mon 2/12/07	Fri 2/23/07
92		G-1 sprinkler piping	10 days	Mon 2/26/07	Fri 3/9/07
93		G-2 CMU	10 days	Mon 2/12/07	Fri 2/23/07
94		G-1 CMU	10 days	Mon 2/26/07	Fri 3/9/07
95		Set mechanical equipment	15 days	Mon 3/19/07	Fri 4/6/07
96		Wire mech equipment	10 days	Mon 4/9/07	Fri 4/20/07
97		MEP start-up	10 days	Wed 8/15/07	Tue 8/28/07
98		Unit Rough In	0 days	Fri 9/21/07	Fri 9/21/07
99		1st floor	0 days	Fri 9/21/07	Fri 9/21/07
100		Sprinkler / Mechanical R-I	10 days	Fri 9/21/07	Thu 10/4/07
101		Electrical R-I	11 days	Fri 10/26/07	Fri 11/9/07
102		R-I Inspection	5 days	Fri 11/9/07	Thu 11/15/07
103		2nd floor section 1	0 days	Wed 2/21/07	Wed 2/21/07
104		Sprinkler / Mechanical R-I	8 days	Wed 2/21/07	Fri 3/2/07
105		Electrical R-I	8 days	Tue 2/27/07	Thu 3/8/07
106		R-I Inspection	6 days	Mon 3/5/07	Mon 3/12/07
107		2nd floor section 2	0 days	Wed 3/7/07	Wed 3/7/07
108		Sprinkler / Mechanical R-I	8 days	Wed 3/7/07	Fri 3/16/07
109		Electrical R-I	8 days	Tue 3/13/07	Thu 3/22/07
110		R-I Inspection	6 days	Mon 3/19/07	Mon 3/26/07
111		2nd floor section 3	0 days	Thu 3/22/07	Thu 3/22/07
112		Sprinkler / Mechanical R-I	8 days	Thu 3/22/07	Mon 4/2/07
113		Electrical R-I	8 days	Wed 3/28/07	Fri 4/6/07
114		R-I Inspection	6 days	Tue 4/3/07	Tue 4/10/07
115		3rd floor section 1	0 days	Wed 4/11/07	Wed 4/11/07
116		Sprinkler / Mechanical R-I	8 days	Wed 4/11/07	Fri 4/20/07
117		Electrical R-I	8 days	Tue 4/17/07	Thu 4/26/07



Project: tech 2 schedule
Date: Mon 4/7/08

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

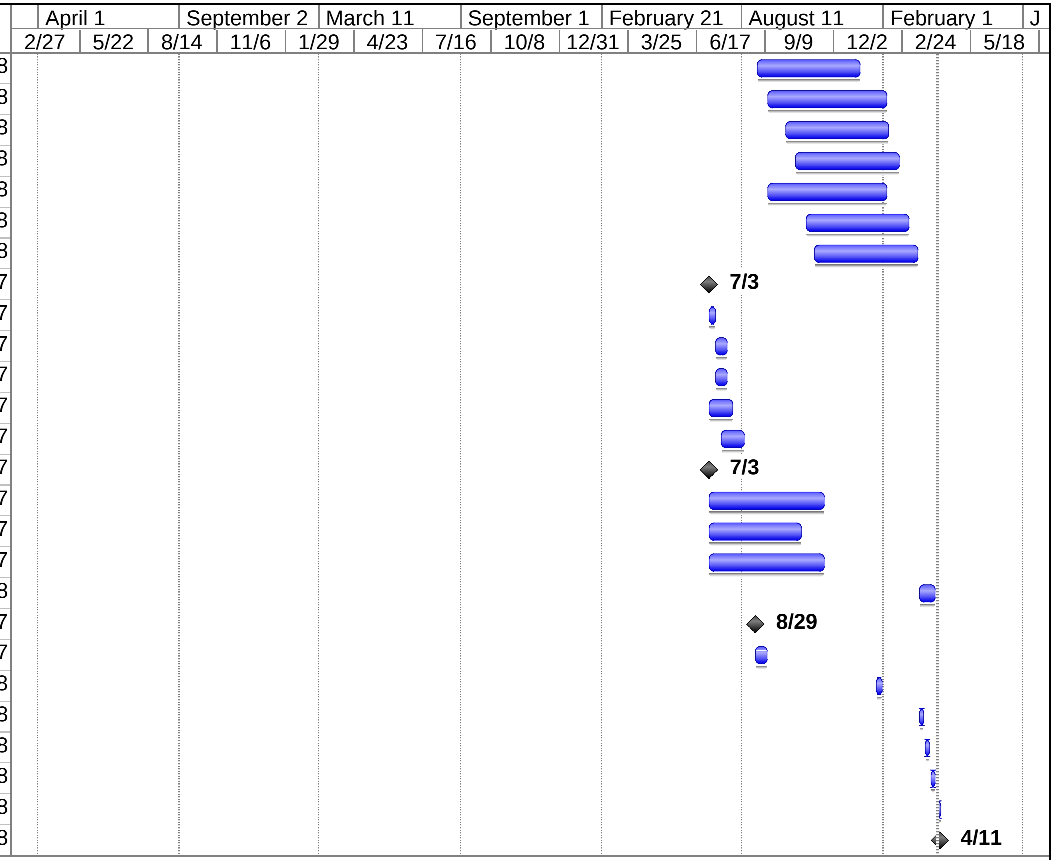
ID		Task Name	Duration	Start	Finish
118		R-I Inspection	6 days	Mon 4/23/07	Mon 4/30/07
119		3rd floor section 2	0 days	Mon 4/23/07	Mon 4/23/07
120		Sprinkler / Mechanical R-I	119 days	Mon 4/23/07	Thu 10/4/07
121		Electrical R-I	8 days	Mon 4/23/07	Wed 5/2/07
122		R-I Inspection	6 days	Thu 5/3/07	Thu 5/10/07
123		3rd floor section 3	0 days	Thu 5/3/07	Thu 5/3/07
124		Sprinkler / Mechanical R-I	8 days	Thu 5/3/07	Mon 5/14/07
125		Electrical R-I	8 days	Wed 5/9/07	Fri 5/18/07
126		R-I Inspection	6 days	Tue 5/15/07	Tue 5/22/07
127		4th floor section 1	0 days	Tue 5/15/07	Tue 5/15/07
128		Sprinkler / Mechanical R-I	7 days	Tue 5/15/07	Wed 5/23/07
129		Electrical R-I	8 days	Mon 5/21/07	Wed 5/30/07
130		R-I Inspection	6 days	Fri 5/25/07	Fri 6/1/07
131		4th floor section 2	0 days	Thu 5/24/07	Thu 5/24/07
132		Sprinkler / Mechanical R-I	8 days	Thu 5/24/07	Mon 6/4/07
133		Electrical R-I	8 days	Thu 5/31/07	Mon 6/11/07
134		R-I Inspection	6 days	Wed 6/6/07	Wed 6/13/07
135		4th floor section 3	0 days	Tue 6/5/07	Tue 6/5/07
136		Sprinkler / Mechanical R-I	8 days	Tue 6/5/07	Thu 6/14/07
137		Electrical R-I	8 days	Tue 6/12/07	Thu 6/21/07
138		R-I Inspection	6 days	Wed 6/20/07	Wed 6/27/07
139		5th floor section 1	0 days	Thu 6/28/07	Thu 6/28/07
140		Sprinkler / Mechanical R-I	9 days	Thu 6/28/07	Tue 7/10/07
141		Electrical R-I	8 days	Thu 7/5/07	Mon 7/16/07
142		R-I Inspection	6 days	Wed 7/11/07	Wed 7/18/07
143		5th floor section 2	0 days	Wed 7/11/07	Wed 7/11/07
144		Sprinkler / Mechanical R-I	8 days	Wed 7/11/07	Fri 7/20/07
145		Electrical R-I	8 days	Tue 7/17/07	Thu 7/26/07
146		R-I Inspection	6 days	Fri 7/20/07	Fri 7/27/07
147		5th floor section 3	0 days	Mon 7/23/07	Mon 7/23/07
148		Sprinkler / Mechanical R-I	8 days	Mon 7/23/07	Wed 8/1/07
149		Electrical R-I	8 days	Fri 7/27/07	Tue 8/7/07
150		R-I Inspection	6 days	Thu 8/2/07	Thu 8/9/07
151		Unit Finishes	0 days	Tue 7/3/07	Tue 7/3/07
152		2nd floor section 1	103 days	Tue 7/3/07	Thu 11/22/07
153		2nd floor section 2	88 days	Thu 7/26/07	Mon 11/26/07
154		2nd floor section 3	88 days	Wed 8/8/07	Fri 12/7/07
155		3rd floor section 1	103 days	Tue 7/3/07	Thu 11/22/07
156		3rd floor section 2	87 days	Tue 8/21/07	Wed 12/19/07



Project: tech 2 schedule
Date: Mon 4/7/08

Task | Milestone | External Tasks
Split | Summary | External Milestone
Progress | Project Summary | Deadline

ID		Task Name	Duration	Start	Finish
157		3rd floor section 3	90 days	Fri 8/31/07	Thu 1/3/08
158		4th floor section 1	104 days	Thu 9/13/07	Tue 2/5/08
159		4th floor section 2	90 days	Fri 10/5/07	Thu 2/7/08
160		4th floor section 3	91 days	Wed 10/17/07	Wed 2/20/08
161		5th floor section 1	104 days	Thu 9/13/07	Tue 2/5/08
162		5th floor section 2	90 days	Tue 10/30/07	Mon 3/3/08
163		5th floor section 3	91 days	Fri 11/9/07	Fri 3/14/08
164		MEP	0 days	Tue 7/3/07	Tue 7/3/07
165		Install RTU's 1,2, and 3	6 days	Tue 7/3/07	Tue 7/10/07
166		Pipe RTU's	10 days	Wed 7/11/07	Tue 7/24/07
167		Wire RTU's	10 days	Wed 7/11/07	Tue 7/24/07
168		Install RT condensing units	21 days	Tue 7/3/07	Tue 7/31/07
169		Wire RT condensing units	20 days	Wed 7/18/07	Tue 8/14/07
170		Vertical Transportation	0 days	Tue 7/3/07	Tue 7/3/07
171		Install elevator 1	101 days	Tue 7/3/07	Tue 11/20/07
172		Install elevator 2	81 days	Tue 7/3/07	Tue 10/23/07
173		Install elevator 3 and 4	101 days	Tue 7/3/07	Tue 11/20/07
174		Final Cleaning	15 days	Mon 3/17/08	Fri 4/4/08
175		Testing andFinal Inspection	0 days	Wed 8/29/07	Wed 8/29/07
176		Parking Garage	10 days	Wed 8/29/07	Tue 9/11/07
177		1st floor	5 days	Thu 1/24/08	Wed 1/30/08
178		2nd floor	5 days	Mon 3/17/08	Fri 3/21/08
179		3rd floor	5 days	Mon 3/24/08	Fri 3/28/08
180		4th floor	5 days	Mon 3/31/08	Fri 4/4/08
181		5th floor	5 days	Mon 4/7/08	Fri 4/11/08
182		Substantial Completion	0 days	Fri 4/11/08	Fri 4/11/08



Project: tech 2 schedule
Date: Mon 4/7/08

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Analysis 1: Prefabrication of the Exterior wall (Depth Study)

Problem

Hand laid brick is the most common method when building the façade of a building. However, this method is slow and takes a lot of time of the schedule.

Goal

On a project that has a big façade; it is worth studying how a prefabricated façade would affect the project. The use of pre-cast brick façade panels rather than hand laid brick could reduce the schedule duration significantly. The goal of this analysis is to see if replacing the bricks with precast brick panels could reduce the schedule duration and cost of the project.

Background

The current façade design calls for stick built 4" masonry on a 7-5/8" metal stud back-up with exterior sheathing board, 1" cavity board insulation and sheet membrane air barrier. Masonry is attached to the structure using masonry ties that are screwed to the metal studs.

Steps for the Analysis

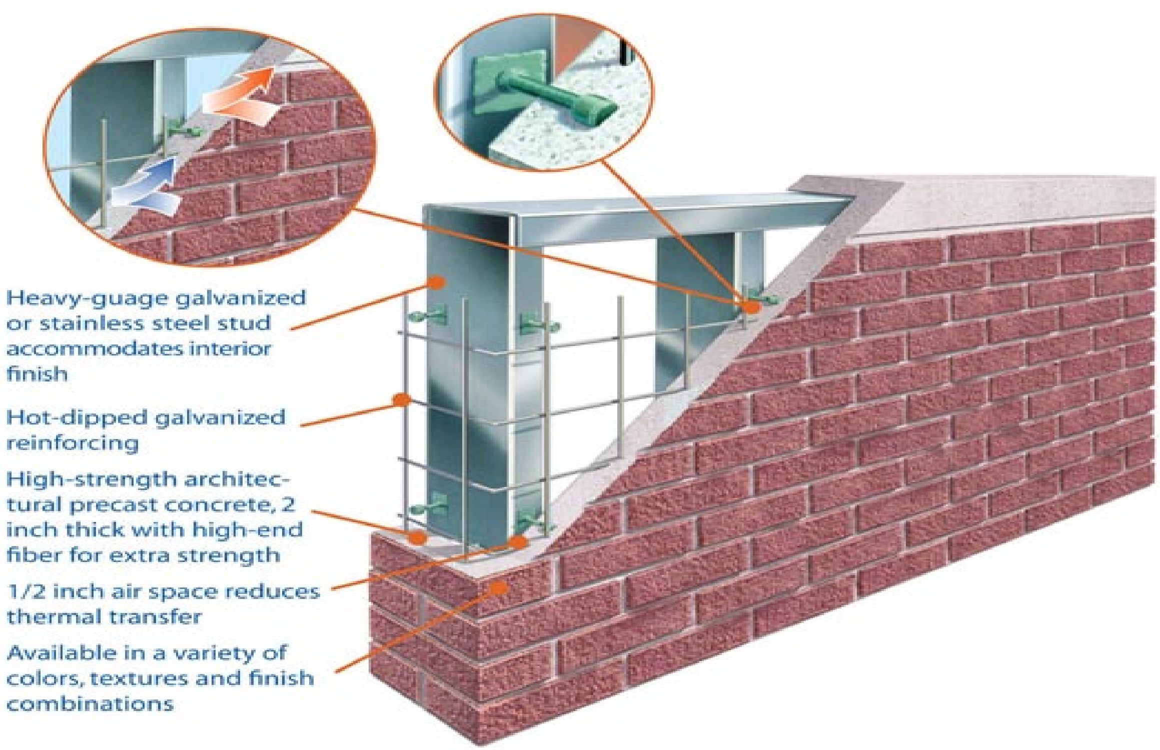
- Perform a Quantity Take-Off of the Existing Façade
- Select an Architectural Precast Brick Panel system to replace the current system.
- Contact the panel manufacturer to determine number of panels, erection costs, and installation costs.
- Investigate typical erection time for each panel.
- Perform a Cost & Schedule Comparison of both Systems
- Perform Structural Analysis to determine if the structure need to be changed

Resources

- Clark Construction Company
- Architectural Engineering Faculty
- EASI-SET® Industries
- RS-Means

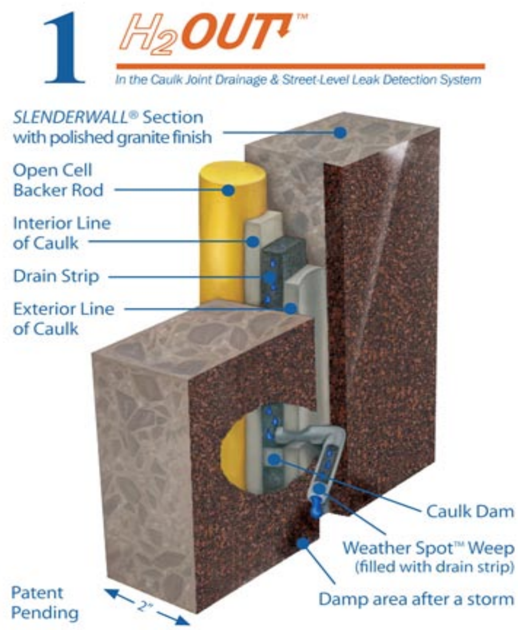
Proposed System

After analyzing many solid precast panels, I realized that the ordinary precast panels weigh significantly more that the existing brick façade, which means that the structure would have to be modified. After further research I found a system called ThermaGuard SlenderWall System, which is an architectural precast concrete system that is much lighter and less expensive than the ordinary solid precast panel system. The Slenderwall consists on a two inch reinforced high-strength architectural precast concrete exterior layer with hot-dipped galvanized reinforcing, and an interior formed by 16 gauge, six inch galvanized steel studs spaced vertically at two foot center. The concrete is securely connected to the steel stud frame with a epoxy-coated stainless-steel welded Nelson anchors. There is also a1/2-inch air space between the concrete panel and metal studs for greater thermal protection. The patented connection prevents corrosion and reduces thermal transfer by as much as 25%, which reduced heating and cooling costs especially during winter and summer.



The Slenderwall system is the only wall system that combines high-strength architectural precast concrete, hot-dipped galvanized welded-wire-fabric reinforcing steel, insulated epoxy-coated stainless- steel Nelson® anchors, and heavy-gauge galvanized or stainless-steel studs. The slenderwall panels weight about 30lbs per square foot, which is about two-thirds less than conventional architectural precast or brick. Moreover, this system offers many combinations of architectural precast textures, colors, shapes and finishes.

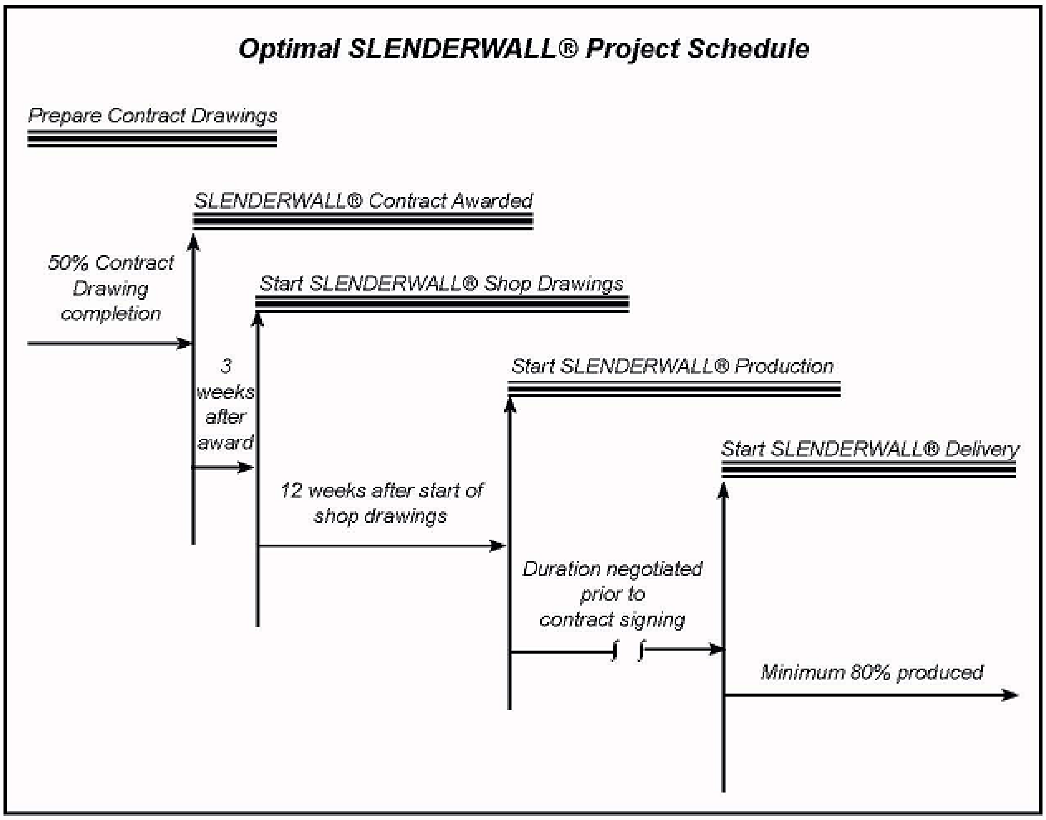
The Slenderwall system has many advantages over the actual hand-laid brick system. It has a drainage system called H2Out, which is the only secondary drainage, street-level, caulk joint leak detection system. As opposed to other system, with the H2Out system, if caulk joints ever fail, they can be easily detected. Another advantage of the Slenderwall system is the precast to stud frame connection called DuraFlex 360. As its name shows, this connection allows a 360° movement to isolate the precast concrete from the structural stresses that can be caused by wind loads, frame movement, expansion, or contraction. DuraFlex 360 allows the structure to maintain its integrity and to maintain the water tightness.



Another advantage of the Slenderwall system, which I think is the most valuable advantage, is the fact that this system has a "Lift-and-Release" mechanism that makes the installation process faster and easier (19 minutes per panel). This mechanism increases panel installation rates by 50% reducing the schedule duration significantly. There are however some implications to the prefabricated panels. The precast panels must be erected with a crane and therefore there is a significant impact to the site planning. In addition, the precast panels are much more expensive than the brick veneer. However After a full analysis that addressed the impacts to cost, schedule, structural loads, and mechanical loads, the Slenderwall system fits better to the project. The sections on the following pages will give a more detailed analysis on each aspect.

Schedule Comparison

Masonry construction is very slow and requires a lot of man-hours. The SlenderWall system provides very significant schedule savings. With the prefabricated system the duration of the wall assembly is reduced 87% from 166 days to 21 days. A production rate of 16 panels per day was used to calculate the schedule. It is important to mention that the prefabricated systems needs contract documents as well as shop drawings. Usually the design of these shop drawings take 12 weeks. Moreover, there should be three weeks between the contract award and the shop drawings deign. However, even with the 15 weeks that have to be added to the schedule, with the prefabricated panels the completion of the exterior wall is still reduced by 14 weeks, which is a significant amount of time.



Item	Quantity	Total Days
Brick/EIFS/CMU	64,000 SF	166 days
SlenderWall Panels	324 Panels	21 days

Even though the wall assembly is not on the critical path, other activities that are on the critical path can start earlier. The prefabricated panels allow interior finishes to start three months earlier reducing the construction duration significantly. The general condition savings as well as all the other cost related analysis are shown on the following section.

Cost Comparison

Apartment Complex has a building envelope system that involves many different elements. The building façade incorporates five major materials: Norman brick veneer, EIFS, CMU, windows, and doors. The envelope estimate was approximately $2,155,913, which is about 5% of the total cost of the building. The Envelope without windows and doors costs $1,878,050, which is 4.3% of the total cost. The Assemblies Estimate was calculated using *RSMeans Assemblies Cost Data 2007*.

Detailed building envelope estimate

Category	CSI	Type	Quantity	Unit	Material	Labor	Tot. Unit Price	Total Cost
Masonry	5350	EIFS	14,000	SF	5.7	14.40	20.1	$281,400
	1400	Brick	47,000	SF	15.05	18.35	33.40	$1,569,800
	2750	CMU	3,000	SF	3.05	5.9	8.95	$26,850
Doors	5100	Overhead door	32	EA	1752	703	$2,455	$78,560
	1980	Storefronts	32	EA	743	351	$1,694	$54,208
Windows	5850	Type 1	250	EA	1400	294	1694	$423,500
	5500	Type 2	115	EA	975	243	1218	$140,070
	5250	Type 3	75	EA	535	120	655	$49,125
							Total	**$2,632,513**

Prefabricated panel cost

Item	SF	Cost/SF	Total Cost
Slenderwall Panels	64,000	$36	$2,304,000

Cost Comparison

Item	Cost
Slenderwall Panels	2,304,000
Crane Usage	29,904
General Condition savings	-184,241
Cost of Previous system	-1,878,050
Additional cost of new System	**$271,613**

The Slenderwall system costs $271,613 more. It is true that with the new system there will be more planning and more coordination needed. However the advantages that this system brings to the project overcome the extra cost.

Site Planning Implications

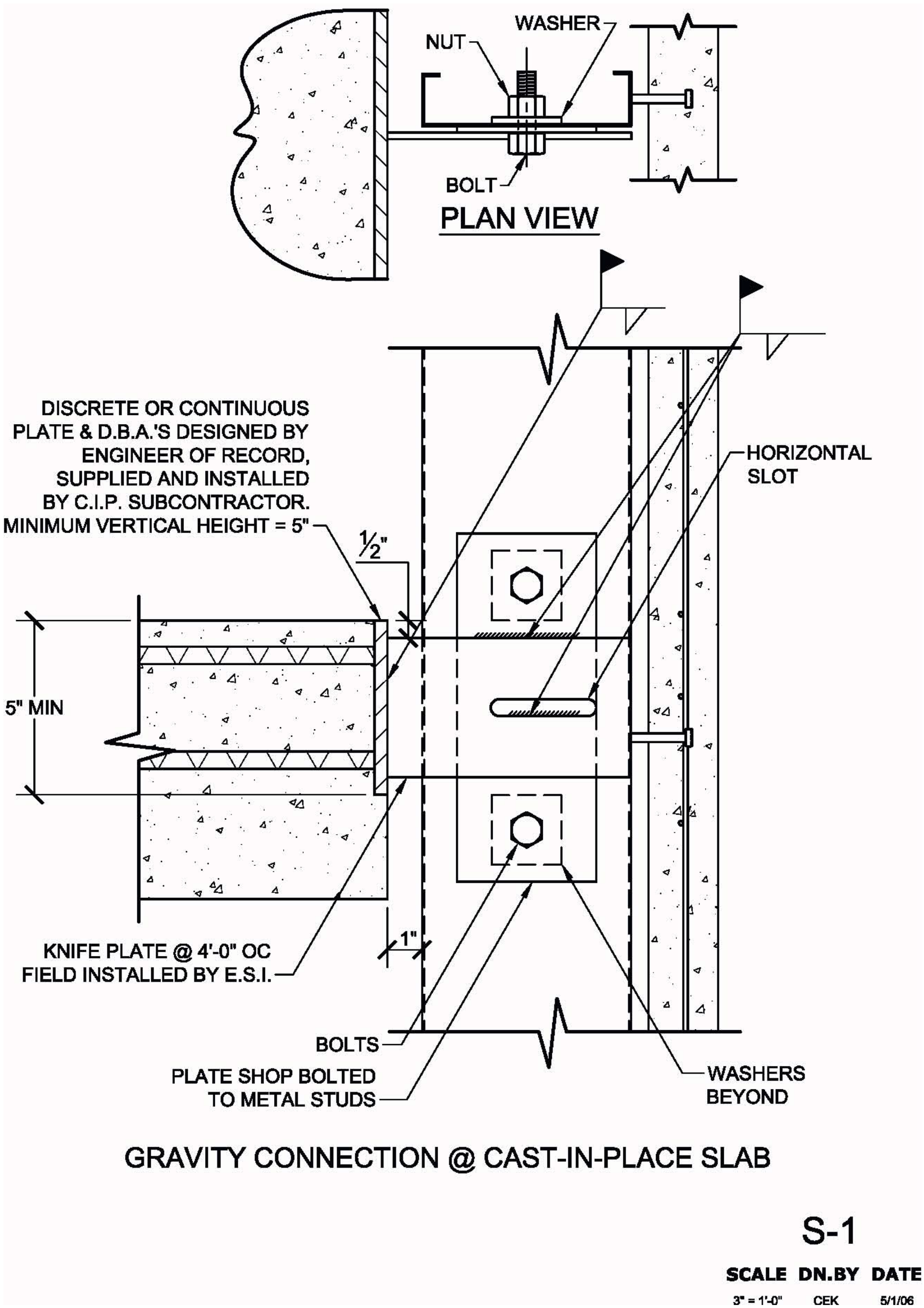
The process of building a prefabricated façade is very different from the process of building a hand laid brick façade. With the prefabricated system, there are many steps that have to be coordinated. Masonry construction requires a lot of man-hours and many scaffolds. The prefabricated system only requires a crane and few workers. Every time that an activity requires the use of a crane, many steps need to be coordinated. Delivery area, stage location, pick-up points, and safety gear are some of the aspects that have to be considered with the new prefabricated system.

The jobsite is congested as it is, and with the delivery and staging of the prefabricated panels it will be even more congested. That is why coordination will be key in the success of this process. The best way to erect the façade is to pick the panels directly from the delivery trucks. That way there will be no need to store any material. However, in order to do so it is necessary to calculate the exact amount of panels that will be erected each day so that the exact amount of panels are delivered. The fact is that the advantages that this system brings to the project are worth all the extra coordination and extra planning.

Connection Details

Another advantage of the SlenderWall system is that weights two thirds less than the average precast panel. The SlenderWall panels weight 30 psf, which means that the structural system does not have to change. The current system is able to support the panels as long as the necessary connection angles are installed. The SlenderWall panels are attached to the building perimeter by gravity and lateral connection at the floor slab. The current system calls for 12 gage galvanized masonry straps with 3/16" diameter ties @ 24" a/c horizontally and 16" 0.C. vertically between veneer walls and back-up wall. The masonry ties are screwed to the metals studs. The masonry assembly rests on 1/2"x 3 1/2x 5/16" continuous angles welded to the pour stops.

See Connection details on the next page.


WASHER
NUT
BOLT
PLAN VIEW
DISCRETE OR CONTINUOUS
PLATE & D.B.A.'S DESIGNED BY
ENGINEER OF RECORD,
SUPPLIED AND INSTALLED
BY C.I.P. SUBCONTRACTOR.
MINIMUM VERTICAL HEIGHT = 5"
½"
HORIZONTAL
SLOT
5" MIN
KNIFE PLATE @ 4'-0" OC
FIELD INSTALLED BY E.S.I.
1"
BOLTS
PLATE SHOP BOLTED
TO METAL STUDS
WASHERS
BEYOND
GRAVITY CONNECTION @ CAST-IN-PLACE SLAB
S-1
SCALE DN.BY DATE
3" = 1'-0" CEK 5/1/06

Conclusion

As with every system, there are always advantages and disadvantages. In order to decide whether or not a system is worth using, the only thing we need to see is if the advantages are greater than the disadvantages. That is how I approached this analysis. I compare advantages and disadvantages and then decided that the prefabricated system was worth using. In first place, the system reduces the schedule significantly, which means that the construction process can be done faster and cheaper. Moreover the Slenderwall system has better performance than the regular brick façade in the sense that isolates the building more. This means that there is less heat loss in the building, and less energy is required to maintain the building's desired temperature. Another advantage of using prefabricated panels is that since they are built indoors, weather is not a factor and it can never delay the project.

On the other side, using a prefabricated system means that there will be additional costs. Since the panels are made off site, they need to be stored and transported to the jobsite. Transportation and storage are very costly. Moreover, when using prefabricated panels, there is the need of additional designing since connection and installation details are needed. Furthermore, the design process needs to be done ahead of time meaning that more coordination and early planning is necessary. Another disadvantage of using the Slenderwall precast panels is that additional crane picks are needed, which means that there will be additional cost and additional crane coordination.

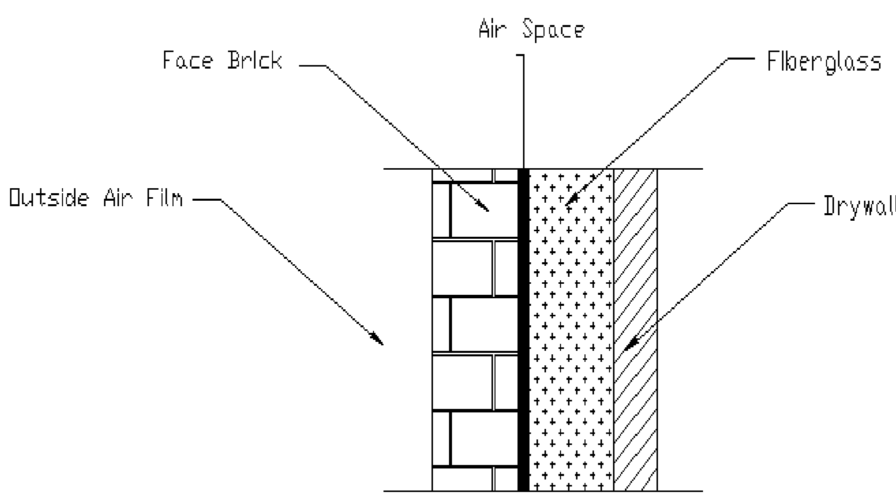
After analyzing the advantages and disadvantages of the prefabricated system, I got to the conclusion that the Slenderwall system is a very good alternative for the hand laid masonry system currently being used in the project. The prefabricated system helps the project in many areas such as schedule, cost, and performance. In my opinion, cost, schedule, and performance are the most important aspect of a project. A project that has low cost, good performance, and it was done in less time than it was expected, it becomes automatically on a successful project. That is why I think that the implementation of the Slendewall system is a good idea and it will benefit the project significantly.

Analysis 2: HVAC System Reduction (Breadth Study)

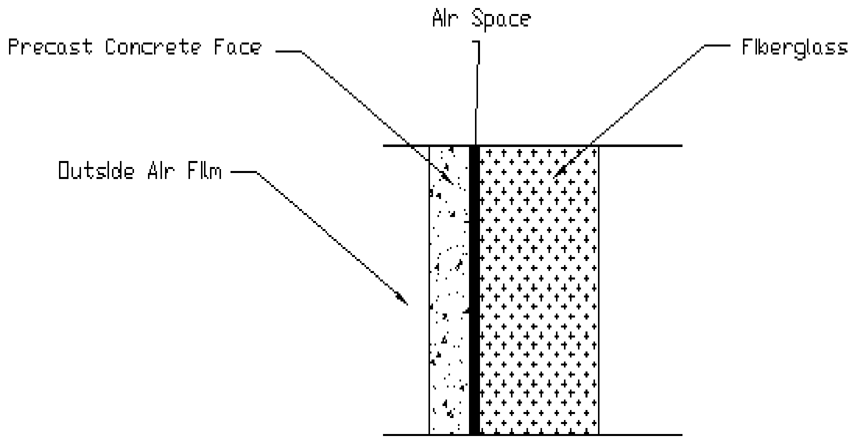
The new Slendelwall System does no only contribute to the project by reducing the duration of the project, but also it insulates the building better. The Slenderwall panels have a 1/2-inch air space between the concrete panel and stud, and the exclusive epoxy-coated stainless-steel Nelson® anchor that prevents corrosion and reduces thermal transfer by as much as 25%. The additional insulation reduces heating and cooling costs.

This analysis investigates the effects of the additional insulation on energy savings and the effects on the HVAC system in terms of cost savings. The additional insulation of the exterior wall could potentially save cost by downsizing some of the HVAC equipment used in the building.

Impacts to the mechanical system were analyzed by first calculating the R-Values for each system. The original brick assembly included a 4” thick face brick, 1” air space, and 1” thick extruded polystyrene rigid insulation. The Slenderwall System includes a 2” thick architectural concrete layer, ½” air space, and 6” steel frame supports filled with fiberglass batt insulation. The R- Values demonstrated that the Slenderwall® will reduce the thermal conductivity significantly. Impacts to the mechanical system will be studied on the next section of this analysis. Sections of both systems as well as the R-Values calculation are shown below.



Existing Design



Proposed Design

Current Brick assembly R-Values

Layer	Thickness	R-Value/inch	Total R-Value
Unit	(in)		(hr-SF-F/BTU)
Outside Air Film	∞	0.17	0.17
Brick	4	.8/thickness	0.8
Drywall	2	0.9	1.8
Air Space	0.5	1	0.5
Fiberglass	4	3.2	12.8
			16.07

SlenderWall System R-Values

Layer	Thickness	R-Value/inch	Total R-Value
Unit	(in)		(hr-SF-F/BTU)
Outside Air Film	∞	0.17	0.17
Precast Concrete face	2	0.8	1.6
Air Space	0.5	1	0.5
Fiberglass Batt insulation	6	3.14	18.84
			21.1

R-Values and U-Value

System	R-Value	U-Value
Unit	hr-SF-F/BTU	BTU/hr-SF-F
Current Brick system	16.07	.0622
SlenderWall System	21.1	.0474

Load Analysis

	Area (SF)
Perimeter Wall	65,000

Winter Temperature In Washington DC	
To	15°F
Ti	70°F
Change in Temperature	55°F

Summer Temperature In Washington DC	
To	95°F
Ti	70°F
Change in Temperature	25°F

Heat Loss During Winter				
System	U-Value (BTU/hr-sf-F)	Area (SF)	Δ T (F)	Heat Loss (BTU/hr)
Current Brick Façade	.0622	65,000	55°F	222,365
SlenderWall System	.0474	65,000	55°F	169,455
			Difference	**52,910**

Heat Gain During Summer				
System	U-Value (BTU/hr-sf-F)	Area (SF)	Δ T (F)	Heat Loss (BTU/hr)
Current Brick Façade	.0622	65,000	25°F	101,075
SlenderWall System	.0474	65,000	25°F	77,025
			Difference	**24,050**

With the SlennderWall system, The HVAC system would have to provide 52,910 BTU/Hr less in the winter and 24,050 BTU/Hr less in the summer. Since the HVAC system would have to deliver less BTU/Hr, there is the possibility that it can be downsized. The purpose of reducing the HVAC system is that it would decrease the costs of electricity and increase energy savings. The savings would be noticeable right away, and in the long run as well. The possibility of downsizing the HVAC system to reduce costs will be studied on the next section.

Current Mechanical System

The mechanical system consists on three rooftop units, and two air-handling units located on the first floor that serves the retail stores, restaurants, and the parking garage. The HVAC system for the residential part consists on individual HVAC units for each apartment. The mechanical system contains thirteen different types of pumps. It has two 400 ton chillers and two 1200 GPM 400 ton cooling towers. The air is distributed through galvanizes steel ducts that run all throughout the building. The building has a wet pipe sprinkler system. Smoke detectors as well as sprinklers are located all throughout the building.

For this analysis, I will only focus on the reduction of the HVAC system serving the residential part. Since each apartment has its own HVAC unit, I wanted to see if with the additional insulation of the building, provided by the Slenderwall panels, I could reduce the number of HVAC units in the building. Maybe some apartment could now share a HVAC unit. In the entire building, there are 180 apartments; 53 in the second floor, 35 on the third, 57 on the fourth, and 35 apartments on the fifth floor. The HVAC unit used on each apartment is a WY13B33A 12,500 BTU/Hr Friedrich Cooling/Heat Pump Air Conditioner.

Cooling Capacity: 12,500/12,100 BTU/h

Heating Capacity: 10,400/10,000 BTU/h

EER: 9.0/9.0

Moisture Removal: 3.2 Pints/Hr.

Room Side Air Circulation: 280 CFM

Volts Rated: 230/208

Cooling Amps: 6.4/6.8

Cooling Watts: 1,389/1,352

Heating Amps: 5.4/5.7

Heating Watts: 1,182/1,136

The Most Energy Efficient Solid-side Air Conditioner

° High efficiency operation saves on energy costs
° Residential/ commercial application
° Mounts flush with the exterior wall for a neat appearance
° Ideal for thicker wall installations, where side fins don't fit
° Exact fit for Fedders A and B sleeves. Sleeves measures 27" W x 16 3/4" H
° Easy-to-reach, top mount controls
° Three-speed fan
° Magna 1 copper coils
° Efficient rotary compressor
° Easy-to-clean filter

Mechanical System Impacts

The implementation of the Slenderwall system reduced the amount of BTU/Hr needed. My intention was to reduce the BTU/Hr necessity so that some HVAC units could be downsized. The approximate cost of each unit is $1000. There are 180 units in the building meaning that $180,000 was spent on the residential HVAC individual units.

There were three approached that I could have taken. The first one was to eliminate as many HVAC units as possible considering the reduction of BTU/Hr needed. The second approach was switch to a central HVAC system that served the entire space. The third option was to divide the BTU/Hr that are not needed anymore into each unit. That way the BTU/Hr needed on each apartment would be reduced, and therefore the HVAC individual units could be downsized.

After analyzing all options, I realized that neither one really works. Taking in account the summer and winter, which are the season that people will need the HVAC units the most, the Slenderwall system would only eliminate two to four units. That would mean that only $4,000 would be saved. Moreover this approach would not have worked anyways since each apartment needs one unit. Four thousand dollar is not a significant amount and therefore the idea of eliminating some individual units is not really a good option.

The second option of implementing a central HVAC system was not a good idea either since the entire structure would have to be redesigned. A central HVAC system is not necessarily cheaper since there is the need of installing ductwork. In the end, the individual units work bets for this project.

The Third option did not work either. With the slenderwall system, each apartment would need 294 BTU/Hr less in the winter and 134 BTU/Hr less in the summer. The current individual HVAC units have a cooling capacity of 12,500 BTU/Hr and a heating capacity of 10,400 BTU/Hr. The table below shows some other individual HVAC units that provide less heating and cooling tons. The current units are model WY13B33A. If we were to downsize the individual units, the next model on the list is WY10B33A. This unit has a cooling capacity of 10,100 BTU/Hr and a heating capacity of 10,400 BTU/Hr. The reduction of BTU/Hr needed on each apartment due to the Slenderwall system is not enough to downsize the individual units.

Model	Cooling BTU/h	Heating BTU/h	Volts	Amps**	EER	Height in.	Width in.	Depth in.	Circuit Breaker	Weight lbs.
WS08B10A	8000		115	6.8	10.5	16-3/4	27	16-3/4	125V-15A	93
WS10B10A	10000		115	8.7	10.5	16-3/4	27	16-3/4	125V-15A	103
WS14B10A	13500		115	12.0	9.5	16-3/4	27	16-3/4	125V-15A	112
WS10B30A	10000		230/208	4.6/5.0	10.0	16-3/4	27	16-3/4	250V-15A	101
WS13B30B	12500		230/208	6.3/6.7	8.9	16-3/4	27	16-3/4	250V-15A	109
WS16B30A	15800		230/208	7.8/8.5	9.0	16-3/4	27	16-3/4	250V-15A	119
WE10B33A	10000	11000	230/208	16.0/14.7	10.0	16-3/4	27	16-3/4	250V-20A	103
WE13B33B	12500	11000	230/208	16.0/14.7	8.9	16-3/4	27	16-3/4	250V-20A	111
WE16B33A	15800	11000	230/208	16.0/14.7	9.0	16-3/4	27	16-3/4	250V-20A	121
WY10B33A	10100	8100*	230/208	3.9/6.0	10.0	16-3/4	27	16-3/4	250V-20A	107
WY13B33A	12500	10400*	230/208	5.4/5.7	9.0	16-3/4	27	16-3/4	250V-20A	116

Conclusion

After analyzing the data and studying the different possibilities, I came to the conclusion that even thought the Slenderwall panel system provides greater insulation to the building, the HVAC system is not really affected by it. The precast system does have many advantages that where pointed out on the first analysis. However, the HVAC system is not really beneficed by it. Maybe if the HVAC system for the residential area would be a central system, then maybe downsizing the system would have been possible. However, since the HVAC system serving the residential area are individual units for each apartment, then the precast system does not help at all, and the system has remain the same. The only advantage that the precast panels would provide to the mechanical system is that with the additional insulation, electricity costs would decrease since heat loss through the walls would decrease.

Analysis 3: Interior Structure Redesign (Breadth Study)

Problem

Wood is a cheap and workable material. However, it is a material that is not durable. Metal is a more durable and resistant material that would benefit the building in the long run. Moreover, metal studs come with pre-punched holes for plumbing and electrical conduits to run through. With wood, you need to drill those holes, which cost money and time.

Goal

In this project, all the interior framing, as well as the floor system was done with wood. I believe that wood was used in this project due to its low cost. However, I think that it is worth studying how the project would be affected if metal studs had been used instead. Metal studs, and metal joist would certainly increase the cost of the project, but they would also increase the value of the building. Metal studs, and metal joist are more resistant, more durable, and they have pre-punched holes for the plumbing and electrical conduits already. Therefore, replacing wood framing for metal framing would increase the value of the building and reduce the schedule as well. This analysis will explore how the project would benefit from switching to metal framing in terms of cost, schedule and method of construction.

Background

The Apartment Complex has a combination of structural systems. Concrete is only used up to the second floor slab. Cast in place concrete is used in this project for the foundations, perimeter wall up to the second floor, and beams and columns that extent from G2 level until the first floor slab. From the second floor to the fifth floor is all wood and metal studs. All the exterior and interior framing is load bearing. The metal studs are used on the exterior of the building, while the wood studs are used on the interior framing. The floor joist system was also done with wood. The problem of having many different components in one system is that many trades have to work on the same structure. When many trades work together, most likely there will be conflicts. With many trades, there is the need of extra coordination to avoid conflicts. Maybe by simplifying the structure, conflicts could be avoided, and the schedule could be reduced.

Steps for the Analysis

- Perform a Quantity Take-Off of the Existing Structure
- Perform a load analysis of the building
- Compare the current system with the proposed new system.
- Perform a Quantity Take-Off and Cost analysis of the Proposed Structure
- Perform a Cost & Schedule Comparison of both Systems
- Conclusion: Advantages and Disadvantages of new system

Quantity Take-Off of the Existing Structure

For the sake of this analysis, I decided to study only one part of the building since the interior structure is very repetitive. From the quantity take-off of this analysis I will estimate the cost of the entire interior wood structure. The quantity take-off will be done to the 4th floor east wing, which is located on the east side of Festival Street. The size of this area is 18,000 SF. This section of the building contains seventeen units. There are six different types of units in this area that will be analyzed later in this section. The total cost of this section is shown on the table below.

Unit	# of Units	# of wood studs	Total Studs	Cost per Stud	Total Cost
1F	2	66	132	$2.55	$336.60
2LCU	1	134	134	$2.55	$341.70
2LAU	1	135	135	$2.55	$344.25
2LDU	14	129	1806	$2.55	$4,605.30
1+DAMPDU	1	159	159	$2.55	$405.45
ILBU	3	110	330	$2.55	$841.50
				Total Cost	**$6,874.80**

Unit	# of Units	# of wood joists	Total Joists	Cost per Joist	Total Cost
1F	2	15	30	$40.00	$1,200.00
2LCU	1	18	18	$40.00	$720.00
2LAU	1	15	15	$40.00	$600.00
2LDU	14	19	266	$40.00	$10,640.00
1+DAMPDU	1	15	15	$40.00	$600.00
ILBU	3	25	75	$40.00	$3,000.00
				Total Cost	**$16,760.00**

Unit	# of Units	# of wood Trusses	Total Trusses	Cost per Truss	Total Cost
1F	2	1	2	$90.00	$180.00
2LCU	1	0	0	$0.00	$0.00
2LAU	1	0	0	$0.00	$0.00
2LDU	14	2	28	$120.00	$3,360.00
1+DAMPDU	1	2	2	$110.00	$220.00
ILBU	3	2	6	$120.00	$720.00
				Total Cost	**$4,480.00**

The cost shown on the tables only reflects the east wing of the forth floor, which is 18,000SF. To calculate the entire cost of the wood structure I calculated the cost per square feet and then multiply it by the complete area of the wood structure.

($6,874.80 + $16,760.00 + $4,480.00) / 18,000 SF = 1.56 $/SF

Floor	Area (SF)
2	54,650
3	49,893
4	56,050
5	51,263
total	**211,856**

211,856 SF x 1.56 $/SF = $330,905

Total Cost of interior wood structure is $330,905

Load Analysis

The load calculations shown below are the load on the interior structural system of the 4th floor east wing. The load is transferred from the slab to the floor joist system. The load from the floor joist system is then transferred to the wood trusses that are acting as girders. The load is then transferred from the wood trusses to the exterior metal frame studs, which transfer the load from the fifth floor to the first floor, where the concrete structure begins. The concrete beams and columns transfer the load from the first floor all the way to the foundations, which are below the second garage level.

Since I am replacing the interior framing from wood studs to metal studs, I am also replacing the wood floor joist system to a metal floor joist system. I am also replacing the wood trusses for metal joist girder. The load calculations shown below were done to determine the loads on the current wood joist system so that I can replace it for a metal joist system. In order to design the new system, I used the Standard Load tables for Open Web Steel Joist Systems from "Load tables and weight tables for steel joist and joist girders". Each type of unit had a different floor joist system, so a load analysis was done for each unit type.

Unit IF

S = 4.38 ft

Live load = 40psf x (4.38 ft) = 175.2plf

Dead load = 4.38 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 543.12plf

Then use an Open Web steel joist k-series 16K6 (dead load = 576plf / live load = 238plf)

P = (543.12plf) x (25ft) = 13.58Kips   Use 15.0 Kips

Then, based on the Joist Girder Design Guide use a 35G8N13.6K (42plf)

Unit ILBU

S = 4.17 ft

Live load = 40psf x (4.17 ft) = 166.8plf

Dead load = 4.17 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 517.08plf

Then use an Open Web steel joist k-series 12K5 (dead load = 555plf / live load = 198plf)

P = (517.08plf) x (21ft) = 10.86Kips   Use 12.0 Kips

Then, based on the Joist Girder Design Guide use a 50G12N10.9K (65plf)

Unit 1+DAMPDU

S = 4 ft

Live load = 40psf x (4 ft) = 160plf

Dead load = 4 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 496plf

Then use an Open Web steel joist k-series 12K5 (dead load = 555plf / live load = 198plf)

P = (496plf) x (21ft) = 10.42Kips   Use 12.0 Kips

Then, based on the Joist Girder Design Guide use a 32G8N10.4K (32plf)

Unit 2LDU

S = 4.17 ft

Live load = 40psf x (4.17 ft) = 166.8plf

Dead load = 4.17 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 517.08plf

Then use an Open Web steel joist k-series 12K5 (dead load = 555plf / live load = 198plf)

P = (517.08plf) x (21ft) = 10.86Kips   Use 12.0 Kips

Then, based on the Joist Girder Design Guide use a 50G12N10.9K (65plf)

Unit IF

S = 4.38 ft

Live load = 40psf x (4.38 ft) = 175.2plf

Dead load = 4.38 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 543.12plf

Then use an Open Web steel joist k-series 16K6 (dead load = 576plf / live load = 238plf)

Unit IF

S = 4.38 ft

Live load = 40psf x (4.38 ft) = 175.2plf

Dead load = 4.38 ft x [(1.6) x (40psf) + (1.2) x (4in / 12) x (150psf)] = 543.12plf

Then use an Open Web steel joist k-series 16K6 (dead load = 576plf / live load = 238plf)

Current system Vs New proposed system

There is no overall plan of the interior wood framing. The framing for each unit type was detailed individually. The individual unit framing plans shows the type, spacing, and quantity of woods studs used on each wall. Moreover, wherever there is an opening, there is the need of extra studs. The individual unit framing plans also shows the extra studs needed on openings, which are called posts. Depending on the dimensions of the opening, the Jack/King stud schedule will determine how many extra studs are needed. The legends of the marks on the plans are shown below.

Wood Wall Schedule	
MARK	Wall Construction
W12	2x4 @ 16" O.C.
W13	2x4 @ 12" O.C.
W14	2x4 @ 12" O.C. +1
W15	(2) 2x4 @ 16" O.C.
W16	(2) 2x4 @ 12" O.C.
W17	(3) 2x4 @ 12" O.C.
W22	2x6 @ 16" O.C.
W23	2x6 @ 12" O.C.
W24	2x6 @ 12" O.C. +1

Lightgage Wall Schedule	
Mark	Wall Construction
M12	600S162-43 @ 16" O.C.
M13	600S162-43 @ 12" O.C.
M14	600S162-54 @ 16" O.C.
M15	600S162-54 @ 12" O.C.
M16	600S162-97 @ 16" O.C.
M17	(2)600S162-54 @ 16" O.C.
M18	(2)600S162-68 @ 16" O.C.
M19	(2)600S162-97 @ 16" O.C.
M20	(3)600S162-54 @ 16" O.C.
M24	800S250-54 @ 16" O.C.
M25	800S250-54 @ 12" O.C.

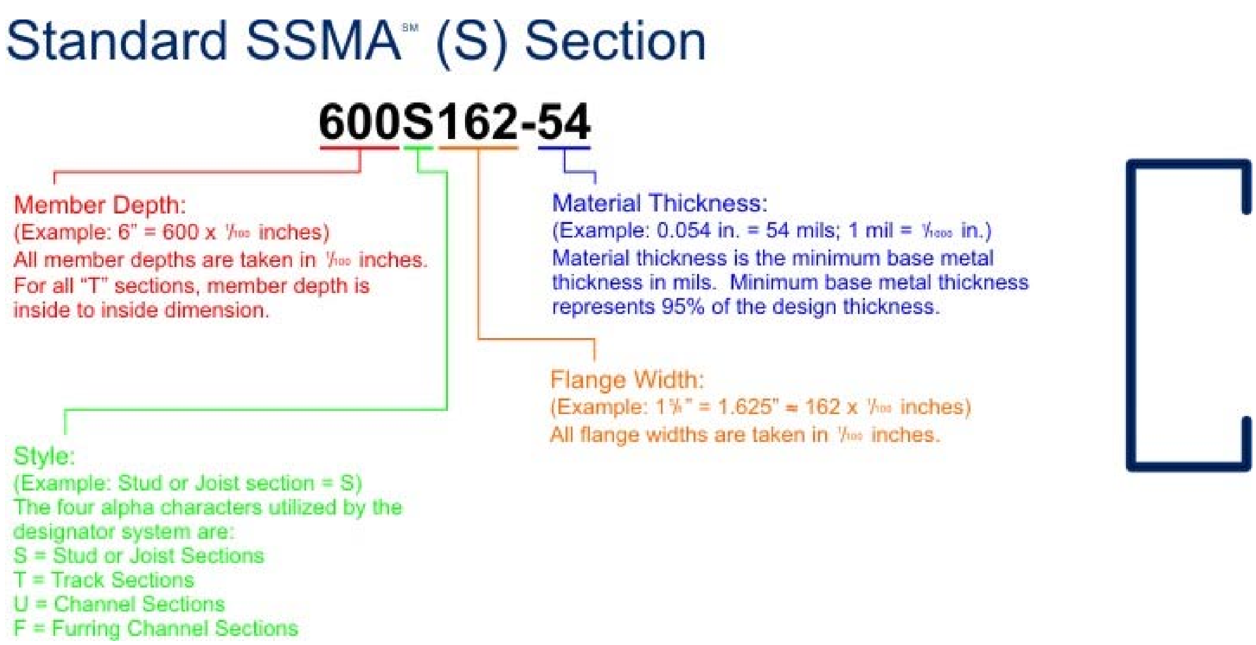
Wood/Steel Post Schedule	
MARK	Post Construction
P12	(2) 2x4
P13	(3) 2x4
P14	(4) 2x4
P15	(5) 2x4
P16	(6) 2x4
P17	(7) 2x4
P18	(8) 2x4
P19	(9) 2x4
P110	(10) 2x4

Jack/King Stud Schedule		
MARK	0'-0" - 4'-0"	4'-1" - 7'-0"
W12	1k + 2j	2k + 2j
W13	1k + 2j	2k + 2j
W14	2k + 2j	3k + 2j
W15	2k + 2j	4k + 2j
W16	3k + 2j	5k + 2j
W17	5k + 2j	7k + 2j

Lightgage Post Schedule	
MARK	Post Construction
MP1	(2)-400S162-54
MP2	(2)-400S162-54 (1)-400T125-54
MP3	(2)-400S162-54 (2)-400T125-54
MP4	(3)-400S162-54 (2)-400T125-54
MP5	(3)-400S162-54 (3)-400T125-54
MP6	(4)-400S162-54 (3)-400T125-54

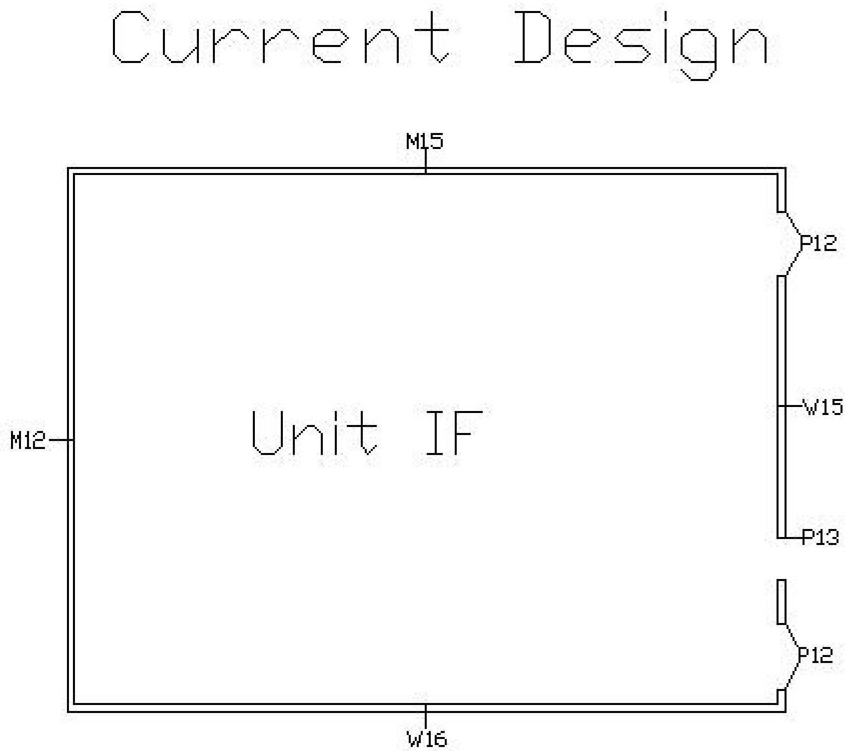
Simple Mils to Gauge Conversion Chart	
Minimum Thickness (mils)	Reference Gauge Number
33	20
43	18
54	16
68	14
97	12
118	10

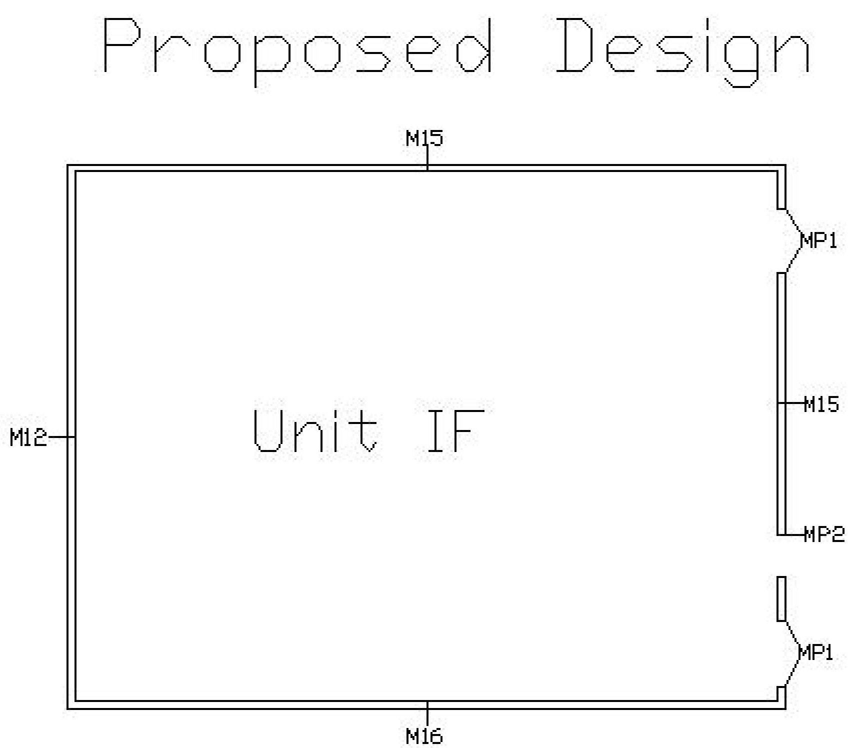
Load	Metal Stud
4k	400S162-54
8k	400S162-97
12k	(2) 400S162-54
16k	(2) 400S162-68
20k	(2) 400S162-97
24k	(2) 400S162-97
30k	(3) 400S162-54



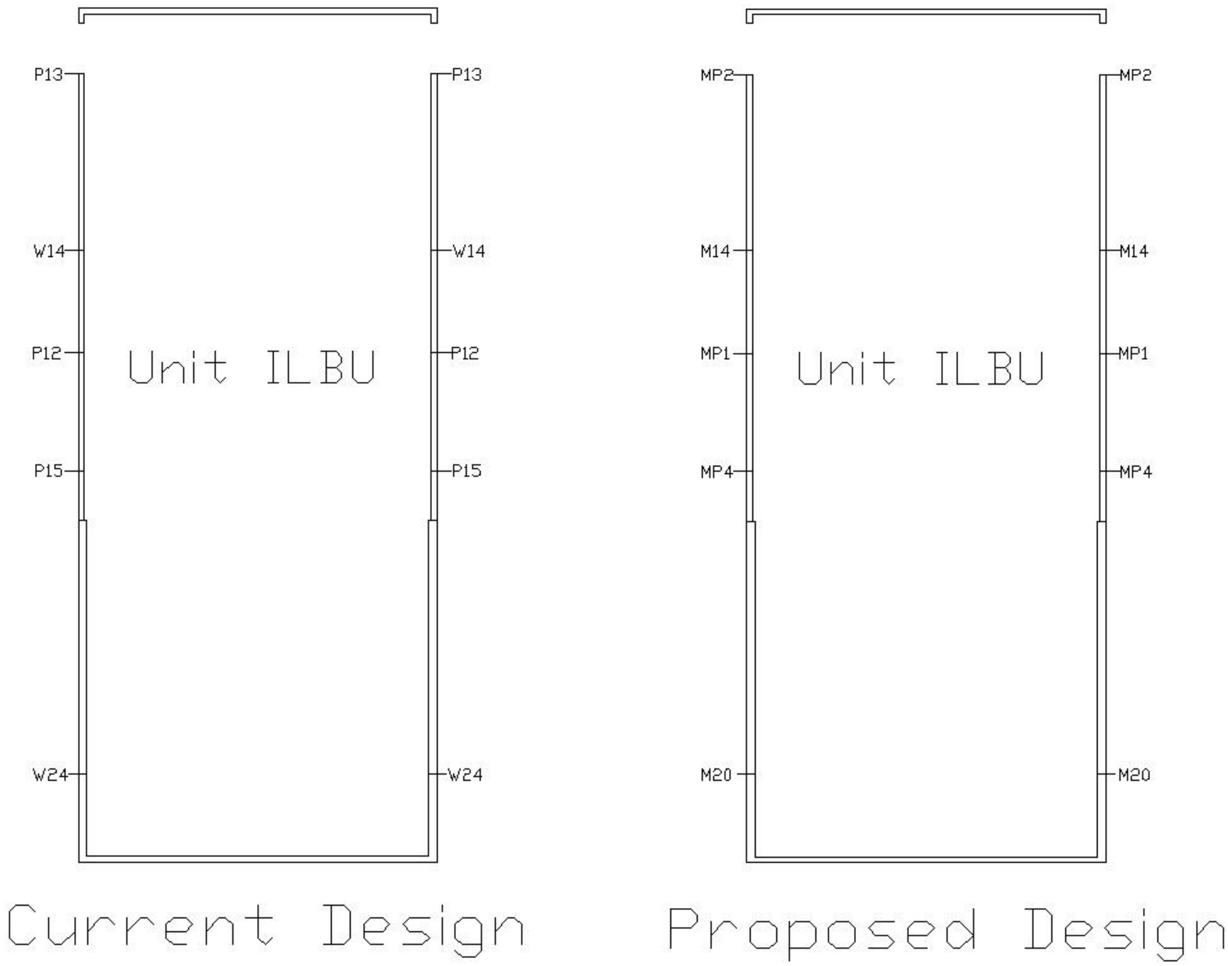
After proposing a new floor joist system, and a new joist girder system, the only wood members remaining are the wood studs used on the interior framing. Based on the load analysis and the wood framing analysis, I proposed a new system that will replace all the wood studs for metal studs. Each unit was analyzed and a new framing system with metal studs was proposed. The unit comparison plans are shown below. Use the legend tables above to read the plans.

Unit IF

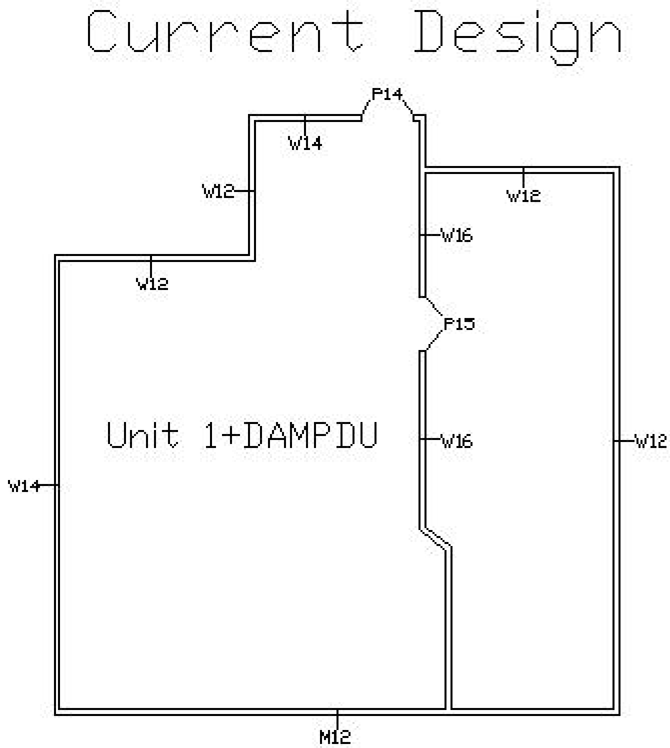

Current Design
M15
P12
V15
M12
Unit IF
P13
P12
W16

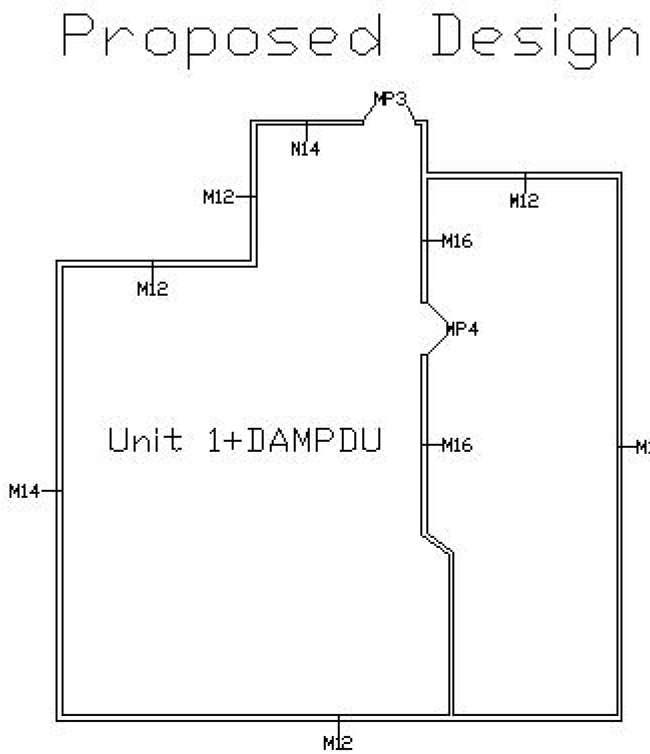

Proposed Design
M15
MP1
M15
M12
Unit IF
MP2
MP1
M16

Unit ILBU

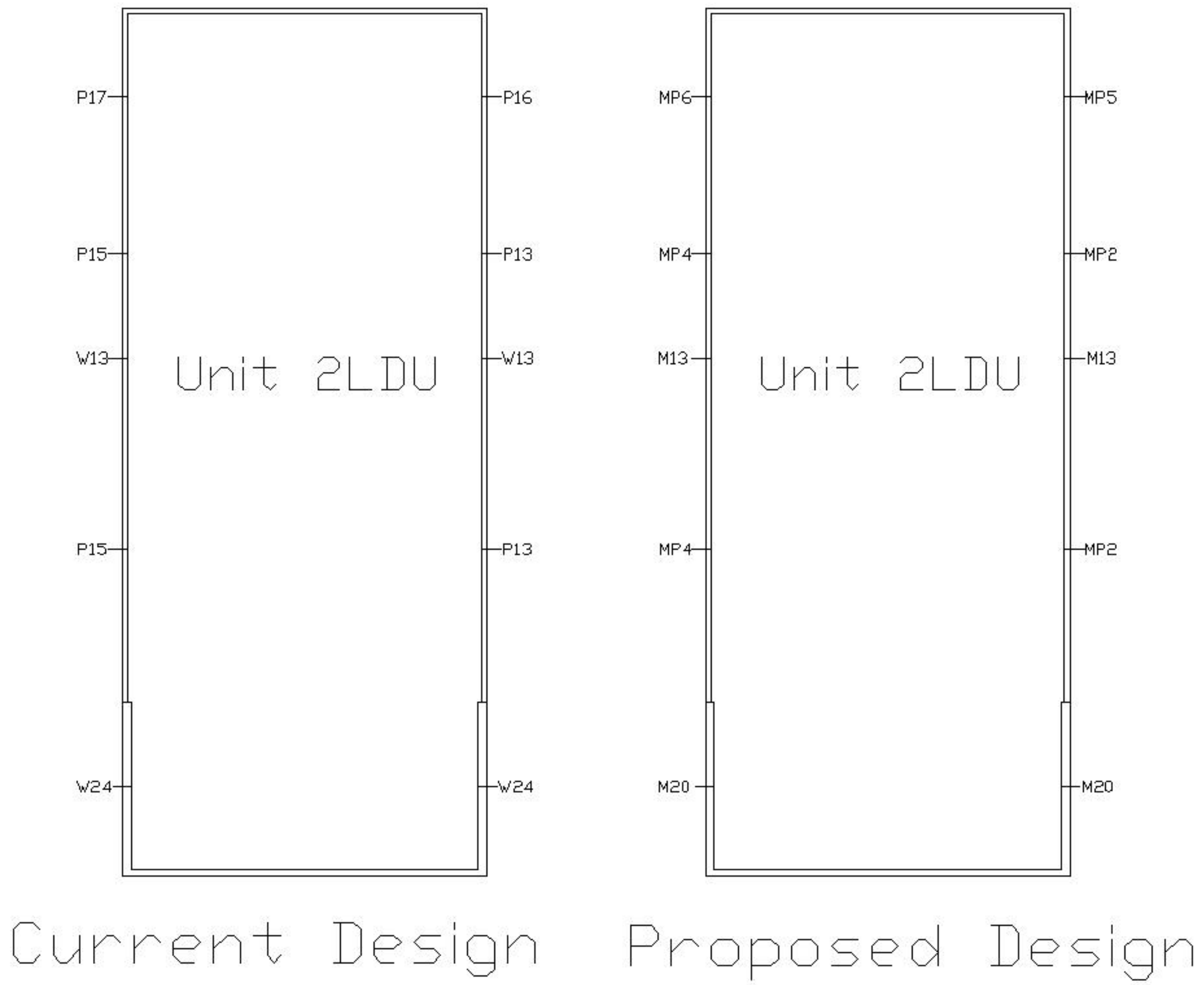

P13
P13
W14
W14
P12
P12
Unit ILBU
P15
P15
W24
W24
MP2
MP2
M14
M14
MP1
MP1
Unit ILBU
MP4
MP4
M20
M20
Current Design
Proposed Design

Unit 1+DAMPDU



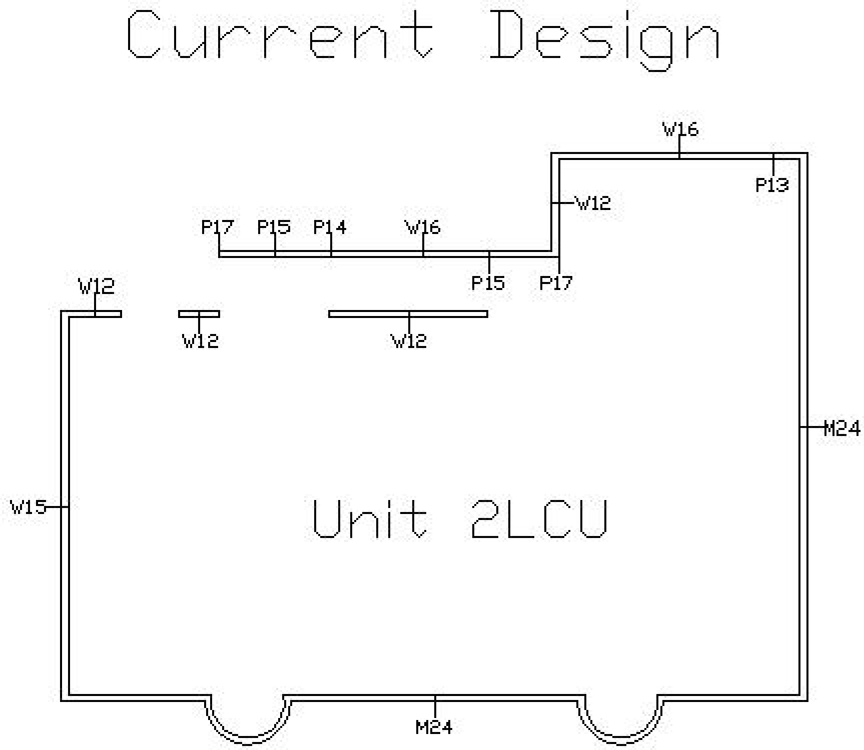


Unit 2LDU

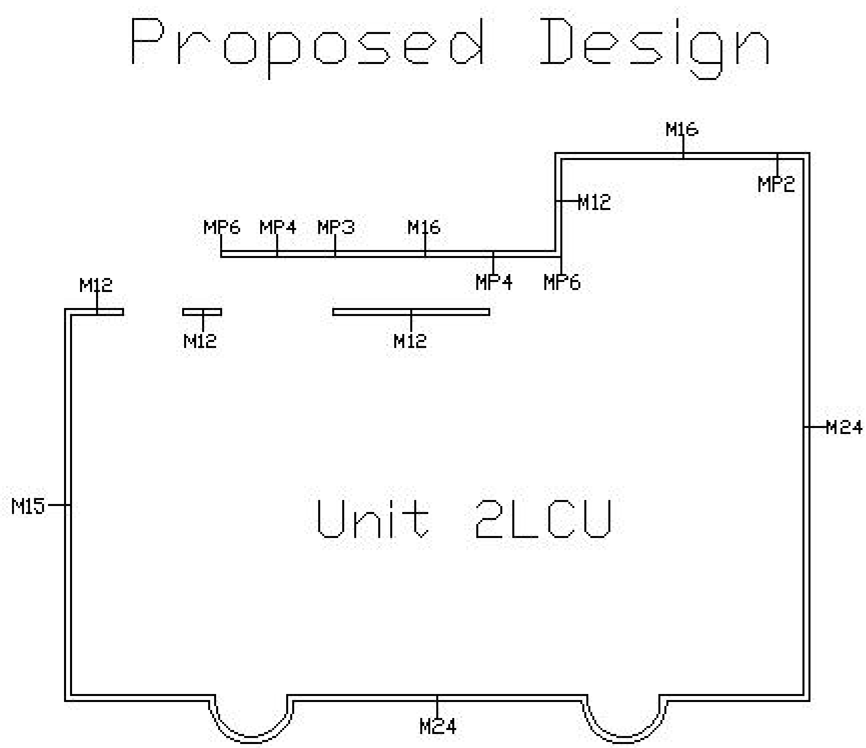


P17
P16
P15
P13
W13
Unit 2LDU
W13
P15
P13
W24
W24
MP6
MP5
MP4
MP2
M13
Unit 2LDU
M13
MP4
MP2
M20
M20
Current Design
Proposed Design

Unit 2LCU

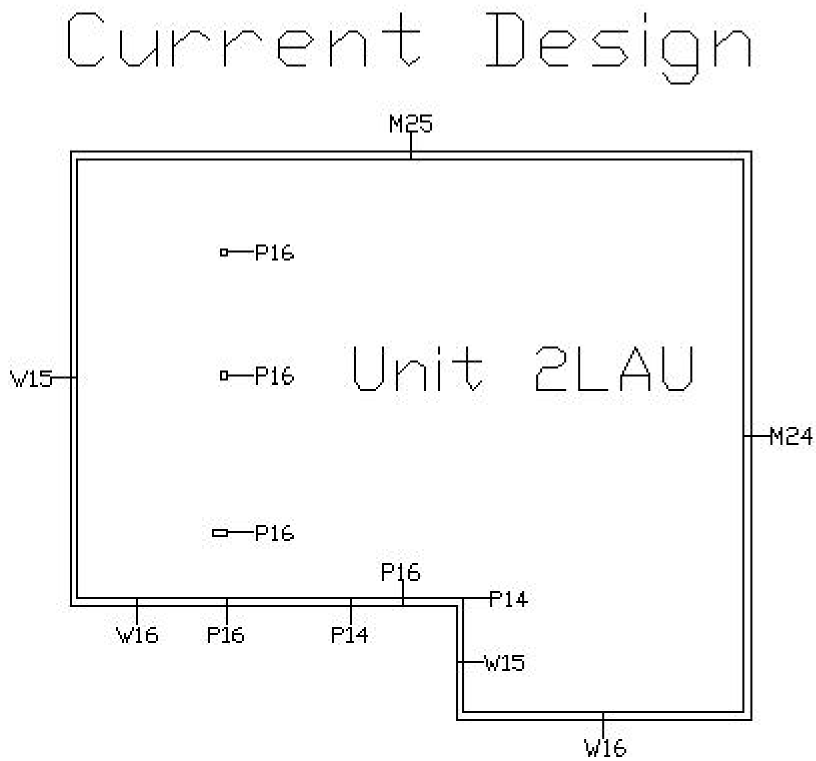


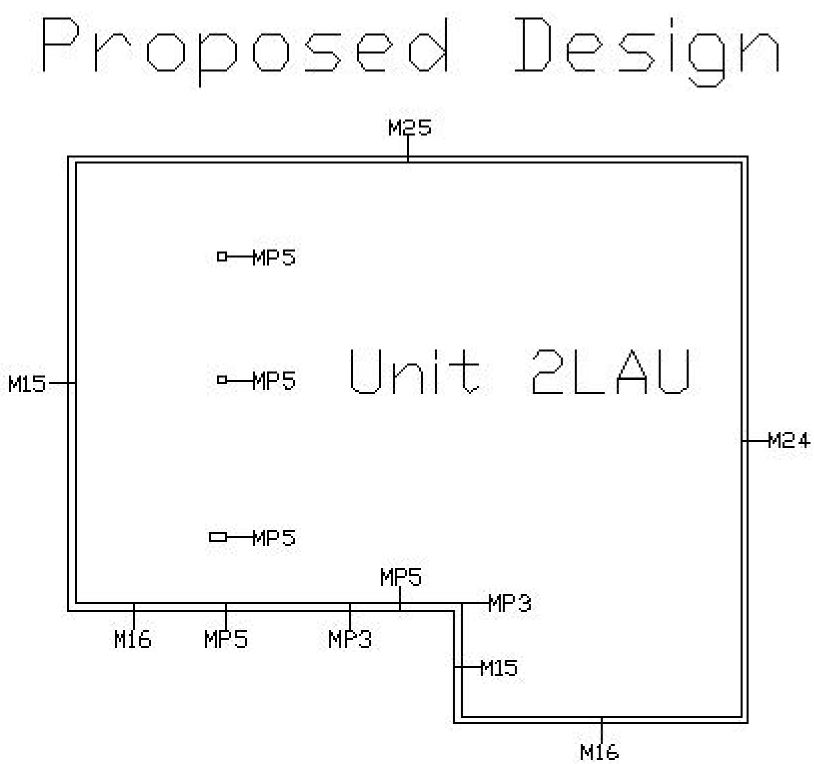
Current Design
W16
P13
W12
P17
P15
P14
W16
P15
P17
W12
W12
W12
M24
W15
Unit 2LCU
M24



Proposed Design
M16
MP2
M12
MP6
MP4
MP3
M16
MP4
MP6
M12
M12
M12
M24
M15
Unit 2LCU
M24

Unit 2LAU


Current Design
M25
P16
P16
Unit 2LAU
W15
M24
P16
P16
P14
W16
P16
P14
W15
W16


Proposed Design
M25
MP5
MP5
Unit 2LAU
M15
M24
MP5
MP5
MP3
M16
MP5
MP3
M15
M16

Cost of New proposed system

The cost analysis will focus on the same section as before, which was the 4th floor east wing. This way I can compare the cost of both systems.

Unit	# of Units	# of Metal studs	Total Studs	Cost per Stud	Total Cost
1F	2	51	102	$3.45	$351.9
2LCU	1	102	102	$3.45	$351.9
2LAU	1	105	105	$3.45	$362.25
2LDU	14	129	1806	$3.45	$6,230.7
1+DAMPDU	1	110	110	$3.45	$379.5
ILBU	3	110	330	$3.45	$1,138.5
				Total Cost	**$8,814.75**

Unit	# of Units	Metal joists weight	Total Weight	Cost per Ton	Total Cost
1F	2	.433	.867	$1,500	$1,300
2LCU	1	.433	.433	$1,500	$650
2LAU	1	.433	.433	$1,500	$650
2LDU	14	.607	8.49	$1,500	$12,740
1+DAMPDU	1	.433	.433	$1,500	$650
ILBU	3	.607	1.82	$1,500	$2,730
				Total Cost	**$18,720**

Unit	# of Units	Metal joists weight	Total Weight	Cost per Ton	Total Cost
1F	2	.108	.216	$1,300	$280
2LCU	1	0	0	$1,300	$0.00
2LAU	1	0	0	$1,300	$0.00
2LDU	14	.308	4.31	$1,300	$5,600
1+DAMPDU	1	.231	.231	$1,300	$300
ILBU	3	.308	.923	$1,300	$1,200
				Total Cost	**$7,380**

($8,814.75 + $18,720.00 + $7,348.00) / 18,000 SF = 1.94 $/SF

211,856 SF x 1.94 $/SF = $411,000

Total Cost of new proposed structure is $411,000

Cost Comparison

Since metal is a better quality material than wood in so many aspects, the cost was expected to be greater. The new proposed system costs 24% more than the previous structural system. 24% increase may sound a lot but compared to the entire cost of the building is not much. The new proposed system increases the overall cost of the building by 0.2%. Maintenance cost of wood is much greater that maintenance cost of metal, so even thought the initial cost of metal is greater, the initial cost savings of wood is lost due to a higher maintenance cost. Considering the advantages that metal brings to the projects, a 0.2% cost increase is not much.

Schedule Comparison

Before doing this analysis, I had the impression that wood construction took longer. However, after talking to industry professionals, I realize that the duration of the installation of metal and wood studs is the same. However, due to the fact that metal studs have already pre-punched holes, they do save some time. Wood studs need to be punched before installation in order to be able to install all the conduits that go through the wall. However, even though metal studs save time due to the pre-punched holes, the schedule does not really change much. The truth is that the schedule is really not impacted much by the new proposed system.

Conclusion

As we can see from the analysis above, the new system increases the cost and it really does not change the schedule much. However, even thought the cost of the building increases, the value of the building also increases. The main reason why I think that the new system should replace the current system is because metal will add so much value to the building that it will overcome the additional cost in the long run. Metal has many advantages over wood. Some of those advantages are shown below:

- Steel is stronger, lighter and more dimensionally stable than wood.
- Steel stud interior walls provide an uncommonly straight and stable wall. This reduces call backs for sheet rock separation, nail pop-outs, molding separation and warping.
- Pre-punched service holes in studs for electrical wiring, plumbing or other utility lines save time and money.
- Steel framed homes are safer in fires – they will not add fuel to a fire nor collapse as easily as wood.
- Stronger: steel framed homes greatly exceed all wind and seismic codes without adding any additional cost.
- Lightning protection: steel gives electricity a pathway to ground resulting in less secondary fires and explosions.
- No mold, mildew or rotting
- Super Insulated – no air infiltration if insulated with foam.
- Avoid termite problems
- Less repairs and maintenance
- No wasted scrap – all extra material can be recycled.

Analysis 4: Workforce Development (Depth Study)

The construction workforce's image has been deteriorating throughout the years. Today, a predominant percentage of construction workers are immigrants. The problem with illegal immigrants has been an issue that has affected the construction industry. There is a reason why children always want to be football players, astronauts, etc. There is a reason why young college students want to be engineers, businessman, etc. There is a reason why very few people want to be construction workers these days. That reason is image. Children as well as college students want to be successful, wealthy, and happy. It seems to me that the image of a construction worker does not portrait success, or wealth.

Owners do not care about the workforce image; they just want to build buildings. Owners just care about budget. That is the reason why there are so many construction workers that are immigrants. The fact is that immigrants are seen by the industry as cheap labor. Money is the main factor driving the construction industry. It seems to me that, for the industry, it is more important to have cheap labor rather than improve the industry's image.

It is hard to say exactly why the construction manpower is predominantly Latin-American people. Some people say that the construction industry's image has been deteriorating throughout the years making the construction worker job to be an undesirable job. Some people say that immigrants can be cheap labor and having foreigner manpower can lower the budget of a project. My personal belief is that there is a large percentage of Latin-American workers due to the combination of many factors that will be analyzed later in this section. However, the real problem is that those Latin-American workers are Spanish speakers who do not know how to speak English. The other side of the problem is that most of the project engineers, construction managers, and superintendents do not know how to speak Spanish. This creates a big problem to the industry since there is a problem with communication. One thing that I have learned through my short experience in construction is that without good communication things cannot be properly done. Without good communication, it is impossible for a project to be completed without conflicts. On my previous two internships, which were in Washington DC, I realized that having workers that do not speak English was a problem. Even a simple task, such as telling a worker to do something, was hard. Communication between the engineering staff and the workers is essential. The language barrier between these parties is creating a problem for the entire construction industry.

I am from Venezuela, and therefore I know Spanish. During my two internships in Washington DC I realized the advantage that I had over my coworkers just because I knew Spanish. I am sure that if we could eliminate the language barrier, projects would run smoother. I plan to study in more depth the effect of the language barrier on the construction process. My goal is to determine how much this language barrier is hurting the industry. I think that if we give this problem the attention it needs, we can find a solution. Giving Spanish classes to the management staff, or giving English classes to construction workers could be an easy solution to the problem. This is a problem that concerns the entire construction industry. If we could eliminate the language barrier, the entire industry would be beneficed.

Problem statement – The language barriers that the industry is facing has become a problem. However, there is little information about how is this problem affecting the industry in terms of costs and productivity.

Goal - This analysis will explore the consequences in terms of; costs, safety, and production, associated with the language barrier on construction projects in Washington DC. This analysis will also explore possible solutions to this problem.

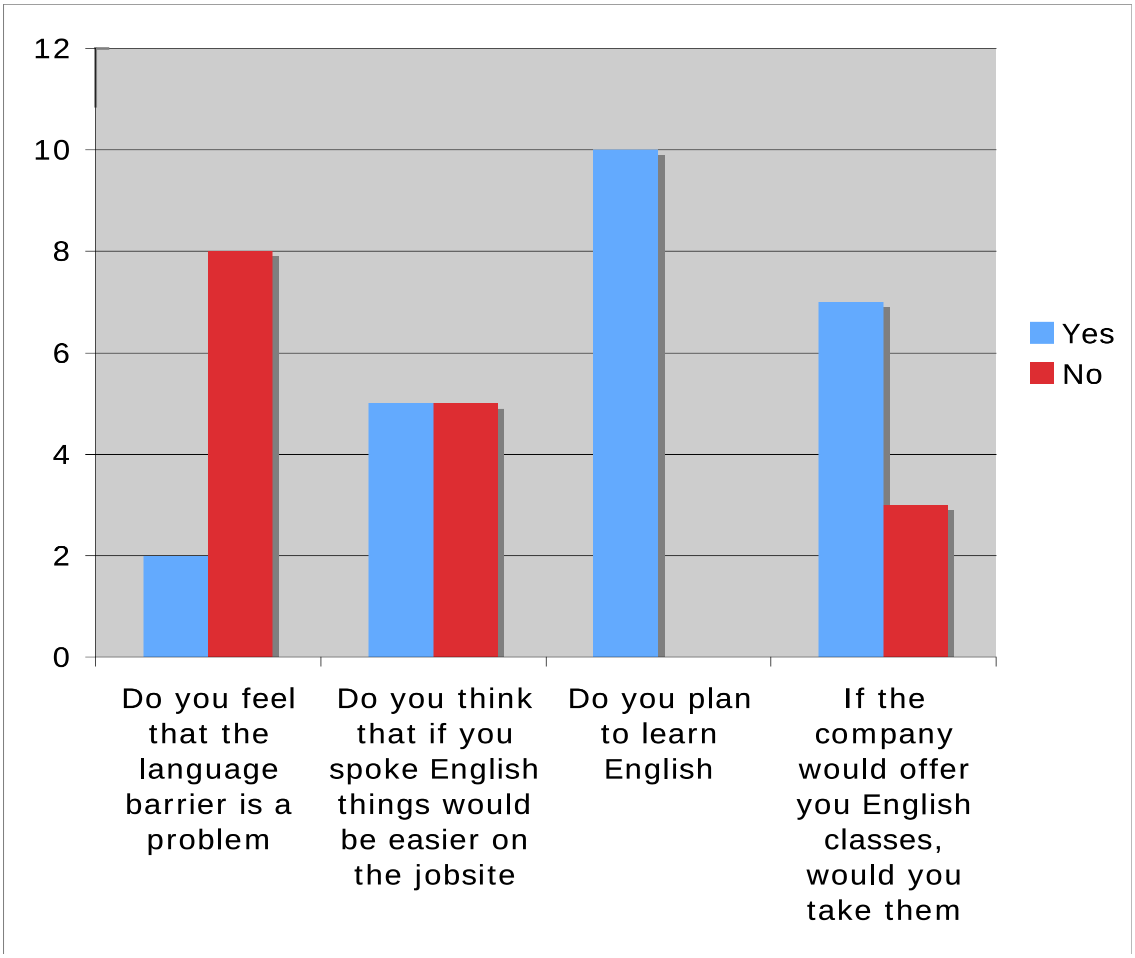
Expected Outcome - This research should identify if the is a pattern, regarding costs, safety, or production, that can be seen in projects where the language barrier is present. If a pattern is found, then solutions or strategies can be proposed. One solution, that I already thought, could be to implement intensive Spanish classes to the management staff on site. Hopefully, other solutions will emerge as I do my research.

The Best way to find out how is this problem affecting the industry is to ask the people in the business. Below there are two different surveys; One is for the management people that only speak English, and the other one is for those construction workers that only speak Spanish. These surveys are intended to find out and understand the issues that the language barrier has brought to the industry on each side.

Spanish Speakers Survey	
Position	
Do you feel that the language barrier is a problem	
How does the language barrier affects you	
Do you think that if you spoke English things would be easier on the jobsite	
Have you worked in construction before	
Do you plan to learn English	
If the company would offer you English classes would you take them	

English Speakers Survey	
Position	
Do you feel that the language barrier is a problem	
How does the language barrier affects you	
Do you think that if you spoke Spanish things would be easier on the jobsite	
Have you had any problems with workers not understanding you	
Do you plan to learn Spanish	
If the company would offer Spanish classes would you take them	
Do you think the language barrier could affect the safety on the project	
Do you think the language barrier affects the efficiency and productivity on the jobsite	
Do you think the industry should pay more attention to this issue	
Do you think it should be mandatory for construction workers to speak English	
Do you think is worth investing money on this issue	
What do you think could be a solution to this problem	

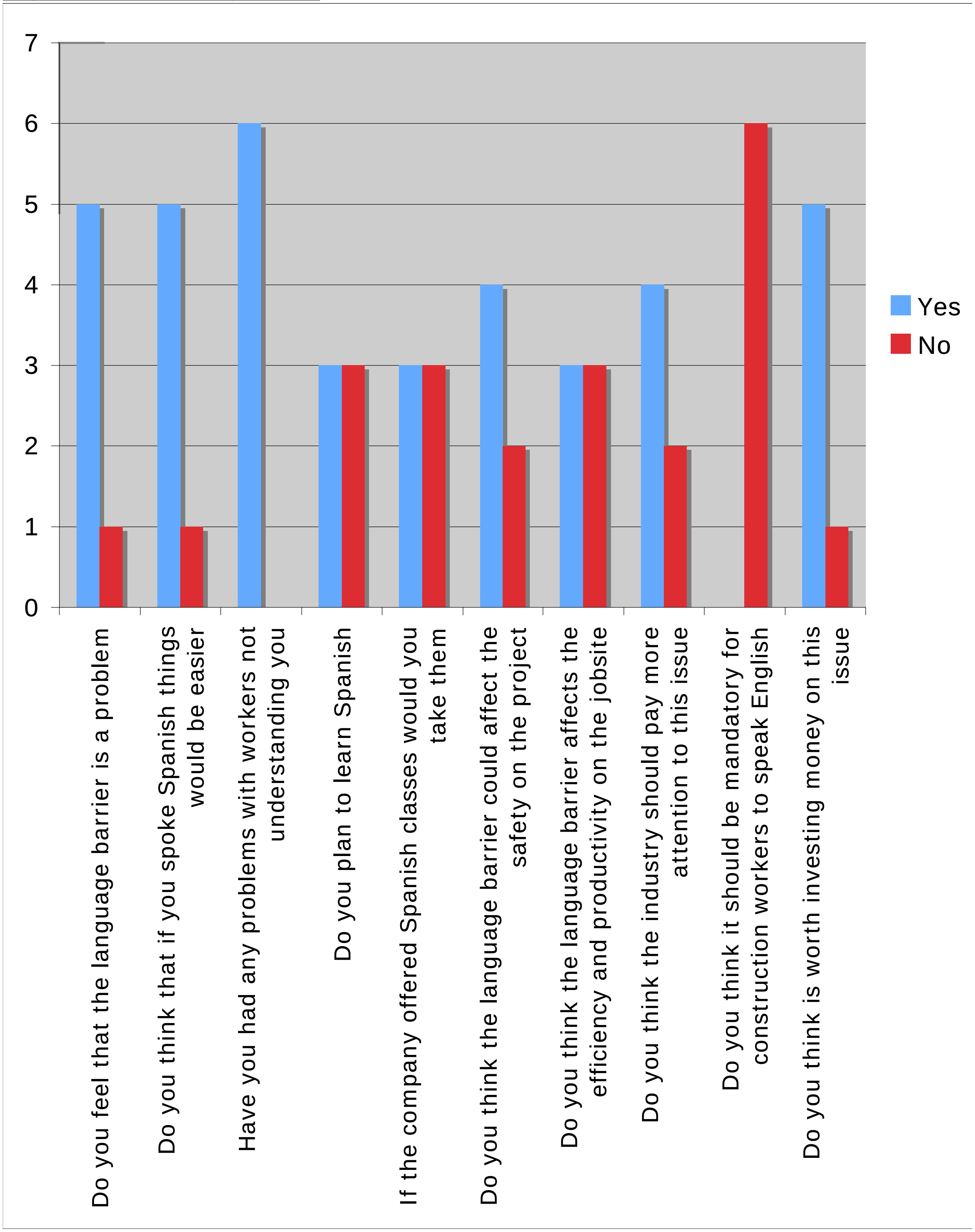
Spanish Speaker Survey Results



The graph above summarizes the results of the survey done to ten Spanish speakers workers in the Washington DC area. The information that I got from their answers helped me understanding what Spanish speakers construction workers think about the language barrier problem. To be honest, I was surprised with the answers that I got. First of all, most of them, to be exact eighty percent, thought that the language barrier is not a problem. Most of them think that not knowing English is not affecting their job and they think that they can perform their job even without knowing any English. However half of them did think that things would be easier if they knew English.

On the other hand, when I asked them if they were planning to learn English at some point, they all said yes. Furthermore, when I asked them if they would take English classes if the company offered them, seven of them told me that they would take the classes. From the answers that I got, my impression is that the language barrier is not really affecting the workforce performance.

English Speaker Survey Results



The graph above summarizes the results of the survey done to six project Managers and Superintendents in the Washington DC area. From the answers that I got, I realized that the language barrier problem is affecting more the management area. Five of the six people thought that the language barrier is a problem to the industry. Moreover, five of them told me that they thought that if they knew Spanish, things would be much easier on the workplace. All of them admitted to have had an experience where a construction worker did not understand what they were told due to the fact that they did not understand English. After that, I asked them if they were planning to learn Spanish and just half of them said yes. Furthermore, when I asked them that if they would take Spanish classes if the company offered them, only the same three answered yes.

I also asked them if they though that the language barrier could affect the safety on a project, and four of them answered that the language barrier could definitely affect the safety on a project. Moreover, I asked them if they thought that the language barrier could affect the efficiency and productivity on a jobsite, and half of them said yes. I also asked them if they thought that the industry should pay more attention to this problem, and four of them said yes. The next question that I asked them was if they thought that speaking English should be mandatory for construction workers, and surprisingly all of them answered no. That made me realize that they know that it is their responsibility to fix the problem. By answering no, they basically admitted that solving this problem is up to them. Lastly, I asked them if they thought that it is necessary to invest money in this problem, and five out of six said yes.

After summarizing and analyzing the results form the surveys, I got to the conclusion that the construction workers are not being affected much by the language barrier problem, but the management part is. Therefore, out of all the possible solutions, the most appropriate solution is to give Spanish classes to the management employees. Companies rather invest their money on their employees rather that in construction workers who may work for many other companies afterwards. After talking with some companies, I realize that there are in fact some companies that are already offering Spanish classes to their employees.

From my experience I have come to realize that it is impossible to learn a new language in a classroom. In a classroom you tend to learn the basics, but to really learn a language you need to practice, study, and dedicate a lot of time to it. That is why I felt the necessity to do another survey to project managers/superintendents that were interested on learning Spanish asking them if they were willing to spend time studying Spanish after work. The results of the survey are shown below.

	Yes	No
Would you take Spanish classes if the company offered it?	5	0
Would you spend time studying Spanish at home after work?	1	4

The construction business is very difficult as it is. People get to their homes exhausted from work. The people that I interviewed told me that they rather spend their free time with their friends and family rather than study Spanish after work. I did tell them that through my experience I have come to realize that you need to spend time studying outside class in order to learn a new language. They told me that in that case they rather not learn Spanish since they value more the time spend with their family and friends.

The only way to learn a new language is to be motivated, willing to make some effort, and willing to make some sacrifices. Maybe Spanish classes will not eliminate the problem completely, but at least it will help a lot. I think that offering Spanish classes to the management staff is the first step that we need to take in order to eliminate the language barrier problem.

Credits / Acknowledgements

I would like to thank those who took their time to guide and help me throughout my thesis

- **The Pennsylvania State University**
  - Dr. John Messner – AE Faculty
  - Dr. David Riley – AE Faculty
  - Professor Kevin Parfitt – AE Faculty
  - Professor Robert Holland – AE Faculty
  - Professor Michael Horman – AE Faculty

- **Clark Construction**
  - Justin Hollier
  - Jeanna Wallace

- **Owner of the building for letting me use his project for my thesis.**
- **Industry Mentors for helping us throughout the entire process.**
- **Pace Roundtable Members.**
- **All the participants that helped me with my survey.**
- **All my friends and family for their support.**