New York Police Academy

ARCHITECTURAL ENGINEERING SENIOR THESIS 2010-2011

Thesis Proposal
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Structural Option
Faculty Consultant – Dr. Boothby
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AE 481W

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The New York Police Academy is a building that is meant to consolidate the entire New York Police recruit training into one facility. This building is located in College Point, New York and is 536 feet long, 95 feet wide and 150 feet high. The building has a gravity system consisting of lightweight concrete on metal deck. In the East/West direction the building has moment connections and one double bay of HSS cross bracing to resist lateral loads. In the North/South direction the lateral resisting system consists of HSS cross bracing in two of the three bays.

The focus of this thesis is to alter the lateral resisting systems of the New York Police Academy. The proposed lateral systems will utilize eccentrically braced frames and will be compared to the existing moment and concentrically braced frames. The most efficient combination of lateral resisting systems will be chosen based on the following criteria: frame stiffness, lateral movement, and both the direct and torsional shear.

After the most efficient combination of lateral resisting systems is chosen, the connections will be re-designed to suit the new systems. The connections of the existing systems are very complex and will be altered in order to increase efficiency in regards to construction. The change in lateral system yields simpler and less labor intensive connections. This is meant to increase the rate of construction and decrease costs, while maintaining structural adequacy. The change in lateral systems will also alter the glass façade of the New York Police Academy calling for a complete re-design of the North- and South- faces.

To complete the above tasks a strict schedule was created in order to present the thesis to a faculty jury on April 29, 2011. The schedule is broken up into four milestones. The first milestone will be complete after the approval of this proposal. The second milestone will be complete after the lateral system has been re-designed, while the third milestone will be complete after the construction and architectural aspects of this report are finished. The fourth milestone ensures that the written report is finished in time to edit and add any necessary final touches.

INTRODUCTION

The New York Police Academy is located in College Point, a neighborhood in Queens, New York. This building is an 8-story structure with a west and east campus. It is the first and largest phase of a multiphase project. The west campus houses a physical training facility and a central utility plant while the east campus houses an academic building. The east campus was analyzed in earlier technical reports. The physical training facility includes a 1/8 mile running track and special tactical gymnasiums. The academic building has a wide variety of classrooms ranging from a capacity of 30 to 300 cadets. Some classrooms create a mock environment for the cadets to experience immersion learning. This phase is expected to cost $656 million. Construction began in October 2010 and will culminate in December 2013.

FIGURE 1: THIS IMAGE SHOWS THE LOCATION OF THE NEW YORK POLICE ACADEMY IN ITS SURROUNDINGS.

The purpose of the Thesis Proposal is to change facets of the existing building to improve it. A different lateral resisting system will be proposed in this report. This will increase the rate of construction while limiting the cost. This alteration also will change the façade of the New York Police Academy. These topics will be discussed in more detail throughout this proposal.

ARCHITECTURAL OVERVIEW

This 8-story 1,000,000 SF structure is used as an academy to train New York Police Department recruits. The building was designed for LEED Silver Certification as designated by the United States Green Building Council (USGBC). This is accomplished by using numerous tactics to minimize its carbon footprint. Certain features encourage environmentally friendly means of commuting. This building also utilizes green roofs among various other strategies to create a healthier environment.

FIGURE 2: THIS IMAGE SHOWS THE GLAZED ALUMINUM CURTAINWALLS WITH ALUMINUM PANELING. THIS RENDERING IS COURTESY OF TURNER CONSTRUCTION.

The façade of this building is embellished with glazed curtain walls and shimmering aluminum paneling. The aluminum panels act as louvers above the windows both to shade and channel natural light into the building (See Figure 2).

EXISTING STRUCTURAL SYSTEM OVERVIEW

The New York Police Academy's East Campus is 536 feet long and 95 feet wide. The floor to floor height ranges from 14 feet to 16 feet. A green roof system is present on the top of the building. The structure of the New York Police Academy consists predominantly of steel framing with a 14" concrete slab on grade on the first floor. All other floors have a lightweight concrete on metal deck floor system. All concrete is cast-in-place.

FOUNDATION SYSTEM

The geotechnical engineering study was conducted by the URS Corporation. The study showed a variety of soil composition, with bedrock reasonably close to the surface. The building foundations for the New York Police Academy bear on piles with a minimum bearing capacity of 100 tons as specified by the URS Corporation. All piles are driven to bedrock. All exterior pile caps are placed a minimum of 4'-0" below final grade. Please see Figure 3 for example pile cap. Concrete piers, walls, structural slabs on grade, pile caps and grade beams are placed monolithically. Piles are 16" in diameter.

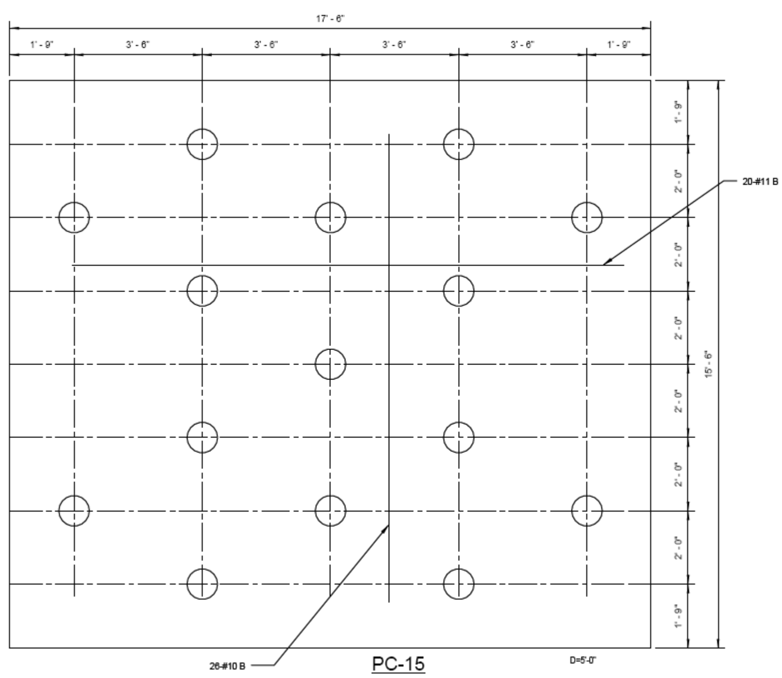


FIGURE 3: THIS IS PLAN OF A SAMPLE PILE CAP. DETAIL COURTESY OF TURNER CONSTRUCTION.

FLOOR SYSTEM

The floor system is made up of 3.25" lightweight concrete slab on 3" - 18 gage metal decking. This will form a one-way composite floor slab system. Units are continuous over three or more spans except where framing does not permit. Shear stud connectors are welded to steel beams or girders in accordance to required specifications. See Figure 4 for details.

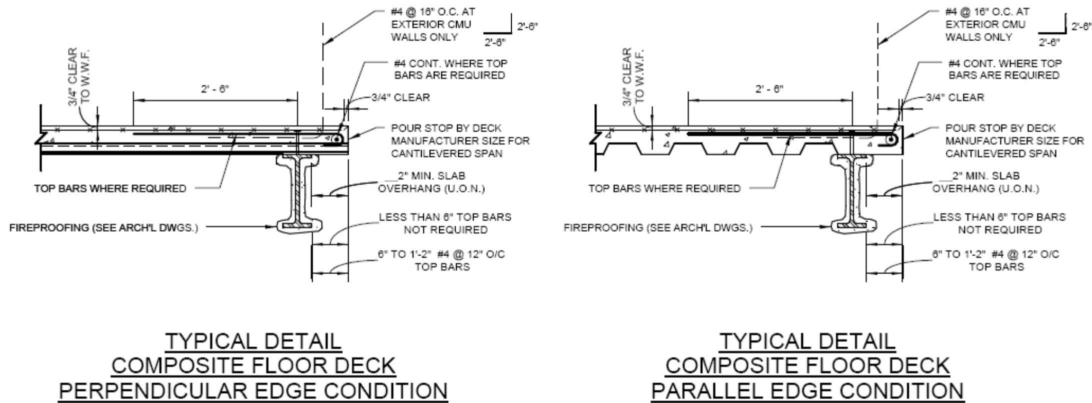
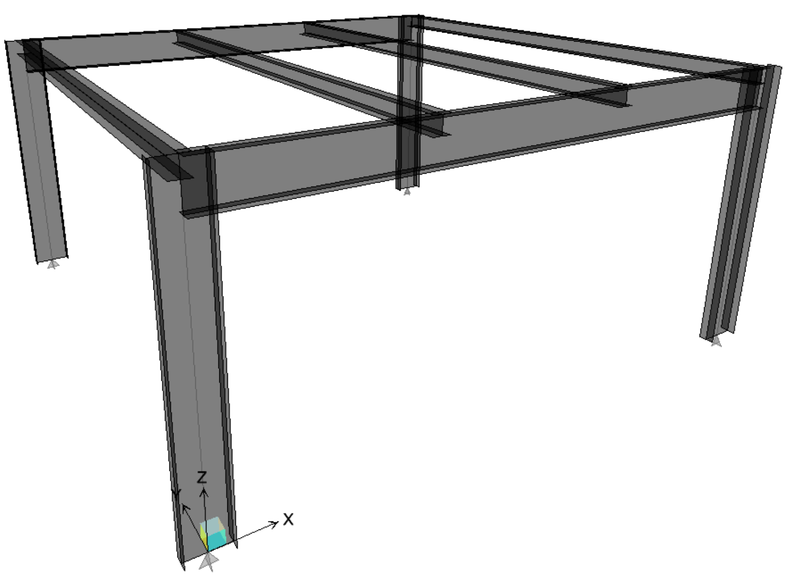


FIGURE 4: TYPICAL SLAB ON DECK FLOOR SECTIONS. DRAWINGS NOT TO SCALE. DETAIL COURTESY OF TURNER CONSTRUCTION.

FRAMING SYSTEM



The superstructure is primarily composed to W18 beams, W24 girders and W24 columns. Beams are spaced at 10' increments while girders are spaced at 30' increments. Columns are on a 30'x30' grid. The columns are spliced at 4' above every other floor level and typically span from 30' to 34'. A typical bay is shown in Figure 5.

FIGURE 5: THIS IS AN ETABS MODEL OF THE TYPICAL BAY FRAMING.

LATERAL SYSTEM

The lateral resisting system in the New York Police Academy consists of steel moment connections in the East/West direction with concentrically braced HSS members and wide flanges in the North/South direction. The lateral resisting connections can be seen in Figure 6 below. The HSS bracing ranges from HSS10x10x½ to HSS16x16x½. The two lateral resisting systems can be seen on the next page.

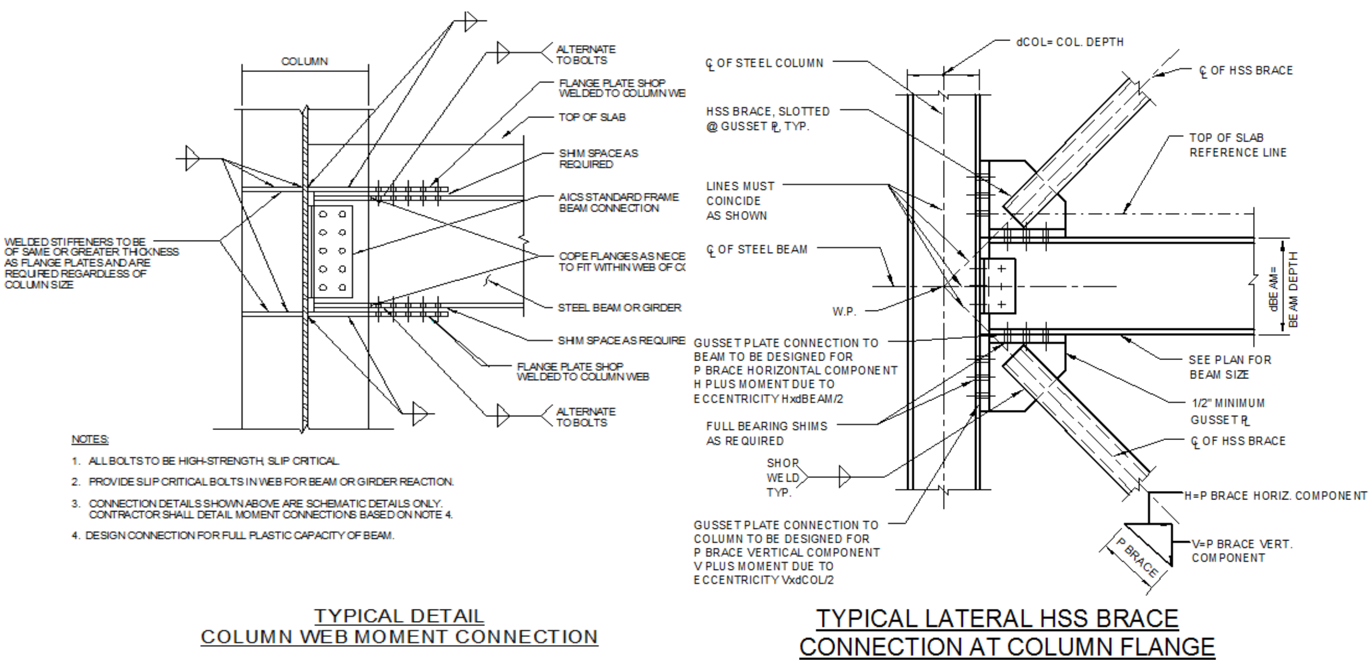


FIGURE 6: TYPICAL COLUMN WEB MOMENT CONNECTION (LEFT). TYPICAL LATERAL HSS BRACE CONNECTION (RIGHT). DRAWINGS ARE NOT TO SCALE. DETAILS COURTESY OF TURNER CONSTRUCTION.

X-FRAME

The East/West bracing system is demonstrated by the X-Frame in Figure 7 below and consists of moment connections throughout the building except where the HSS cross bracing can be seen. The HSS cross bracing is where the bridge from one part of the building connects to another section of the building.

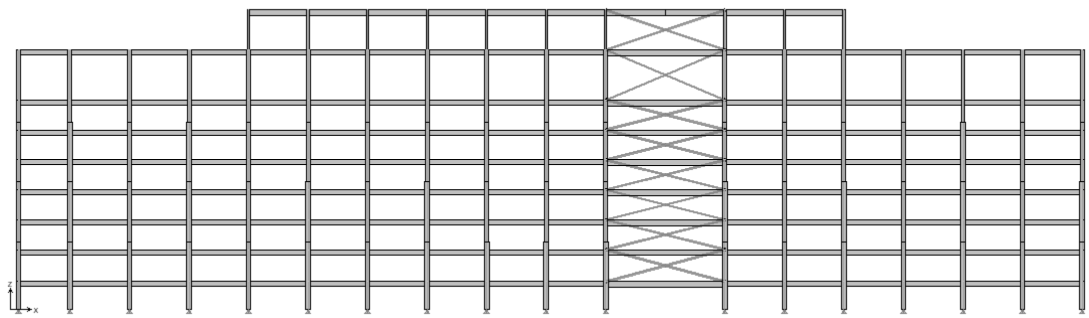


FIGURE 7: THIS IS AN IMAGE OF THE X-FRAME LATERAL RESISTING SYSTEM IN THE NEW YORK POLICE ACADEMY.

Y-FRAME

The lateral force resisting system in the North/South direction is referred to as the Y-frame. This frame has HSS cross bracing to resist lateral loads and all connections are pinned. This can be seen in Figure 8 to the right.

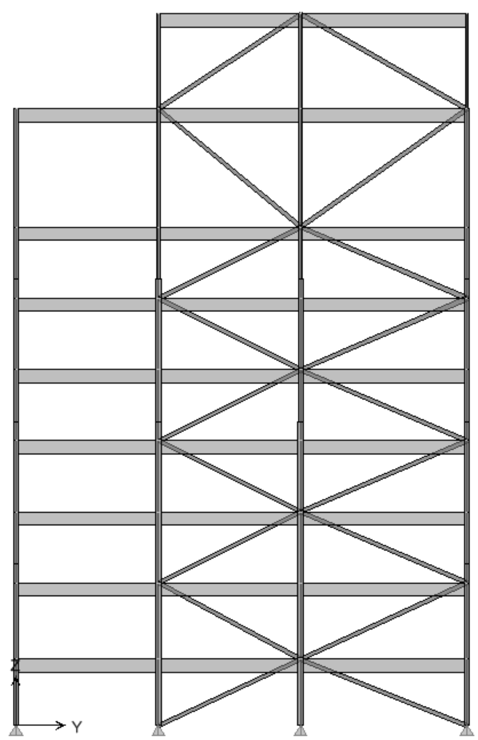


FIGURE 8: THIS IS AN IMAGE OF THE Y-FRAME LATERAL RESISTING SYSTEM IN THE NEW YORK POLICE ACADEMY.

PROBLEM STATEMENT

There are different types of steel connections in the lateral resisting systems of the New York Police Academy, most of which are rather complex. As seen in Figure 9 to the right, to construct the concentrically braced lateral resisting systems in both the X- and Y- Frames, HSS braces must be welded to plates, which are welded to double angles. The double angles are then bolted to both the supporting columns and beams. Please note that weld arrows were erased from this detail for viewing purposes.

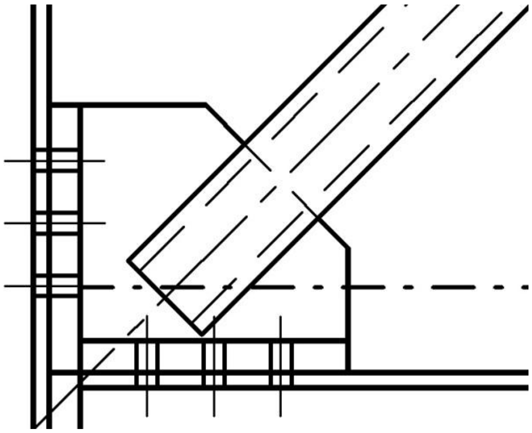


FIGURE 9: THIS FIGURE SHOWS A CLOSE UP VIEW OF THE LATERAL HSS BRACED CONNECTIONS.

The steel connections in the X-Frame are moment connections, which incorporate both welds and bolts in various locations. This connection also includes column stiffeners as seen in Figure 10 to the left. Please note that weld arrows were erased from this detail for viewing purposes. Both of these connections are very complicated and labor intensive. It is time consuming to construct these connections and skilled workers must be used.

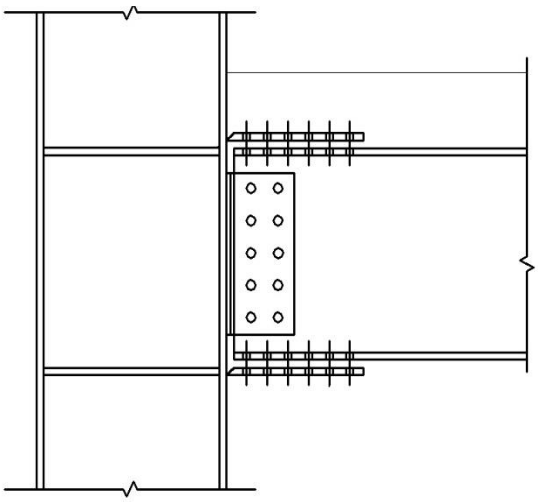


FIGURE 10: THIS FIGURE SHOWS A CLOSE UP VIEW OF THE MOMENT CONNECTIONS.

PROPOSED SOLUTIONS

If the lateral resisting system in the X-Frame was adjusted from moment connections to an eccentrically braced system and the Y-Frame was adjusted from a concentrically braced system to this same eccentrically braced system, then these substantial connections would no longer be needed. The connections would be simpler and easier to construct, so less-skilled professionals (less expensive laborers) could construct these connections. Because this system would be used in both X- and Y- Frames the laborers would be able to construct these connections faster because of repetition.

To determine if eccentrically braced frames are more efficient, a comparison will be done relating the following lateral frames in both North/South and East/West directions in Table 1 below.

LATERAL SYSTEM POSSIBILITIES		
COMBINTION #	X-FRAME	Y-FRAME
1	MOMENT FRAMES	CONCENTRICALLY BRACED FRAMES
2	MOMENT FRAMES	ECCENTRICALLY BRACED FRAMES
3	MOMENT FRAMES	MOMENT FRAMES
4	CONCENTRICALLY BRACED FRAMES	CONCENTRICALLY BRACED FRAMES
5	CONCENTRICALLY BRACED FRAMES	ECCENTRICALLY BRACED FRAMES
6	CONCENTRICALLY BRACED FRAMES	MOMENT FRAMES
7	ECCENTRICALLY BRACED FRAMES	CONCENTRICALLY BRACED FRAMES
8	ECCENTRICALLY BRACED FRAMES	ECCENTRICALLY BRACED FRAMES
9	ECCENTRICALLY BRACED FRAMES	MOMENT FRAMES

TABLE 1: THIS TABLE SHOWS THE DIFFERENT TYPES OF LATERAL SYSTEMS WILL BE ANALYZED.

This assessment will be done in ETABS and compare frame stiffnesses, lateral movement, and both direct and torsional shear as calculated in the Lateral System Analysis and Confirmation Design Technical Report. The system with the most efficient behavior will be selected and then the breadth topics will be completed.

BREADTH TOPICS

EFFECTS ON CONSTRUCTION

The change in connections for the structural aspect of this project directly correlates to the construction facet of building design. The following construction topics will be analyzed in the spring semester:

- Effects on prefabrication
- Amount of labor hours reduced
- Type of laborers needed for construction
- Amount of money saved by
  - Reduced time of construction
  - Reduced time/skill of laborers
- The construction sequence
  - The effects the reduced construction time has on the installation of other systems

Most of the information that will be needed to complete this portion of the senior thesis project was taught in AE 372. Expert professionals will be contacted and research will be done in order to obtain any information that was not included in this class.

EFFECTS ON ARCHITECTURE

Moment connections are used to resist lateral loads in the X-Frame so that the entire façade in the North and South facing directions can be glazed. If concentrically or eccentrically braced frames are used then the façade would need to be changed in order to accommodate the new lateral resisting system. To complete this task information from the four architectural studios that were taken throughout the Architectural Engineering curriculum will be used.

GRADUATE COURSE INTEGRATION

The thesis topic chosen directly correlates to two graduate level courses. This building will be modeled and analyzed in ETABS, which reflects the information that was taught in AE 597A, Computer Modeling. This model will be used to evaluate the building under wind and seismic loads. The alteration to steel connections will also include material that was taught in AE 534, Steel Connections.

SOLUTION METHODS

The redesign of The New York Police Academy will be performed using the followings codes and resources; ACI 318-08, AISC Steel Manual 2005 and Design Guides, ASCE 7-10, IBC 2006, ETABS, RSMeans and Revit Architecture.

STRUCTURAL SOLUTION: ALTERNATE LATERAL SYSTEM

An ETABS model of the existing lateral resisting system was created in the Lateral System Analysis and Confirmation Design Technical Report. The existing lateral resisting systems will be altered and compared to one another. Changes in frame stiffnesses, lateral movement, and both the direct and torsional shear will be analyzed as well as lateral member spot checks.

CONSTRUCTION SOLUTION: EFFECTS OF ALTERNATE LATERAL SYSTEM

To determine the effects that the new connections have on prefabrication is a three-part process. First the connection will have to be designed. After the connection is designed, experienced professionals will be contacted to inspect the changes in prefabrication that would need to be made. This would then be compared and contrasted to the original connections.

To obtain information regarding the amount of man hours needed for construction, the type of laborers needed and the sequence of construction, the Turner Construction professional advisor will be contacted. The resulting cost savings from all of the changes will then be obtained using RSMeans 2010

Building Construction Cost Data Book. This information will be compiled in an easy-to-read format using tables and written text.

ARCHITECTURAL SOLUTION: EFFECTS OF ALTERNATE LATERAL SYSTEM

If braced frames are used in the X-Frame to replace moment frames then the New York Police Academy façades must be altered. If the existing glass façade remained then diagonal bracing would be seen through the existing windows. This would not be aesthetically pleasing because either the structural system should be hidden or if it is desired that the structure is shown then it should be emphasized rather than included in the design in an unintentional fashion. Window shapes and sizes will be altered to maintain aesthetics and emphasize the change in structure that is occurring beyond the facade. In the original design there are aluminum louvers used to channel light into and out of the New York Police Academy. This will remain because not only is it aesthetically pleasing, but it channels light and gains points toward LEED certification. The aluminum louvers will be included in the new design, but it will reveal the structure behind it while keeping its aesthetic integrity. Because the lateral bracing will be located throughout the entire X-Frame the whole façade must be redesigned to accommodate the new bracing. A basic example of what the new façade may look like can be previewed in Figure 11 below. Please note that the design will depend on which lateral resisting system is chosen.

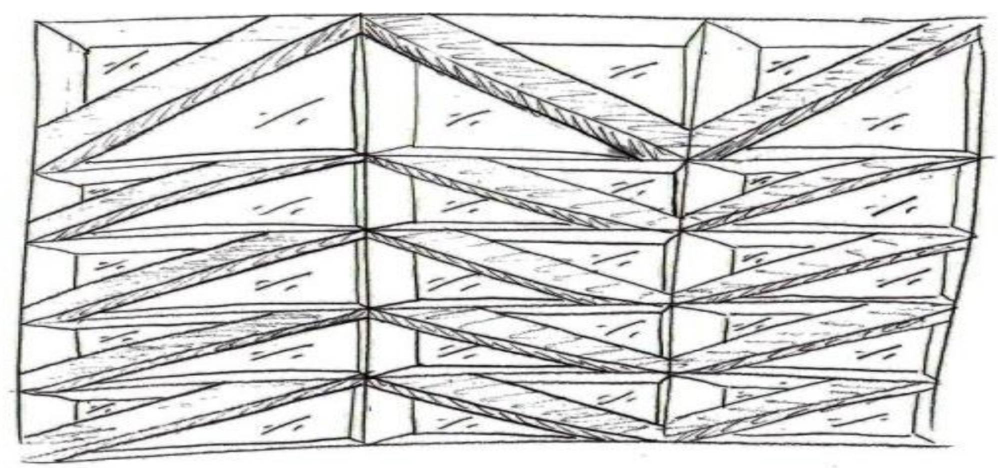


FIGURE 11: THIS IS AN IDEA THAT MAY BE IMPLORED FOR THE UPDATED ARCHITECTURAL FACADE DESIGN. THIS SKETCH SHOWS THREE BAYS OF THE UPPER FIVE STORIES OF THE NEW YORK POLICE ACADEMY.

TASKS AND TOOLS

I. Redesign X- and Y-Frames from moment and concentrically braced frames to eccentrically braced frames
    a. Decide the best location for eccentrically braced frames in both X- and Y-Frames.
    b. Model in ETABS
    c. Compare the following combinations of frames
        i. X: Moment, Y: CBF
        ii. X: Moment, Y: EBF
        iii. X: Moment, Y: Moment
        iv. X: CBF, Y: CBF
        v. X: CBF, Y: EBF
        vi. X: CBF, Y: Moment
        vii. X: EBF, Y: CBF
        viii. X: EBF, Y: EBF
        ix. X: CBF, Y: CBF
        x. Choose the most efficient combination
    d. Detail connection
II. Construction impact and cost analysis
    a. Material Cost
    b. Labor Cost
    c. Scheduling Cost
    d. System Savings
III. Architectural façade alterations
    a. Alter glazing to better suit the optimum lateral systems
        i. Aesthetically
        ii. Structurally
    b. Report any load changes and alter ETABS model as necessary
IV. Compose Final Presentation and Report

SCHEDULE

<table>
<tr><td colspan="3">SENIOR THESIS FINAL PROPOSAL</td><td colspan="7">THE NEW YORK POLICE ACADEMY</td><td colspan="6">JAKE POLLACK</td></tr>
<tr><td colspan="3">12/10/2010</td><td colspan="7"></td><td colspan="6">STRUCTURAL OPTION</td></tr>
<tr><td colspan="16">Proposed Thesis Semester Schedule
January 2011-April 2011</td></tr>
<tr><td>10-Jan-10</td><td>17-Jan-10</td><td>24-Jan-10</td><td>31-Jan-10</td><td>7-Feb-10</td><td>14-Feb-10</td><td>21-Feb-10</td><td>28-Feb-10</td><td>7-Mar-10</td><td>14-Mar-10</td><td>21-Mar-10</td><td>28-Mar-10</td><td>4-Apr-10</td><td>11-Apr-10</td><td>18-Apr-10</td><td>25-Apr-10</td></tr>
<tr><td colspan="2">Revise Thesis Proposal</td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="9">Spring Break 2011</td><td></td><td></td><td></td><td rowspan="9">Final Reports Due Thursday, April 7th 9:00am</td><td rowspan="9">Faculty Jury Presenation</td><td></td><td rowspan="9">Senior Banquet Dinner Friday, April 29th</td></tr>
<tr><td></td><td colspan="2">Model EBF in ETABS</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Compare Systems</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Detail Connections</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Material/Labor/ Scheduling Cost</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Total Savings</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Modify ETABS Model</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Compose Final Presentation and Report</td><td>Editing And Final Details</td><td></td></tr>
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Milestone 1:	January 10th 2010: Fall Thesis Complete	(green)	Analysis 1: Lateral System Re-Design
Milestone 2:	February 14th 2010: All Lateral System Analysis Complete	(orange)	Analysis 2: Construction Alterations
Milestone 3:	March 7th 2010: Breadth Alterations Complete	(purple)	Analysis 3: Architectural Alterations
Milestone 4:	March 28th 2010: Content Complete and Ready for Formatting	(blue)	Organization and Finishing Touches

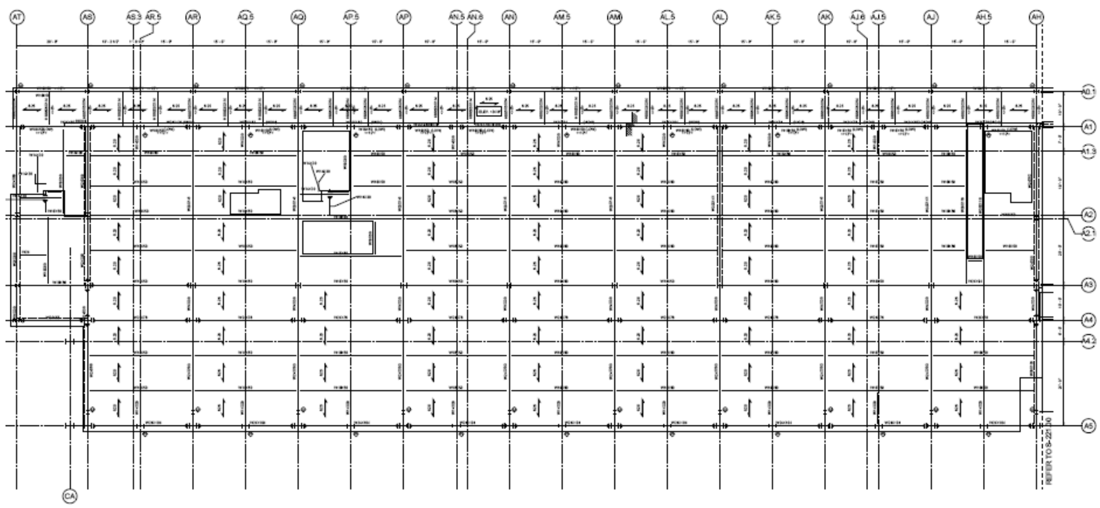
TABLE 2: THIS TABLE SHOWS THE PROPOSED SCHEDULE THAT WILL BE USED TO COMPLETE THE SENIOR THESIS PROJECT ON TIME.

CONCLUSION

By altering structural, construction and architectural aspects of the New York Police Academy, this project will demonstrate the well rounded building-engineers that are created by the Pennsylvania State University's renowned Architectural Engineering program. In addition, the alteration of connections and the use of computer modeling demonstrate the skills learned in courses at the graduate level. The combination of all these will require diligence, dedication and a profound interest to complete the above stated tasks. Hopefully this thesis project will be an example for those to come in the future.

APPENDIX: FRAMING PLANS AND ELEVATIONS

FRAMING PLAN PART 1 (WEST END)



FRAMING PLAN PART 2 (EAST END)

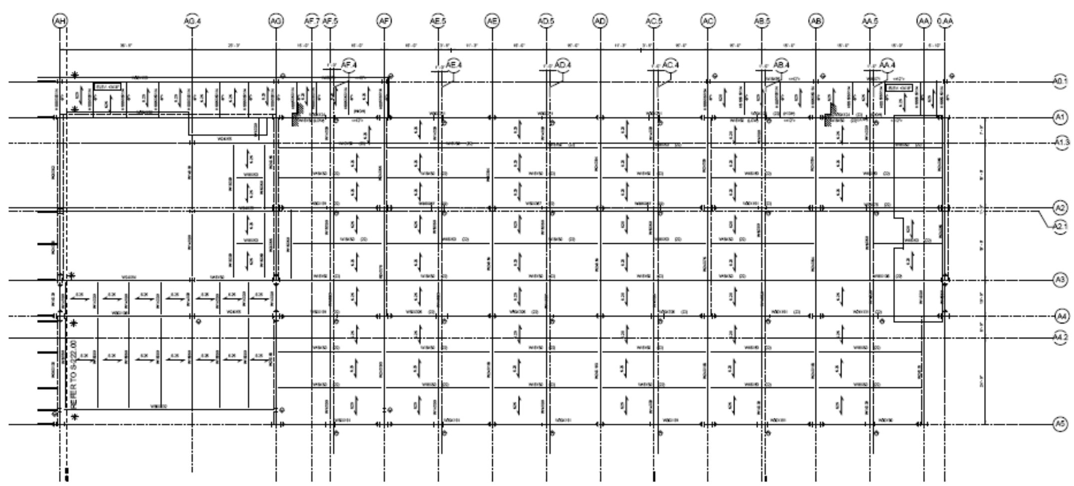


FIGURE 12: THIS IS THE TYPICAL FRAMING PLAN OF ONE FLOOR OF THE NEW YORK POLICE ACADEMY. PLEASE NOTE THAT THE BUILDING IS SO OBLONG THAT EACH FLOOR PLAN IS SPLIT INTO TWO SHEETS WITH PART 1 (THE WEST END) AND PART 2 (THE EAST END).

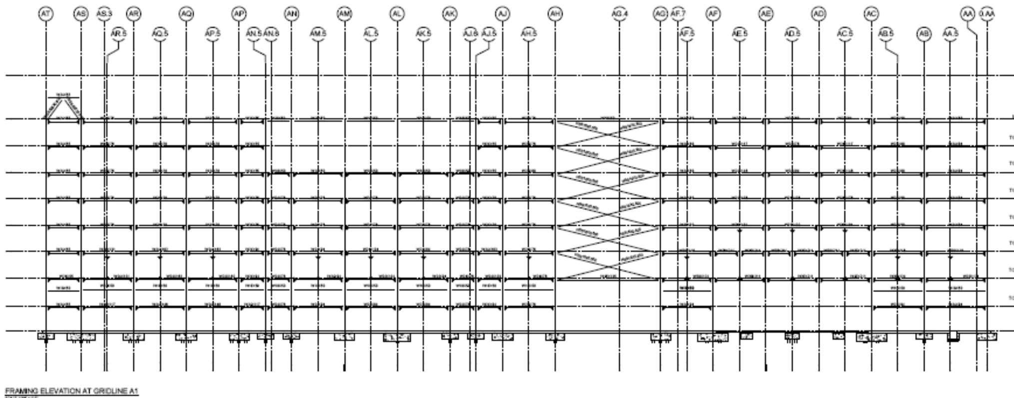


FIGURE 13: ABOVE IS AN ELEVATION OF THE FRAMING SYSTEM LOOKING IN THE NORTH/SOUTH DIRECTION. NOTICE ONLY MOMENT CONNECTIONS EXCEPT FOR THE CROSS BRACING ON THE BRIDGE. BELOW IS AN ELEVATION OF THE FRAMING SYSTEM LOOKING IN THE EAST/WEST DIRECTION. NOTICE THE MAJORITY OF THE CROSS BRACING IN THIS DIRECTION COMPARED TO FEW MOMENT CONNECTIONS.