HUNTER'S POINT SOUTH INTERMEDIATE & HIGH SCHOOL

THESIS PROPOSAL

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Structural Option
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EXECUTIVE SUMMARY

Hunter's Point South School is a 5 story combined intermediate and high school located in Long Island City, New York. At 154,000 square feet, this large school will hold over 1100 students from grades 6-12 and includes a gymnasium, auditorium, roof terrace, and many classrooms and laboratories. The structure includes a lightweight concrete composite floor supported by a steel framing system. Lateral loads are resisted by steel concentric braced frames and several moment frames along the gymnasium and auditorium spaces. The steel columns connect to a foundation of deep caissons, H-piles, and grade beams.

After completing an in-depth technical report on the lateral force resisting system of Hunter's Point, it was found that the braced frames were adequate in resisting the controlling seismic load, yet created a torsional irregularity in the structure. As an academic exercise, this building will be placed in a more severe seismic zone and be redesigned by two different seismic analysis procedures from ASCE7-10 Section 12 to determine the universal feasibility of the building design. Redding, California will be the new site location, due to its similarities to the current site in New York.

To comply with code standards for the higher seismic zone, the lateral system of Hunter's Point will need to be redesigned using a new type of system. A technical report on alternate floor systems showed that the current framing system was most economical, so the steel frame and lightweight slab will still be used. The structural depth study will focus on using the Equivalent Lateral Force Analysis (ELFA) and Modal Response Spectrum Analysis (MRSA) procedures from ASCE7-10 to develop a lateral system comprised only of eccentrically braced frames. Comparisons will be made between each redesign, and to the current design. Conclusions will be made as to whether one procedure is more efficient than the other, and if the current building design is economically practical in a higher seismic zone.

The thesis redesign will also include two breadth studies. The first breadth analysis focuses on the architectural impact of the new eccentrically braced frame lateral system. It will determine if the new layout will work with the current architectural layout, or if it will cause functional or visual hindrances. The second breadth study will be a detailed construction impact study focusing on a cost and schedule comparison. This analysis will look at the effect seismic zones have on building construction. Also, it will determine if a more detailed design phase (using MRSA) will significantly lower construction time and cost.

INTRODUCTION

Hunter's Point South School is a new 5 story educational building being constructed as part of the first phase of New York City's new mixed-use development plan on a 30 acre site of waterfront properties in Long Island City, NY. The new development focuses on creating an affordable middle-income area that includes several new mixed use housing towers, along with supporting retail spaces, a school, and new waterfront park. Hunter's Point South School is being developed by the NYC School Construction Authority (SCA) along with Skanska contracting and FXFowle Architects. The structural engineer on the project is Ysreale A. Seinuk, PC. Construction of the school will last from January 2011 to October 2013, and cost approximately $61Million to complete. Project delivery is lump sum bid. It will open its doors to students in the fall of 2013.

Figure 1: Building design rendering
Rendering by FXFowle Architects

The mixed use intermediate and high school will be nearly 154,500 square feet and house roughly 1100 students from grades 6-12 and District 75 (special needs) from the Queens School District. Being constructed on 51st Avenue, Hunter's Point will take up almost a full city block between 2nd Street and Center Boulevard with space in the corner of the lot reserved for the construction of a new 30 story housing tower to be built right next to the school. The site layout can be seen in Figure 2. It should also be noted that the site sits right across the street from the bay.

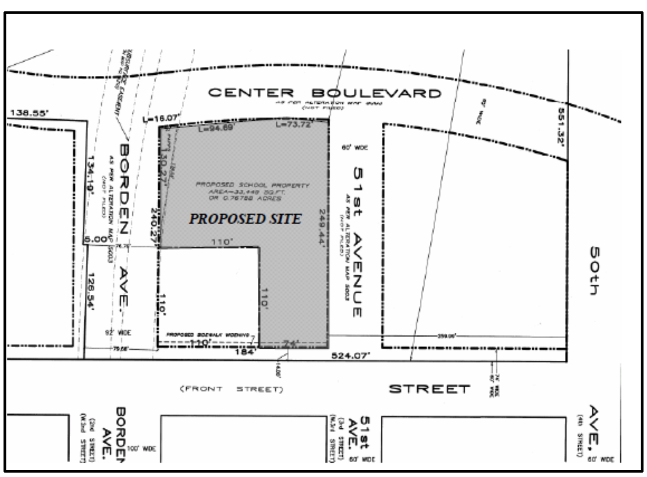


Figure 2: Building site plan
Drawing by FXFowle Architects

Following along with other city development ideals, the school building has a modern architectural feel as it incorporates interesting shapes, cantilevers, and sense of solids and voids together. The cubic shape of the building is broken up with vertical shafts, horizontal windows, and slanted edges. In addition, the SCA is aiming to achieve LEED Silver certification for this building through several different sustainable features and construction procedures.

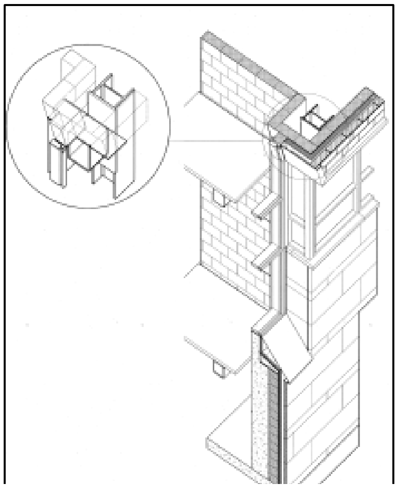


Figure 3: Typical Wall Section Axonometric Detail
Drawing by FXFowle Architects

The 5 story school rises roughly 75 feet off finished grade, with an irregular parapet rising as high as 98 feet on some elevations. It is mainly a structural steel building, with concrete on metal deck floors and an assorted exterior. The exterior façade is comprised of a unique blend of grey brick, slate veneer, concrete block, orange aluminum composite panels, and different types of glazing including translucent panels. Much of the shell is part of a curtain wall system that is supported by the floor above. There is, however, some load bearing masonry used in the design. ***Figure 4*** shows a current mock-up of the planned façade style.

Figure 4: Typical Wall mock-up
Photo by SKANSKA Inc.

Figure 5: Building Section
Rendering by FXFowle Architects

Inside, the building is vertically stacked to separate the schools, but includes ties to each other using shared spaces. The first floor contains athletic space, including a 2 story tall gymnasium and locker rooms for all grades. There are also support rooms/offices for the intermediate school and general storage areas. The second floor contains an auxiliary gym, library, and special education rooms for the

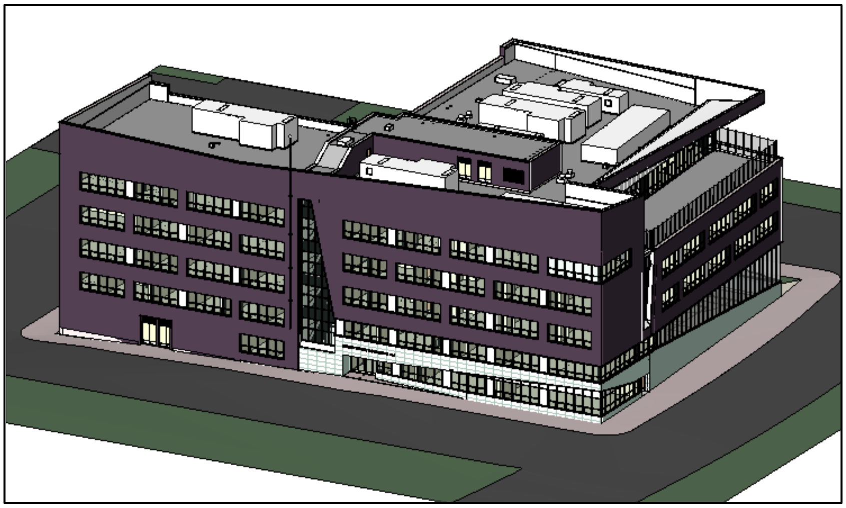


Figure 6: Building Perspective
Rendering by SKANSKA Inc.

District 75 students. The third floor contains a full sized 2 story auditorium that links the high school (HS) and intermediate school (IS) together, along with IS classrooms and IS support rooms/offices. The fourth floor contains high school classrooms with support rooms/offices and access to the auditorium. The fifth floor contains HS and IS cafeterias with a central kitchen space, a connecting 4000sf roof terrace, science labs, and support rooms/offices for the high school. There is a small mechanical penthouse on the top roof.

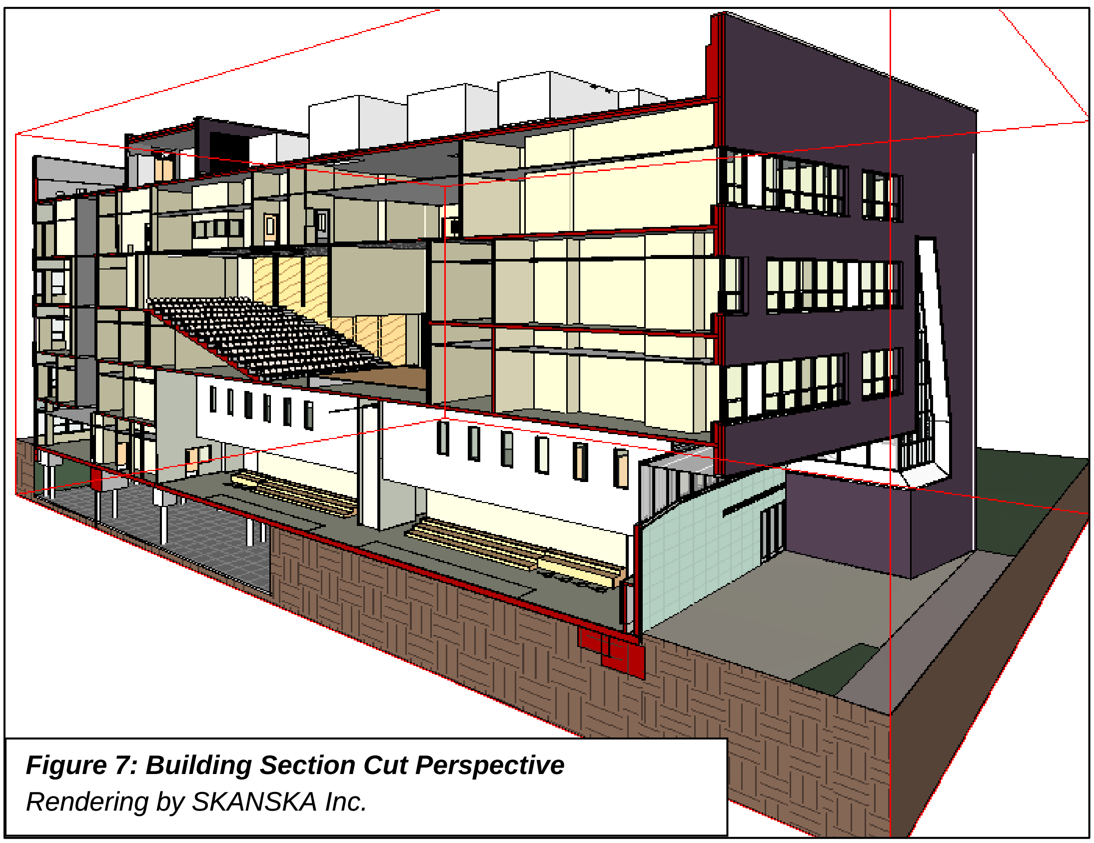


Figure 7: Building Section Cut Perspective
Rendering by SKANSKA Inc.

STRUCTURAL SYSTEMS

This section provides a brief overview of the different structural systems implemented in the Hunter's Point design. The structure consists of a steel framing system with concrete on metal deck floors. There are no subgrade levels, and structural height of the building is 72.3 feet to the roof level with a 13.5 foot parapet wall extending above. All exterior walls are non-loadbearing brick, slate, aluminum panel, or glazing. CMU masonry infill walls are used as a backup wall and are grout filled and reinforced against lateral forces. The steel frame makes up both the gravity and lateral load systems of this building.

Foundation

The foundation consists of a 12 inch 4000 psi reinforced slab on grade supported by a system of grade and strap beams, 14 inch caissons, and steel H-piles. All of these different foundation systems are required due to the poor soil properties on site. A geotechnical survey performed by Langan Engineering showed soil type ranges from grey silty sand fill to clay, with bedrock consisting of gneiss starting at about 40 feet below grade. Deep foundations are installed to at

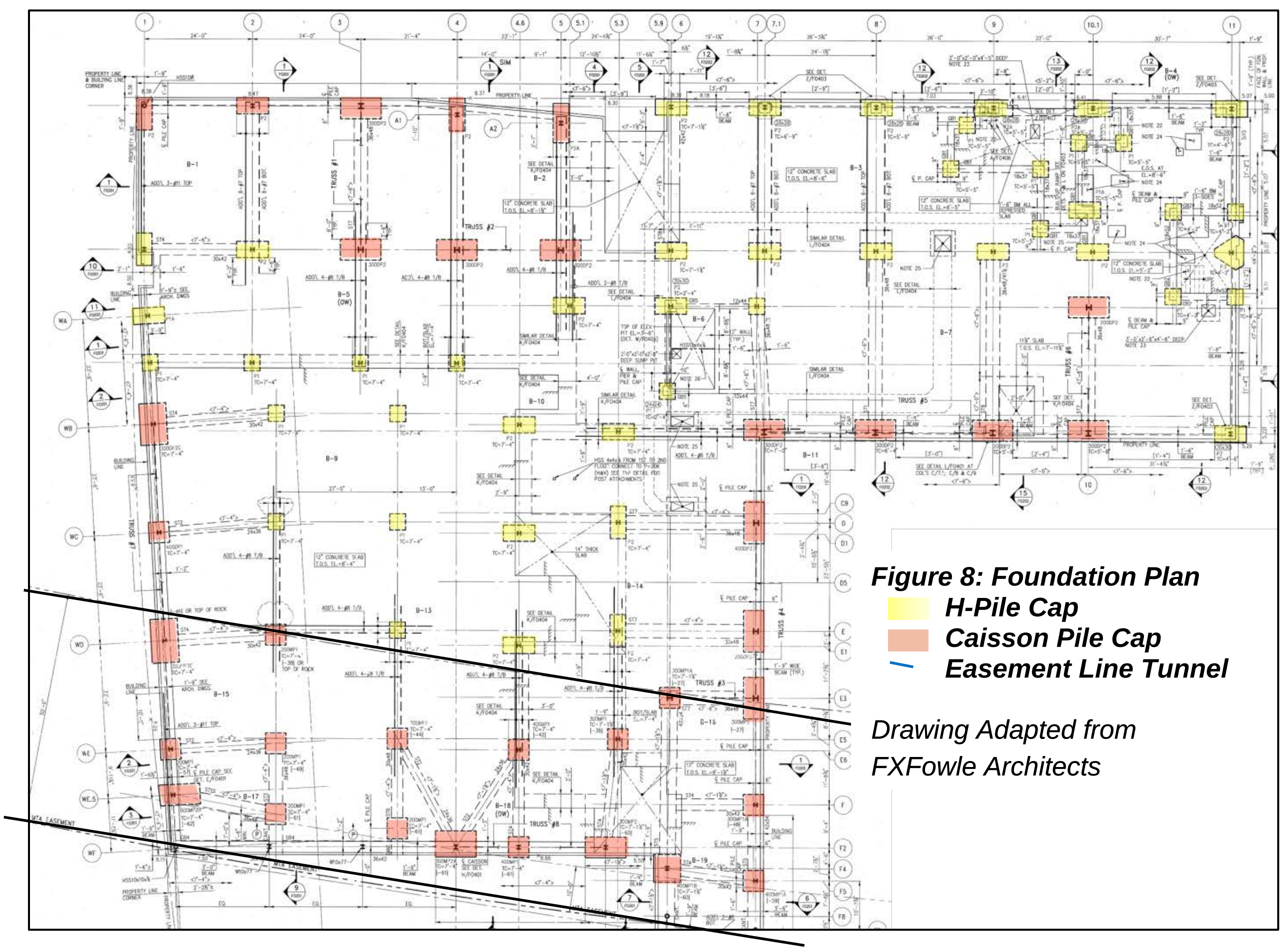


Figure 8: Foundation Plan
H-Pile Cap
Caisson Pile Cap
Easement Line Tunnel

Drawing Adapted from FXFowle Architects

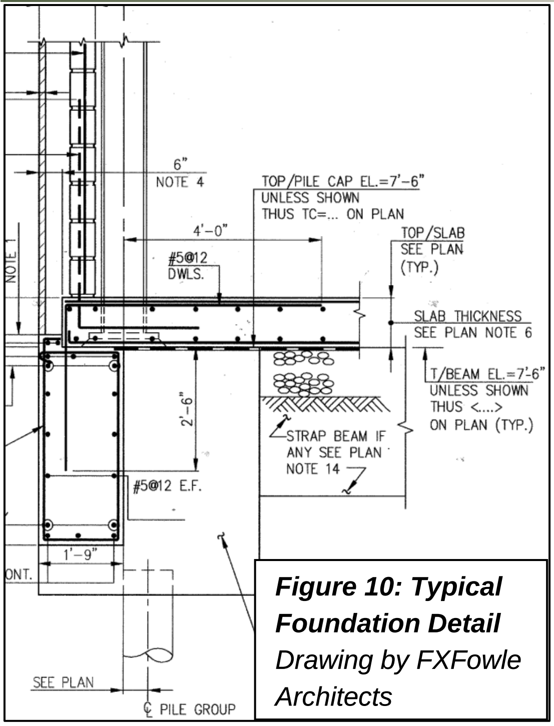


Figure 10: Typical Foundation Detail
Drawing by FXFowle Architects

least this level. H-piles are used mainly within the interior and in the upper north east corner of the site where soil conditions are better. Caissons are installed around the perimeter to help stabilize the building and take the majority of the dead load as it passes down and outward through the structural system. Special isolation caissons, as seen in ***Figure 11***, were used for locations within 50 feet of two subsurface tunnels used for the Queens-Midtown Tunnel easement lines that run E-W through the site. Each caisson has three 20 inch 75 ksi steel threadbars within 8000 psi grout, and can support up to 800kips of compressive force. Ground and strap beams are used to connect pile caps to help prevent lateral column base movement.

Figure 9: Isolation Casing
Photo by SKANSKA Inc.

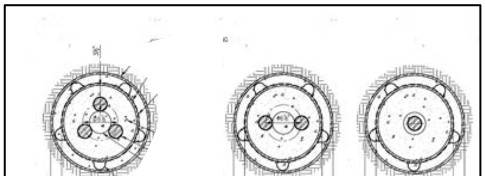


Figure 11: Isolation caisson cross section
Drawing Adapted from FXFowle

Floor and Roof Systems

As seen in ***Figure 12***, the floor system consists typically of 3-¼ inch thick 3500 psi lightweight concrete on 3 inch deep composite 18 gage galvanized metal deck (6-¼ inch total depth) supported by a steel framing system. Concrete is reinforced with 6x6 W2.0xW2.0 WWF. The floor system above the gymnasium uses acoustical metal deck in place of typical deck. The auditorium stadium seating floor will have 16 gage deck in place of typical deck. The typical unsupported span length for the floor deck is 12 feet. All cast-in-place concrete slabs are reinforced by #4 reinforcing

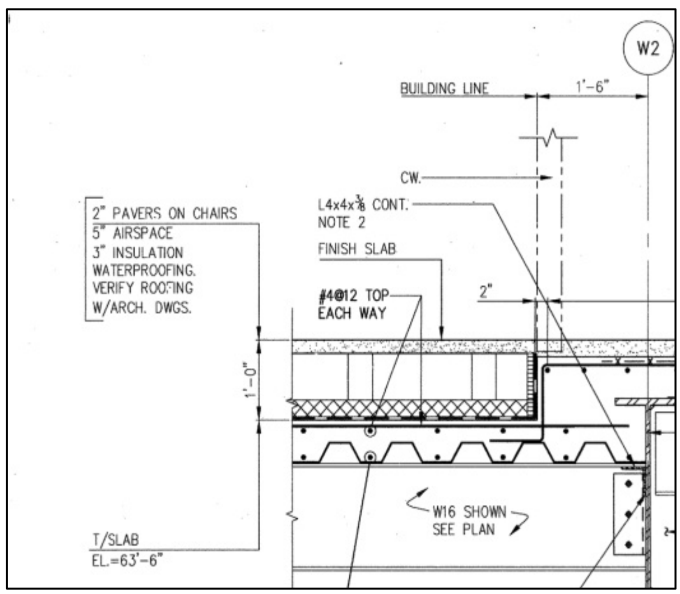


Figure 12: Typical floor system
Drawing by FXFowle Architects

bars spaced 12 inches in both directions. The top roof and terrace roof will have 2 inch thick lightweight concrete pavers over hot applied asphalt roofing membrane on top of the concrete slab.

Framing System

The superstructure of Hunter's Point is typically comprised of W10-W14 steel columns supporting W24 girders and either W14 beams at the building core or W16 beams towards the perimeter of the structure. Overall, sizes and span lengths vary greatly throughout the building and across every floor. The third floor includes special long span plate girders over the gymnasium space (red box, ***Figure 13***). Spanning roughly 80 feet each with a flange thickness

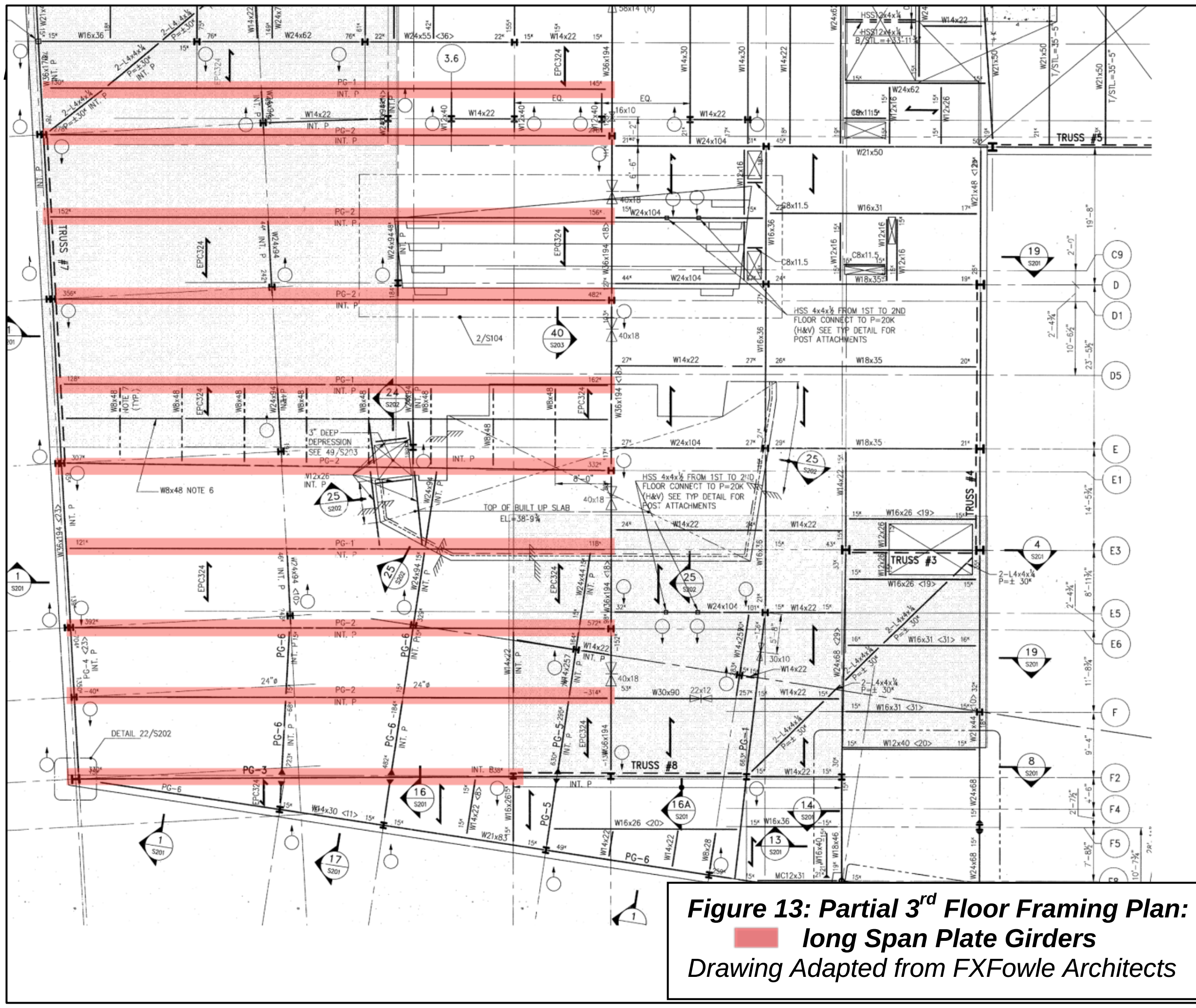


Figure 13: Partial 3rd Floor Framing Plan:
long Span Plate Girders
Drawing Adapted from FXFowle Architects

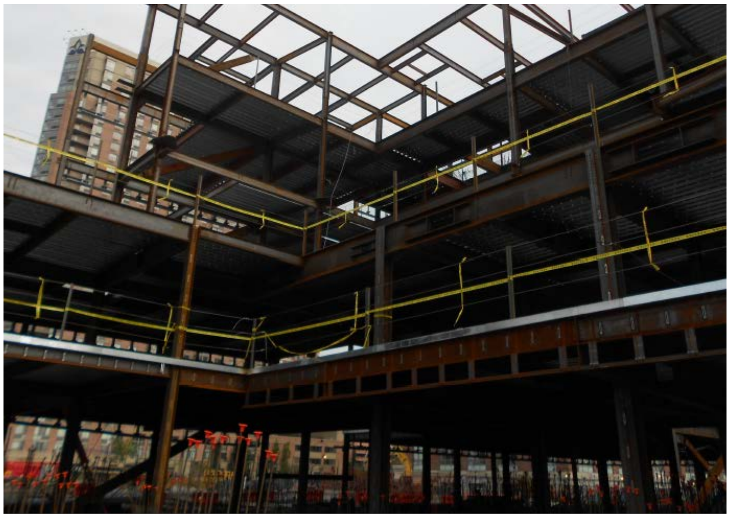


Figure 14: Steel Frame Erection
Photo by SKANSKA Inc.

of 2-4 inches and overall depth of up to 3 feet, these large transfer beams allow for open gym space while adequately supporting the load transferred from the auditorium and cafeteria space in the floors directly above. Gravity loads are transferred from the floor slab to the wide flange beams then to interior and exterior columns down to the foundation system. Exterior walls and cladding transfer their weight to exterior beams.

Lateral System

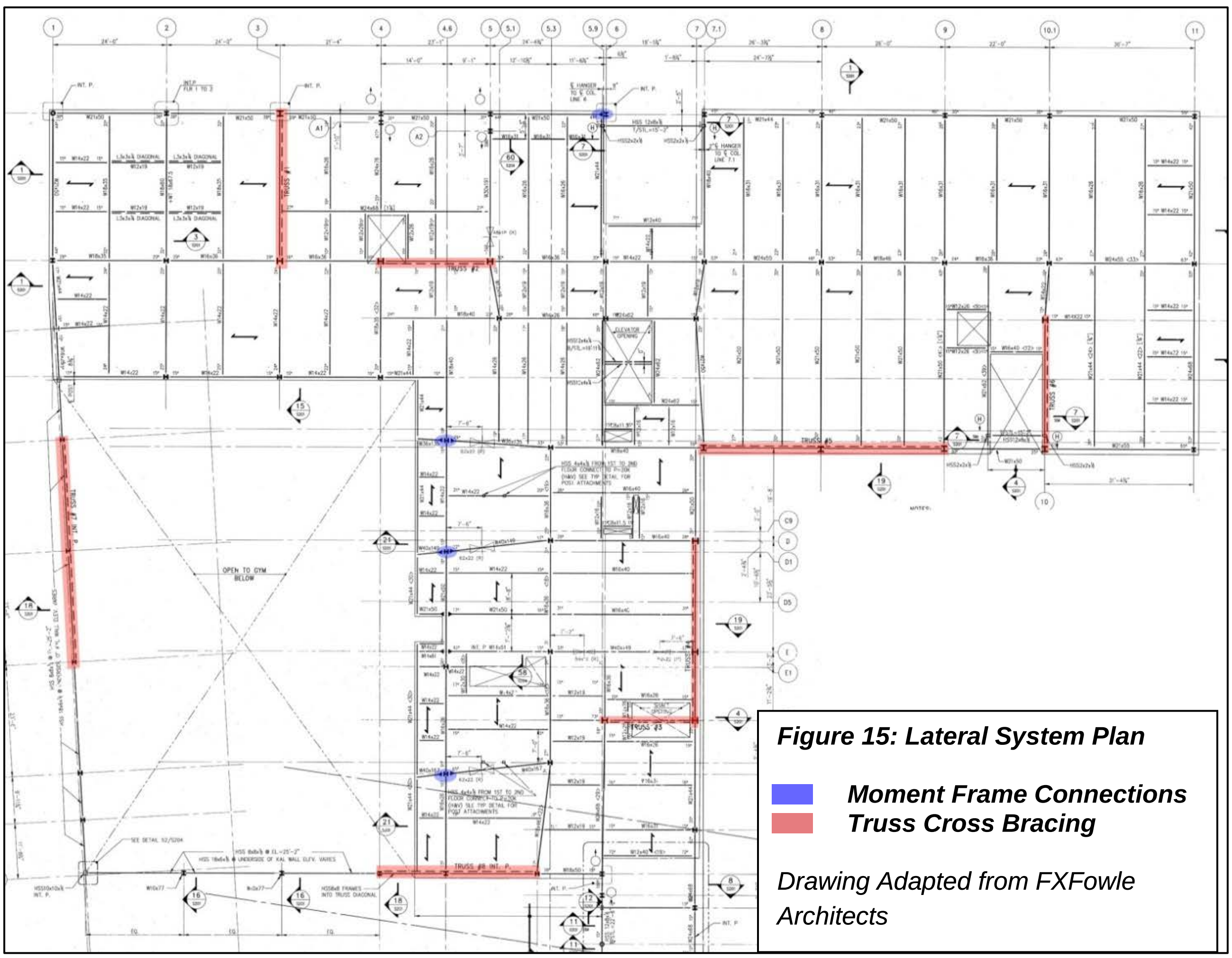


Figure 15: Lateral System Plan

Moment Frame Connections
Truss Cross Bracing

Drawing Adapted from FXFowle Architects

The lateral force resisting system consists of both HSS and wide flange lateral truss bracing (red box, ***Figure 15***), along with steel moment connections at columns around the gymnasium space (blue circles, ***Figure 15)***. There are six different types of truss bracing systems, two of which are shown in **Figure 16** to the right. Single bay trusses are primarily used along interior spaces, while stiffer double bay trusses are implemented along the exterior wall where there is more room. Several of the truss systems allow for architectural use and have odd cross bracing, such as the left truss in **Figure 16.** Trusses run in both the N-S and E-W directions. The first floor implements lateral force resisting systems the most. This is due to the 2 story cavity formed in the framing system to allow for open gym space. A 3D model of the lateral system can be seen in ***Figure 18*** below.

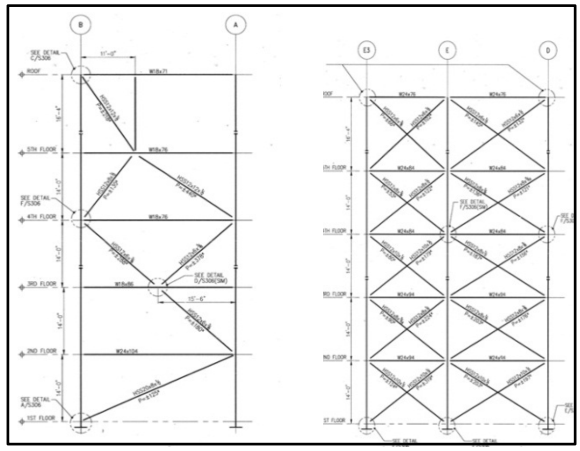


Figure 16: Two types of lateral bracing used in the design
Drawing by FXFowle Architects

Figure 17: Lateral bracing erected
Photo by SKANSKA Inc.

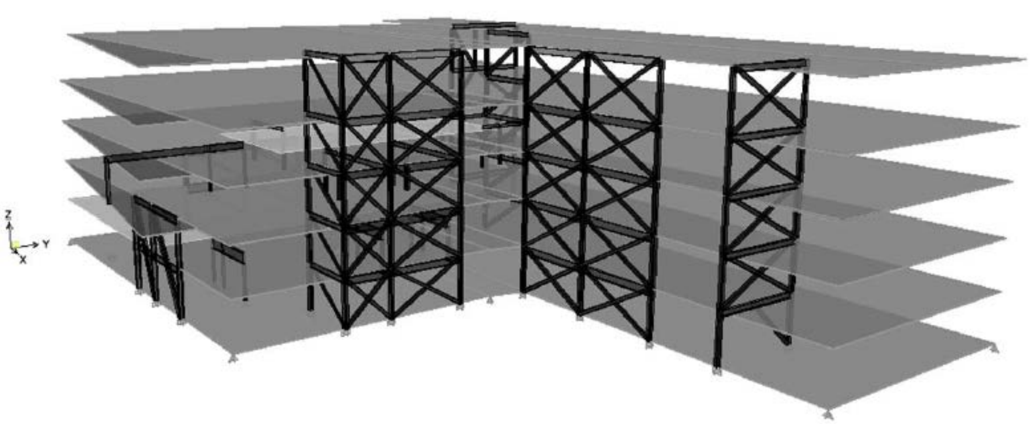


Figure 18: ETABS MODEL: Lateral Force Resisting System

DESIGN CRITERIA

This section provides data regarding codes, materials, and gravity loads for the design of Hunter's Point South. This thesis project will differ from the original design in that it will implement design criteria from ASCE7-10 and IBC 2009 rather than the NYCBC 2008 building code. There are several reasons for doing this. First of all, obtaining outdated copies of the NYCBC and other code books is not an option due to availability. The NYCBC also references the IBC and ASCE7 throughout, so much of the design will be the same. The only issue with using newer codes is that they may have different design procedures, which may change the design slightly. However, using codes up to today's standards will be most beneficial for future use and creating a code compliant redesign.

CODES & REFERENCES

Design Codes

Building Code

- New York City Building Code, NYCBC 2008, (2008)

Reference Codes

- American Concrete Institute Building Code, ACI 318-02, (2002)
- American Institute of Steel Construction, AISC 9th edition (1989)

Thesis Codes

Building Code

- International Building Code, IBC 2009 (2009)

Reference Codes

- American Concrete Institute Building Code, ACI 318-08 (2008)
- American Institute of Steel Construction, AISC 14th edition (2011)
- American Society of Civil Engineers, ASCE 7-10 (2010)

MATERIAL STRENGTHS

Design Materials and strengths were found in the construction drawings on page S001 and in general notes on individual framing plans.

Table 1: Material Strengths

Material Strengths			
Material	**Element**	**Type**	**Strength**
Cast-in-Place Concrete	Pile Caps under Columns	Normal Weight Concrete	f'c= 5950 psi
	Grade & Strap Beams	Normal Weight Concrete	f'c= 4000 psi
	Column Pier and Buttress	Normal Weight Concrete	f'c= 4000 psi
	Slab on Grade	Normal Weight Concrete	f'c= 4000 psi
	Floor Slab	Light Weight Concrete	f'c= 3500 psi
Reinforcing Steel	Concrete Reinforcing bars		FY= 60 ksi
	Caisson Steel threadbars		Fy= 75 ksi
Structural Steel	Steel Wide Flange Members	ASTM A992	Fy= 50 ksi
	Steel HSS Tubes	ASTM A500	Fy= 46 ksi
	Steel Base Plates	ASTM A572 gr 50	Fy= 50 ksi
	Steel Deck	ASTM A653	Fy= 40 ksi
	Steel Bolts	ASTM A325	Fu= 120 ksi
		ASTM A490	Fu= 150 ksi

REDESIGN PROPOSAL

PROBLEM STATEMENT

The in-depth lateral system analysis performed in Technical Report lll showed that Hunter's Point South was adequate at supporting the controlling seismic load case. As an academic exercise, the structure will be moved to a site in a higher seismic zone on the west coast and be analyzed to determine if the lateral system will withstand the increased lateral seismic forces.

Redding, California is chosen as the new building site. This site is chosen because it is a city with almost the same latitude (40.7°), elevation (400 feet), and climate (wind/precipitation/temperature) as the current location. The only main *design* difference is Redding's increased spectral response accelerations prescribed by ASCE7-10 Figures 22-1 and 22-2 for seismic design. The existing lateral system will need to be reevaluated, and perhaps redesigned, to resist the increased earthquake loading.

This redesign will be analyzed to determine if the integrated school building can feasibly be constructed in an area with more rigorous code requirements. The redesign will be designed using two different seismic design methods prescribed by ASCE7-10, and the results will be compared.

REDESIGN PROPOSAL

PROPOSED SOLUTION

The redesign of Hunter's Point South will be a steel design with eccentrically braced lateral load resisting frames. The new lateral system will be modeled in ETABS, and be analyzed under two separate seismic design methods. The first will be the Equivalent Lateral Force Analysis (ELFA), and the second will be the Modal Response Spectrum Analysis (MRSA).

The alternate floor system analysis performed in Technical Report ll proved that the original steel deck on steel frame system was one of the most economic for this structure. Therefore, this thesis redesign will implement the original system. Due to the increased response accelerations found in ASCE7-10, the new site will most likely fall under seismic design category (SDC) D rather than SDC C as it was originally designed for (ASCE7-10 Table 11.6-1). This SDC does not permit the use of the original lateral system, which was comprised of ordinary steel moment frames around the gymnasium and auditorium spaces and concentrically braced frames located throughout the rest of the building. Therefore, to comply with code, eccentrically braced frames will be implemented in place of the original lateral system.

The placement and number of eccentrically braced frames must also be reconsidered in the redesign. This will differ between the two design methods. The original lateral design created an overall torsional irregularity in the structure. Though this was acceptable in SDC C, ASCE7-10 SDC D requires that no such irregularity exists if the Equivalent Lateral Force Analysis is to be used to design the structure for seismic loads. However, if the Modal Response Spectrum Analysis is used, no such requirement exists. Therefore, there is a possibility that the lateral system will not have to be as oversized.

The new lateral system will have an effect on the foundation design. Therefore, localized pile type and pile location may change to function as a suitable foundation for the axial forces caused by the eccentric bracing under seismic loading. No other structural systems should be greatly affected by the lateral system redesign.

REDESIGN PROPOSAL

M.A.E. GRADUATE COURSE INTEGRATION

The redesign of Hunter's Point South School will implement material from several courses that are part of the Master of Architectural Engineering program. The redesigned structure will be modeled in ETABS using knowledge gained in AE597A (Computer Modeling). The design of eccentric braced frames to resist seismic loads will reference material taught in AE538 (Earthquake Design). Material learned in AE534 (Steel Connections) will be used to design typical steel connection details included in the redesign.

BREADTH STUDY 1: ARCHITECTURAL IMPACT

The increase in lateral load will require more lateral support in the building. By adding new braced frames, changing moment frames to braced frames, and moving frame locations to prevent building torsion, the redesign of Hunter's Point South can have an impact on the architectural layout of the building. An architectural breadth study will be completed to see if the new lateral system designs will work with the current building layout (both functionally and visually), or if changes must occur. This analysis will mainly focus on the locations of the gymnasium and auditorium spaces, as well as new locations of eccentrically braced frames. A redesign of the exterior façade and interior spaces will be implemented as needed and presented through revised floor plans, elevations, and section cuts.

BREADTH STUDY 2: CONSTRUCTION AND COST IMPACT

The impact of the redesign on the cost and construction schedule of the Hunter's Point project will be analyzed in the second breadth study. First, the current schedule and cost estimate will be evaluated against each new redesign to see the effect seismic zoning has on the structure. Along with changes in such things as location factors, each new design will create a new critical path schedule in the construction of the structure that will ultimately change both the construction time and overall construction costs. Then, a comparison between the ELFA and MRSA redesigns will be done to establish whether the MRSA process is worth the extra design time in saving cost and construction time.

REDESIGN PROPOSAL

TASKS AND TOOLS

Lateral System Redesign:

- Design of eccentric braced frames using the Equivalent Lateral Force Analysis

  1. Using ASCE7-10 Section 12.8, analyze the new building site for seismic design conditions under ELFA
  2. Determine the most effective location and member type of braced frames (must prevent torsional irregularity)
  3. Use computer modeling programs (including ETABS and STAAD) to determine required sizes of lateral force resisting members
  4. Analyze building output (forces, deflections, etc.) to confirm design adequacy

- Design of eccentric braced frames using the Modal Response Spectrum Analysis

  1. Using ASCE7-10 Section 12.9, analyze the new building site for seismic design conditions under MRSA
  2. Determine the most effective location and member type of braced frames
  3. Use computer modeling programs (including ETABS and STAAD) to determine required sizes of lateral force resisting members
  4. Analyze building output (forces, deflections, etc.) to confirm design adequacy

- Discussion and comparison of new lateral system designs

  1. Compare lateral system design and analysis results for both ELFA and MRSA procedures
  2. Discuss advantages/disadvantages of each design procedure
  3. Discuss feasibility of moving structure to higher seismic response area

Breadth Study 1 (Architectural Impact):

- Effect of new lateral system placement on building layout and design

    1. Compare the new lateral bracing frame locations to architectural design plans and determine where the new system hinders architectural layout or design
    2. Change the architectural layout accordingly if necessary and discuss the ramifications
    3. Include elevations and plans of new layout in a sketch or rendering

Breadth Study 2 (Construction Impact):

- Cost and schedule analysis of redesign 1 (ELFA)

    1. Obtain and review current cost estimates and schedule from project manager
    2. Create new construction schedule for first proposed redesign
    3. Generate detailed cost estimate of first proposed redesign

- Cost and schedule analysis of redesign 2 (MRSA)

    1. Refer to cost estimates and schedule from current project
    2. Create new construction schedule for second proposed redesign
    3. Generate detailed cost estimate of second proposed redesign

- Cost and schedule comparison

    1. Compare the results of redesign 1 (ELFA) and redesign 2 (MRSA) to each other and to the original design

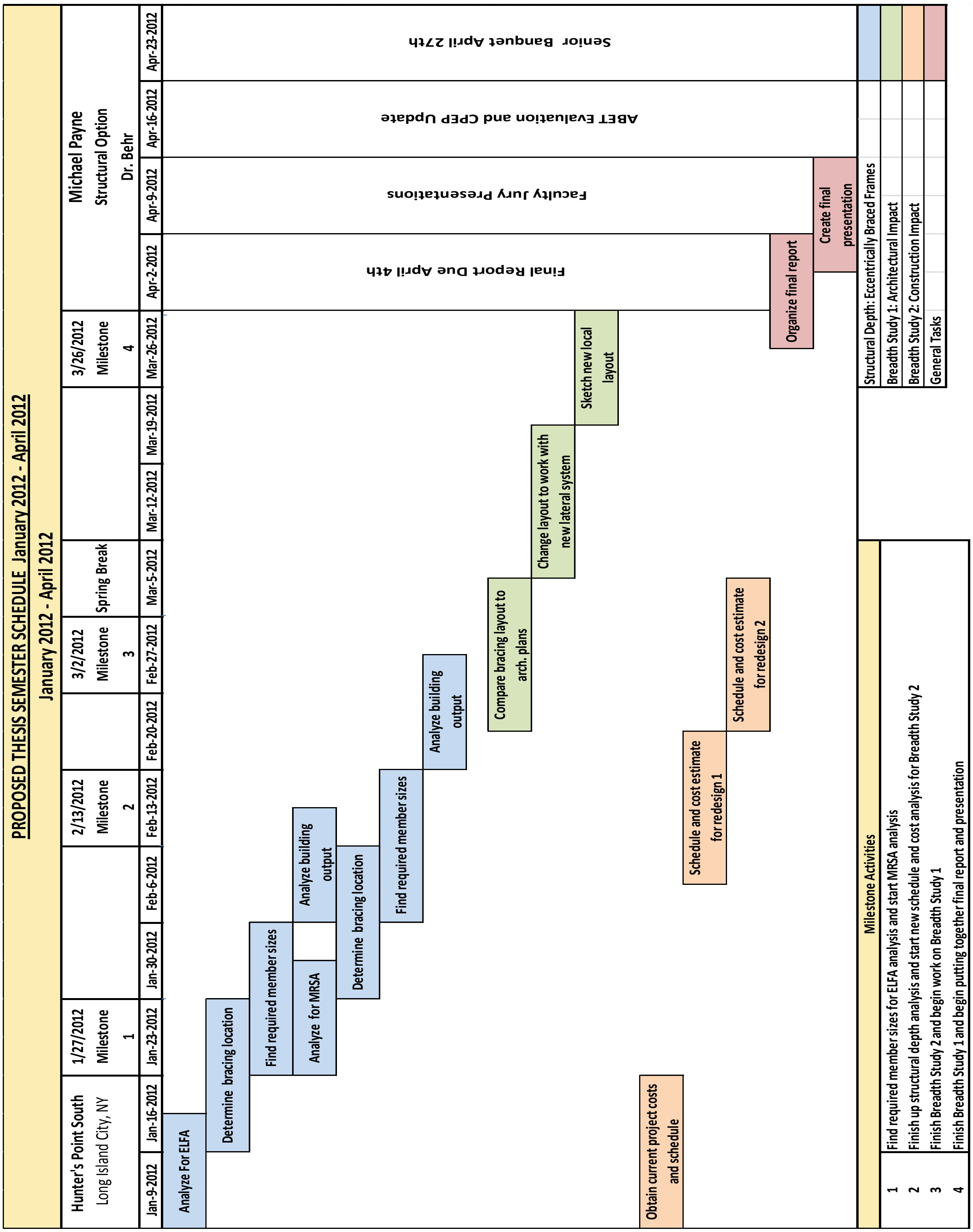
General Tasks

- Other important tasks or procedures required to complete thesis project

    1. Update CPEP site as new information is added
    2. Organize final report and create final presentation

REDESIGN PROPOSAL

SCHEDULE



SUMMARY

The structural depth for this thesis is an academic exercise that will be to redesign the lateral force resisting system of Hunter's Point South School after moving the building site to a higher seismic zone in Redding, California. To comply with more stringent code requirements, the Equivalent Lateral Force Analysis (ELFA) and Modal Response Spectrum Analysis (MRSA) found in ASCE7-10 Section 12 will be used to design two new lateral systems using only eccentrically braced frames. Each new redesign will be analyzed to determine its effectiveness, and be compared to the current design (which is not for high seismic zones) to determine the practicality of implementing the overall structural design on a more universal level. This depth study will also look at the advantages of using a more in-depth seismic response analysis (MRSA) when developing a lateral system in a high seismic zone.

An architectural breadth study will be performed to determine if the new lateral system will obstruct the architectural layout in either a functional or visual manner. Solutions will be suggested if any such obstructions exist. A second breadth study will be developed to analyze the construction impact each redesign will have. Both new designs will be compared to each other, and to the current design, to determine the effect each has on the schedule and cost estimate of the project.