

## EXECUTIVE SUMMARY

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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.

The goal of this thesis is to explore the effects of a more ductile lateral system, and to investigate whether a lateral system redesign for a higher seismic region is an effective and efficient possibility for Hunter's Point South. To start the investigation, the structure is moved to a SDC D seismic zone in Redding, CA, and an Eccentrically Braced Frame (EBF) system is chosen to replace the original lateral system. Using ASCE7-10, two different design methods are used to create two separate redesigns. This is done to help show the transition of design from the original location/design to final redesign/location. Equivalent Lateral Force Procedure (ELFP) and Modal Response Spectrum Analysis (MRSA) are used for design load calculations.

Using AISC 341-10 Seismic Provisions and AISC 327-05 Seismic Design Manual as design references, ETABS structural modeling program is used to design both EBF systems. Once both layouts are created and member sizes are designed, an analysis is performed to compare the strength and serviceability characteristics of each system against the other, as well as comparing each to the original design. Also, as part of an MAE requirement, seismic connection details are designed for each redesign system.

After analysis is performed on the performance of each new lateral system, several breadth studies must be completed to analyze the secondary effects the new systems have on the rest of the building project for Hunter's Point South. First, an architectural impact study is completed to investigate whether the new lateral systems are compatible with the original architectural layout. It is found that in the ELFP design, new EBF frames create façade issues and room lighting issues, so design changes are implemented to the façade and layout of several rooms. Also, a construction impact study is completed to determine the effects of each redesign on the overall construction cost and schedule. Using RS Means, original construction documents, and other research, cost increases are analyzed and the critical construction path is changed to accommodate the new lateral system designs and the seismic detailing that goes with it.

## SUMMARY AND CONCLUSION

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After analysis was completed, it was determined that the school could be moved to a higher seismic zone and a new lateral system could be designed to effectively and efficiently take the increased seismic loading while abiding to code. Both new lateral system designs were successfully designed and implemented into Hunter's Point South. Each system had its own advantages and disadvantages, but one had to be chosen as the best overall choice to redesign the school.

The Equivalent Lateral Force Procedure (ELFP) design is the quicker, simpler process, but has its drawbacks. To prevent lateral torsional irregularity, this system had to be oversized and frames needed to be moved and added. This design created a stronger, more effective system than the original CBF system, but required a lot of changes to do so.

The Modal Response Spectrum Analysis (MRSA) design is the more in-depth process, but the extra work seems to be worth the time and effort. This system creates a very efficient design due to the 15% decrease in design loads as compared to the ELFP design. Allowed to ignore torsional irregular issues, this design was able to keep the original layout of the lateral system CBF's. Though some frames required larger members than in the ELFP design, less steel had to be used overall.

When comparing the two designs as they affected the architectural layout, it was clear which one was better. The MRSA design had absolutely no impact on the architecture. The ELFP design created several architectural issues. Because the frames were moved to the exterior walls, the exterior façade (i.e. windows) had to be changed to hide the structure. This led to insufficient day-lighting in classrooms, which created the need to redesign the layout of the 2<sup>nd</sup> floor special needs classrooms in the east wing.

The cost of each system is the most important factor in the construction industry. The cost increase of the two redesigns must be small enough (or negligible) for the redesign to be an effective substitute. When including the location factor of the new and old locations, both redesigns end up costing the same or less than the original! The ELFP method was found to increase the system cost by less than 1% and delay the entire construction project by 11 days. The MRSA design was found to take only 8 days more than the original design to construct; but had an overall cost savings of 3%!

Overall, it was determined redesigning Hunter's Point South using the MRSA design prescribed in this report would be the best design choice, and would adequately and efficiently support the increased seismic loads in the higher seismic zone.