Thomas Tuttle Medical Center

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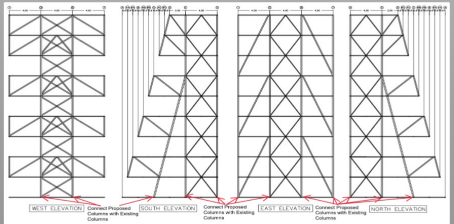
Introduction

Due to the Covid-19 pandemic, Seattle's hospitals are brimming near capacity. As the circumstances surrounding the pandemic have become more dire, an existing hospital has moved its structural addition timeline forward in order to increase its patient capacity to meet the rising demand. To address this need, the following research, analysis, and development has been completed to meet the growing hospital bed demand.

Structural

The existing structure and addition were modeled on SAP2000. The existing structure is 9 stories tall with a total height of 2'-6"and an average floor height of 3", except for the ground floor level which has a height of 6". The floor space per level is 144in². All connections and member intersections were assumed to be continuous, and the diaphragm was modeled as completely flexible with no stiffness. A superimposed dead load of 1.44psf was applied to each floor level. Additional loads such as live, wind, snow, etc. were not considered.

Recorded seismic time histories were provided to the team and the existing structure was analyzed for each time history in both lateral directions. The goal of this analysis was to find the structural response to the ground motions in the form of inter-story drift ratios and member stresses. The maximum allowable interstory drift ratio was 5%. After the drift ratios were calculated for each floor under all time history scenarios, the peak inter-story drift ratio was found to be 0.64%, which is well below the allowable drift ratio. After applying applicable Allowable Stress Design (ASD) load combinations, the structure's members were checked using the American Wood Council's 2018 NDS and NDS Supplement. The members were checked for axial loading, bending, and shear. The largest demand/capacity ratio calculated from worst-case scenario loading conditions was found to be 69.1%. From the results of the inter-story drift ratios and member design checks, it was concluded that the initial design of the structure was effective.

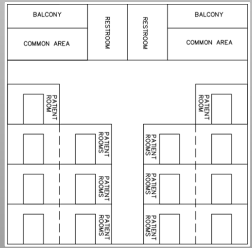


The structure's extension includes 9 additional stories. Due to the close proximity of a high-rise building to the west of the structure, the addition had to be designed such that the structure tapers away from the high-rise to prevent the two structures from pounding as they oscillate during seismic events. As a result of tapering the addition, it was predicted that the structure would have increased torsional effects, and as such, the design of the addition would need to limit these torsional effects. The preliminary extension design includes 27,000 sq.ft of rentable floor area, with an average floor height of 3". In total, the structure is 18 stories tall at a height of 4'-9".

Architectural Concept

Inspired by Amazon Tower I, the *Thomas Tuttle Medical Center* aims to achieve conformity with the iconic Seattle skyline with the addition of some flair. Vertical strips travel up the sides of the structure adding a pop of color to the grey exterior. Tinted windows give patients and medical professionals breathtaking views of the Seattle skyline and neighboring Elliot Bay while simultaneously providing privacy from the bustling surroundings.

The addition provides balconies to both mobile and bed bound patients access to open air. All balconies are equipped with a living walls for patient well-being and sustainability. It is projected to obtain LEED certification with diversified transportation amenities, rainwater management, water efficiency, and the optimization of building materials for a total of 42 points on the BD+C Scorecard.



In order to meet the demand of incoming Covid-19 patients, the addition to the existing structure focuses on patient capacity. A typical floor plan to floors 10, 12, 14, and 16 provide open-air access by way of balconies that are accessible to mobile and bed bound patients. These floors implement an open floor plan with curtain partitions for ease of access to patients by medical professionals.

The retrofit will have minimal impact on the functionality of the hospital. To accommodate structural elements, only the configurations of exterior window placement and interior patient placement within the open floor plan.

Geotechnical & Seismicity

The soil is classified as a Site Class E and is subject to liquefaction, landslides, tsunamis, and flooding. Further research found the water table at 9.5' and unstable soil within the first 55'. Per the boring log and the Standard Penetration Resistance reading of 50+ blows per foot at 55', it was determined that the approximate depth below ground surface that a pile foundation will penetrate was determined to be 60'. The location is also prone to peat-settlement, but several methods such as compaction or a subdrainage system could mitigate this issue.

The site's location is within the vicinity of several fault zones, most notably the Seattle Fault Zone which holds the largest percent contribution to hazard. It was determined that the site has a risk category of IV, with a site classification of D and with approximate spectral accelerations of 0.5g and 0.3g for the existing building and proposed addition, respectively.

Retrofit

The results of the preliminary analysis of the structure made it apparent that failures were occurring due to the concentration of loading on the existing framing. The tapering addition did not have an adequate load path to prevent twisting because of the absence of framing on the structure's east facemeant. As such, stresses from this eccentricity would be concentrated on the frame on the west face where most of the critical members were located. In response, a bracing system on the structure's east face was added from the foundation connecting to the existing bracing found above floor 10. This provides a continuous load path and reduces torsional effects. In addition, the concentrically braced frames in turn provide high lateral resistance, and stiffness which is obtained through tension and compression within the frame.

Another issue that was apparent in the structure was the absence of lateral systems in the East-West direction causing excessive sway. During seismic loading, this rocking effect would transfer the energy from the structure's inertia to the members on the east and west sides of the building. As a result, excessive compressive and tension forces were experienced in the bracing. In response, 4 shear walls were placed in the interior of the building and 2 were placed along the exterior. They are all oriented parallel to the East-West direction. In SAP2000, the shear walls were assumed to have fixed connections at the foundation, and the shear walls were modeled in segments from floor to floor instead of modeling a continuous wall section from the ground floor to the roof. The majority of the shear walls were placed near the east face of the building because there was a direct line of connection from the roof to the foundation. This solution provided the stiffness required to prevent the swaying that was experienced previously.