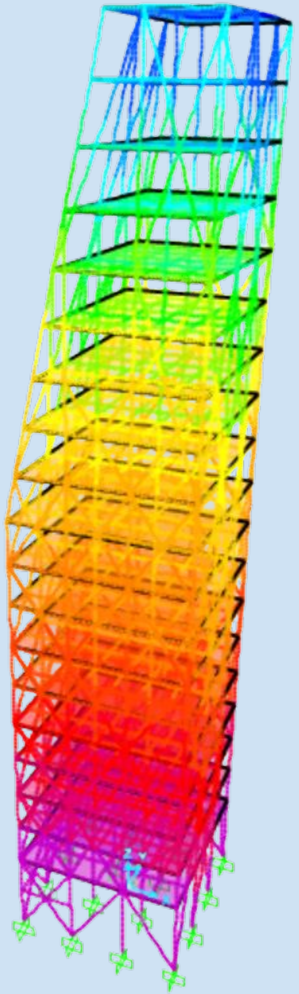
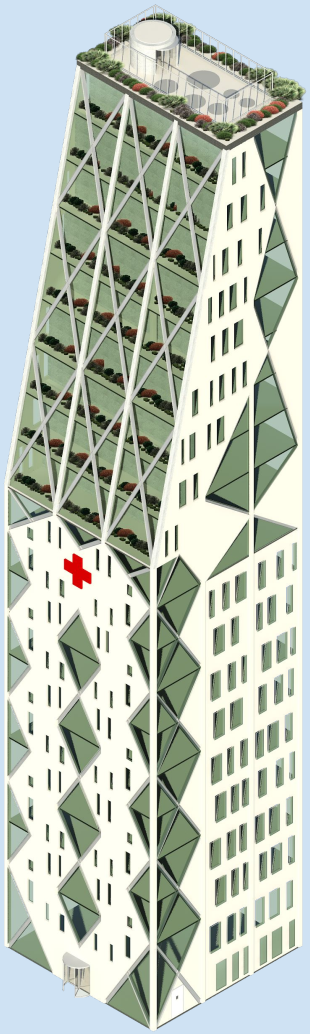
Fauci Tower

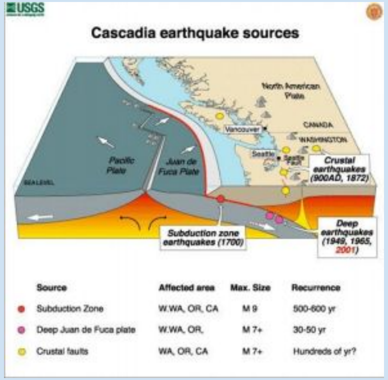
Cornell University

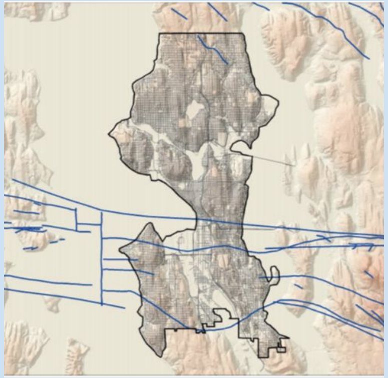




GEOTECHNICAL CONSIDERATIONS

Seattle, a vibrant city on the Pacific Northwest, is vulnerable to seismic activities. The city has three main seismic sources — the Seattle Fault, the intraplate quakes from the subducted Juan de Fuca Plate, and the Cascadia Subduction Zone — although the Whidbey Island Fault and the Tacoma Fault.can also impact Seattle to a lesser extent. Repeated glaciations over Seattle created a basin known as the Puget Lowland, which can trap earthquakes'' energy and amplify their effects. In the basin, prominent geological units like the quaternary continental glacial drift and the quaternary alluvium contain also large quantities of loose glacial and glaciofluvial sand, gravel, and till, which made the soil highly liquefiable and prone to secondary hazards.

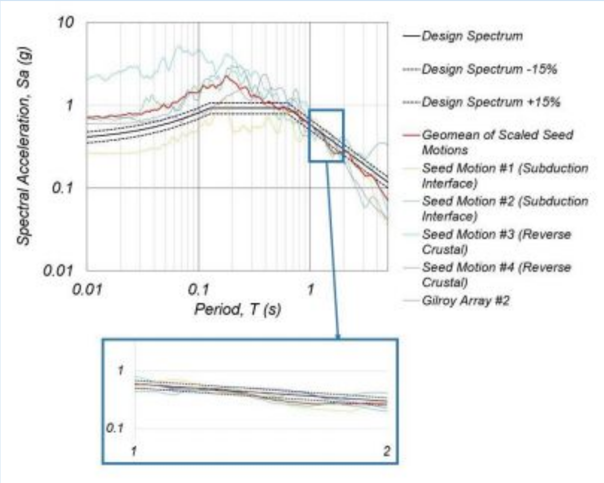




For the site and hospital structure of interest:

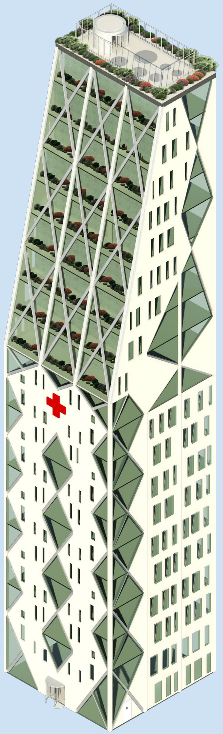
- Risk Category: IV (high of resilience necessary)
- Site Class: E (after mitigating liquefaction, $V_{s,30}$ = 578.6ft/s)
- Seismic Design Category: D (S_{DS} > 0.50 and S_{D1} > 0.20).

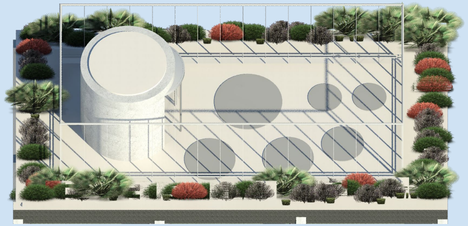
Given the Risk Category, the Site Class, and the 100 ft of liquefiable soil on site, deep piles of least least 110 ft in length should be used as the foundation. Ground improvement techniques, such as stone columns, compaction grouting, and situ soil mixing, should be considered.



Five ground motions, including the 1989 Loma Prieta earthquake measured at the Gilroy Array #2 station (obtained from UC Berkeley's NGA-West2 database), were scaled to mostly be in the ±15% range of the computed Design Response Spectrum for periods of interest (between 1.0 s and 2.0 s).

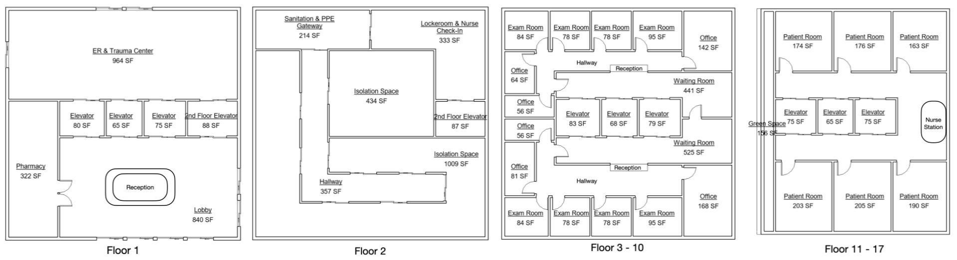
ARCHITECTURE





The architecture concept incorporates Seattle's reputation as the Emerald City, its long unique history evident through the variety of its buildings, and its unwavering commitment to sustainability and green design.

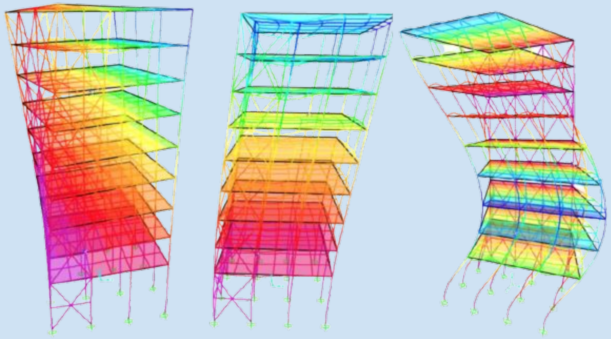
Floor Plans:
Four floor plan designs are implemented throughout the building to divide it into distinct sections, containing a spacious lobby, an infectious disease ward, many specialized discipline centers, and patient/recovery rooms.



LEED and Sustainability:
The design targets a LEED Building Design + Construction (BD+C) healthcare certification. The building will fulfill credits associated with sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality. Examples of LEED features include indoor green spaces, a rooftop garden, utilization of renewable energy, and the collection and storage of recyclable materials.

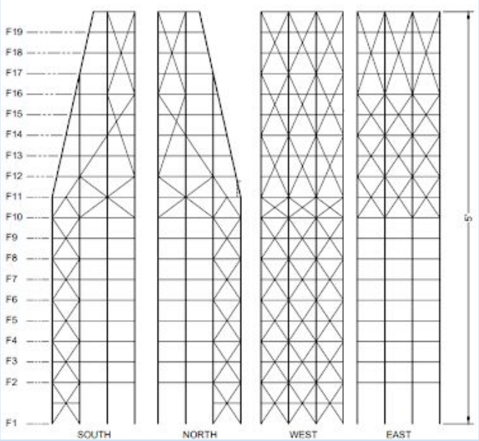
EXISTING STRUCTURE & ADDITION DESIGN

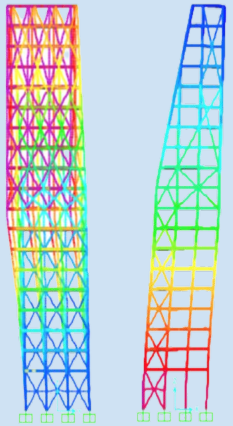
Analysis of Existing Structure:
To analyze the existing structure in SAP2000, it was assumed all connections were fixed. Appropriate load combinations were applied to each ground motion in each shaking direction according to ASCE 7. It was determined through a modal analysis that nine modes are needed to reach a 90% mass participation in both translational directions, and the first three modal shapes were shown below. The maximum inter-story drift is 2.393% (occurring between Floors 5 and 6 under TH1), and the maximum demand/capacity ratio is 0.92 (occurring at a bottom column under compression) Based on accelerations, the floors most suitable for sensitive hospital equipment are the bottom two floors.



Mode 1 Mode 2 Mode 3

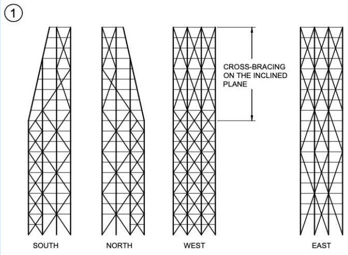
Addition Design:
The main challenge with the addition design is to combat torsional irregularities and create a load path from the sloping addition to the existing lateral bracing on the west side. X-bracing was included on all exterior walls of the addition to stiff the structure. Various versions of bracing patterns were tested in SAP2000. A qualitative assessment of the deformation of each design was used to find a pre-retrofitting optimal design. Elevations of the design and the structure’s deformations under the worst-case ground motion in each direction are displayed below.



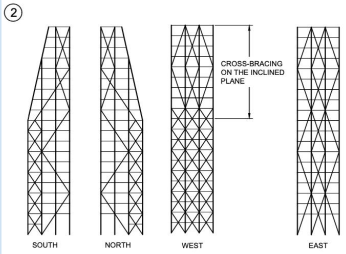


RETROFITTING & FINAL ANALYSIS

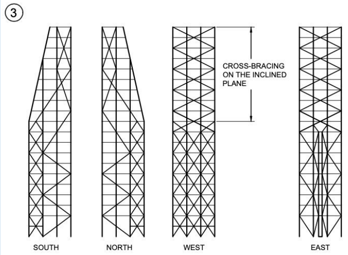
Analysis was performed on the preliminary design (on the previous slide), and it was deemed that retrofitting was needed in order to have inter-story drift under 5% and demand/capacity ratio under 1.



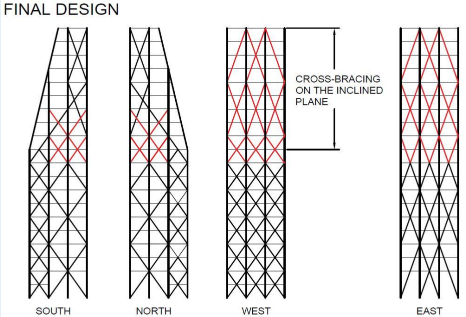
Design 1: Diagonal bracing spanning four stories



Design 2: Diagonal floor beams on 10^{th} floor and up

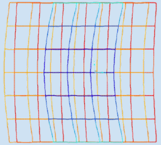


Design 3: Shear wall on lower floors of the east wall

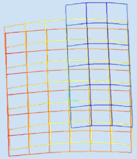


From the first three retrofit designs, it was found that for the specific structure of interest, neither having diagonal floors in the extension nor using shear walls effectively reduced inter-story drifts.

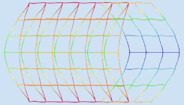
The final design adopts wall braces similar to the ones used in Design 1 and Design 2, and it contains only square floors. The geometric density of diagonal braces were optimized to minimize both deformation and weight. The lines highlighted in red in the final design drawing indicate changes to the original, pre-retrofitting addition design. The final retrofitting matches how real-life structures utilize diagonal steel braces to combat seismic loads. The design can also be further modified to add dampers or hysteretic devices into the braces for serviceability reasons. Most importantly, by using only a small number of external braces, the retrofitting minimizes impact on the operation and architecture of the building. The overall maximum inter-story drifts is 4.68% (between Floors 11-12 under TH3), and the maximum demand/ capacity ratios is 0.53 (for a bottom column under compression). The total rentable floor area is 2384 in^2, and the final weight is 0.491 lbs.



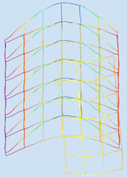
Mode 1



Mode 2



Mode 3



Mode 4

*Only Floors 6,10, and roof are shown for clarity