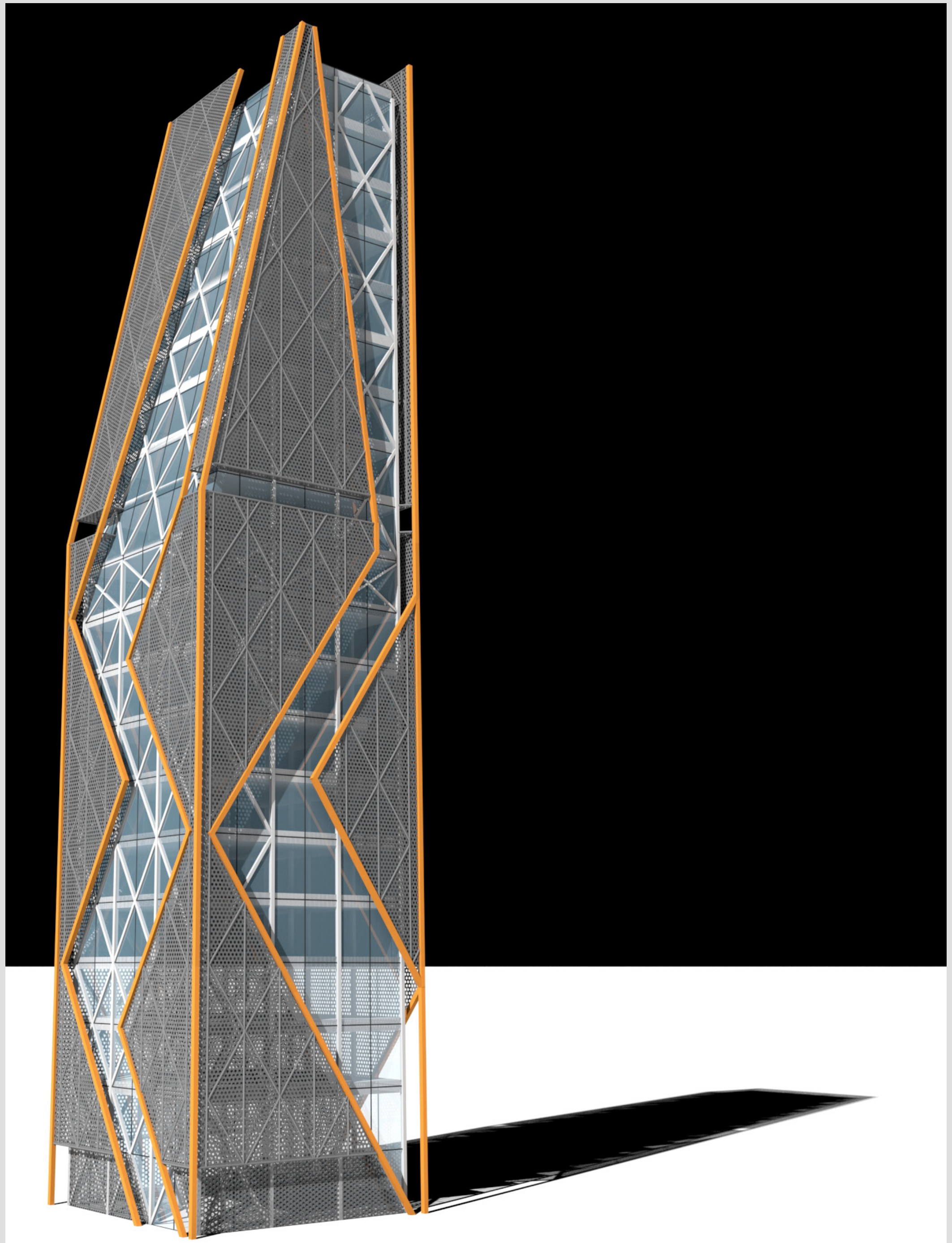
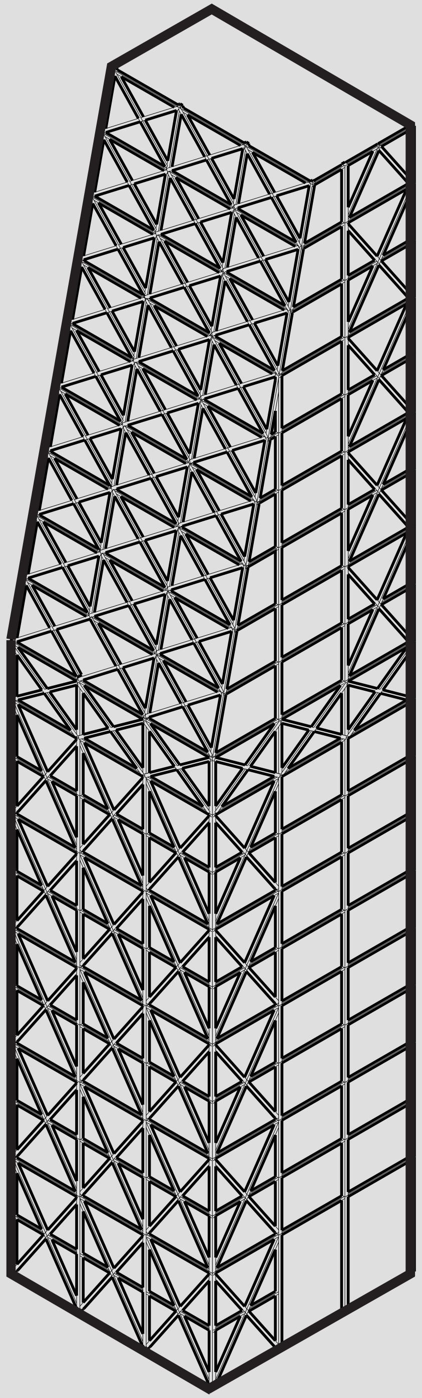
SYMBIOSIS

[n] interaction between two different organisms living in close physical association, typically to the advantage of both

Symbiosis is a hospital with resilience and purpose at the forefront of its design. As we have become more reliant on our emergency rooms during this pandemic, the hospital needed an addition to create space for the influx of patients. This addition prompted a retrofit of the existing structure to ensure the hospital stays open during any disaster. The façade evokes a sense of familiarity while still pushing the boundaries of modern hospital design, keeping the Belltown neighborhood ahead of the times. Symbiosis serves the community, the environment, and the front-line workers who are tirelessly ensuring the health and safety of Seattle.





Cal Poly SLO EERI Student Chapter

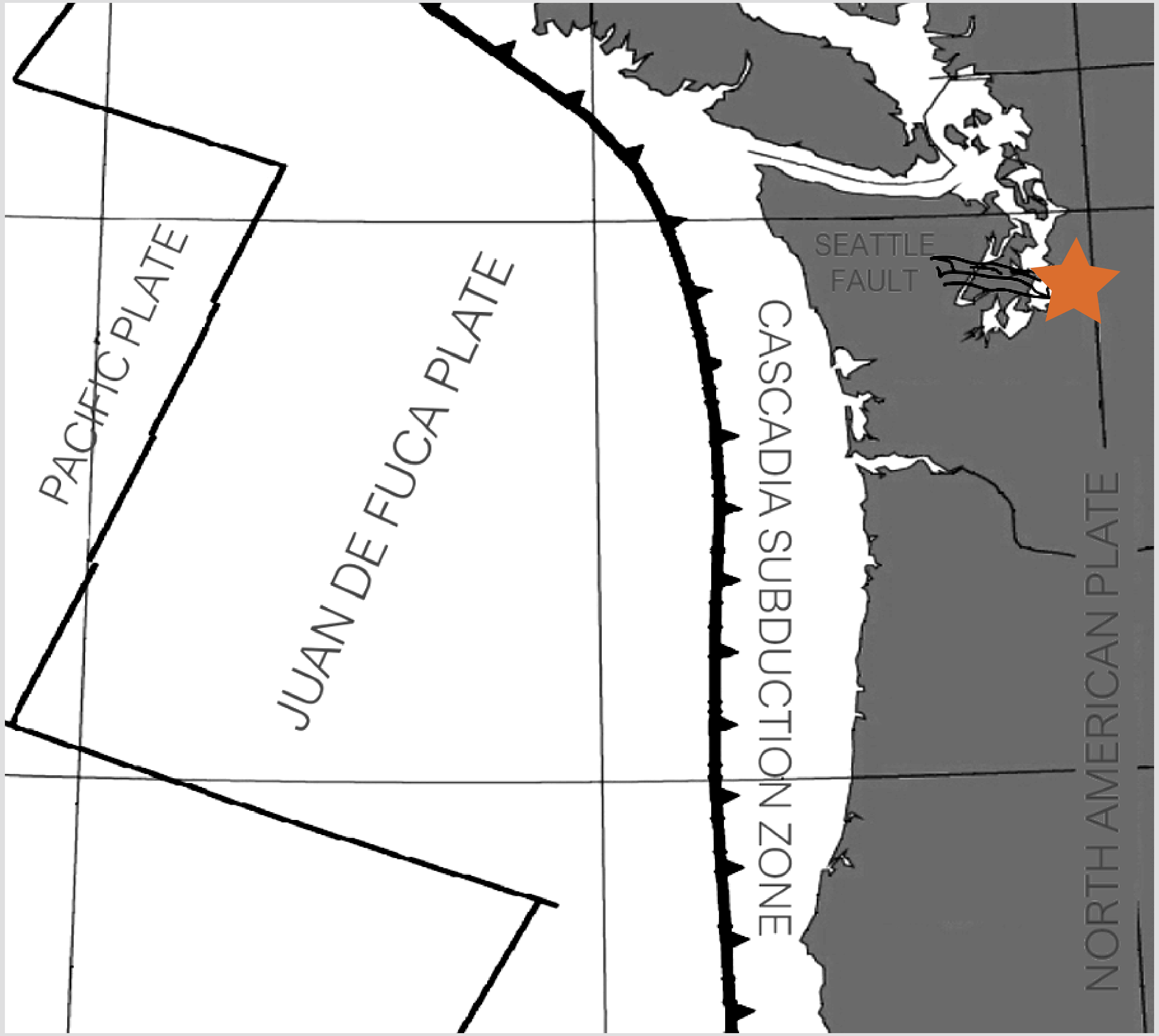
Geotechnical + Seismicity

The location of the hospital (47.6163, -122.3534) is two blocks from the waterfront of Elliott Bay in Seattle's trendy Belltown neighborhood. Here, the Juan de Fuca plate dives under the North American Plate creating the Cascadia Subduction Zone.

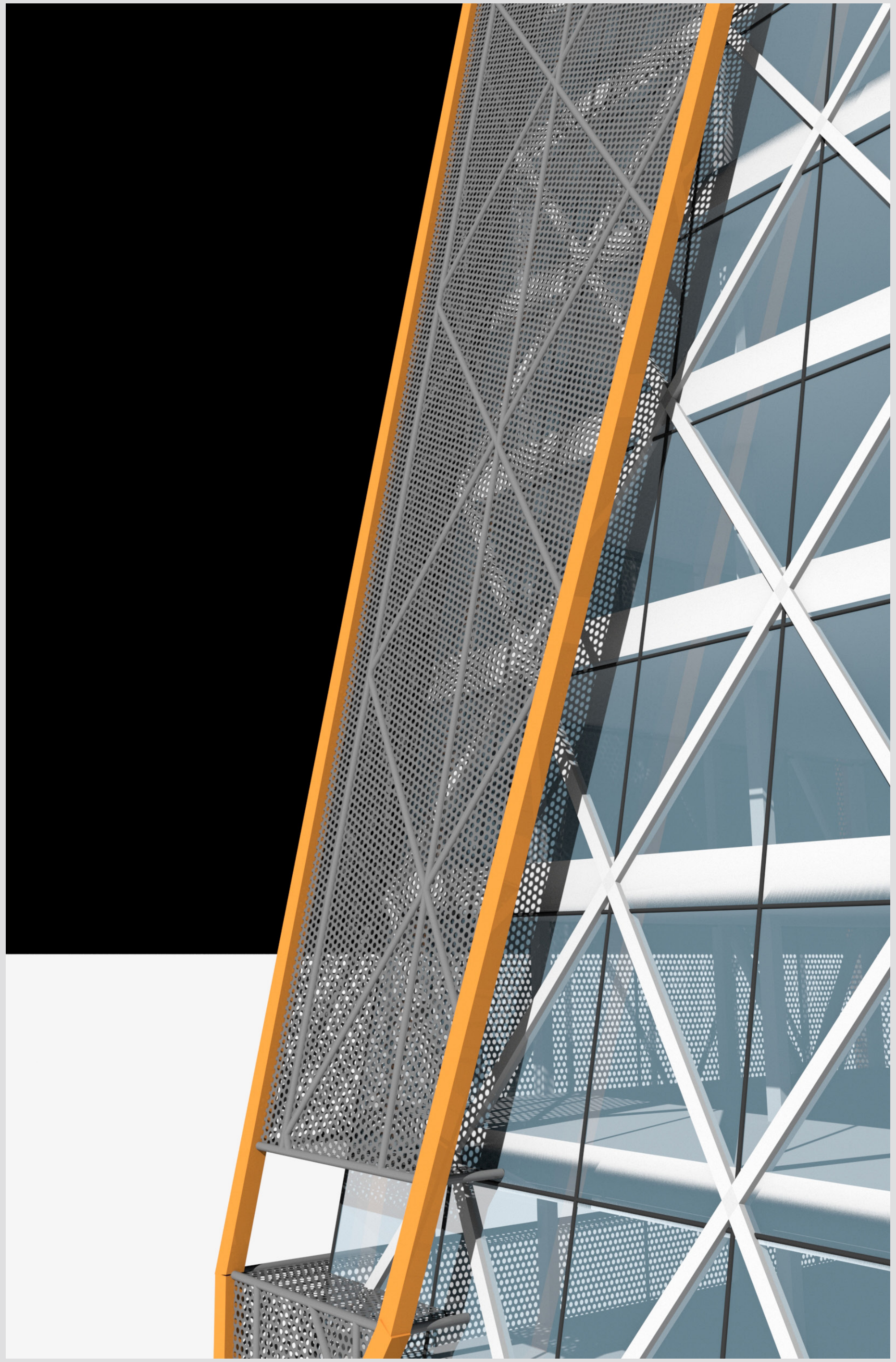
The Cascadia Subduction Zone created many faults in and near Seattle. Of greatest concern is the Seattle Fault, directly south of the site, it runs east-west through the city with the potential earthquake of magnitude 7.5. The Tacoma, Rattlesnake Mountain, and Southern Whidbey Island Fault Zones enclose Seattle to the south, east, and north, respectively.

Subsurface conditions are of great concern as the proposed site sits above 40 ft of potentially liquifiable fill composed of loose to medium dense, moist to wet, very gravelly sand to very sandy gravel with trace silt.

Deaggregation plots were obtained to determine percent hazards within the structure. These hazards provided insight on the type of ground motions that were to be selected. Two ground motions were chosen to represent nearby faults, leaving three to reflect the Cascadia Subduction Zone Interface. These motions were selected based on the following criteria: shear wave velocity, rupture distance, and magnitude of event. This same criteria was used to select a seed motion that was scaled according to the design response spectrum, to help better predict spectral accelerations.



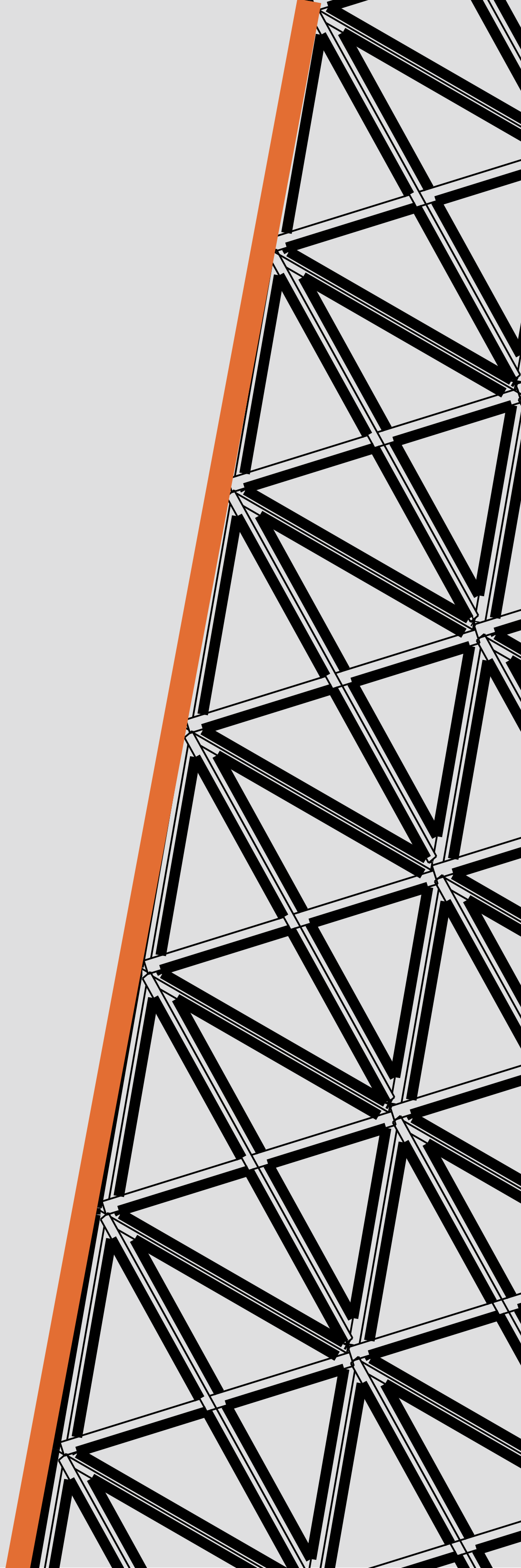
Architecture



Inspired by the trendy neighborhood site of Belltown and the nearby Olympic Sculpture Garden, the bold colors and organic forms seen throughout, were wrapped around the hospital in a façade that allows fantastic views of Elliott Bay and sets a striking precedent for the modern hospital.

The internal layout of the hospital features patient rooms pushed towards the edges of the building for privacy and added sunlight. Circular walkways increase circulation, and multiple access points and passageways to keep patients with different conditions separate. The floor layouts stay familiar and consistent at each level of the hospital.

In striving for LEED accreditation, key aspects for design included materials and resources, indoor environmental quality, energy and atmosphere, and water efficiency. Reusing as much material as possible and ensuring any new materials were responsibly sourced and free of harmful chemicals was crucial. Proper air flow and purification was also important along with adequate sunlight and shading in each room. Energy efficient fixtures and appliances work to keep the operational carbon impact low.



Structure

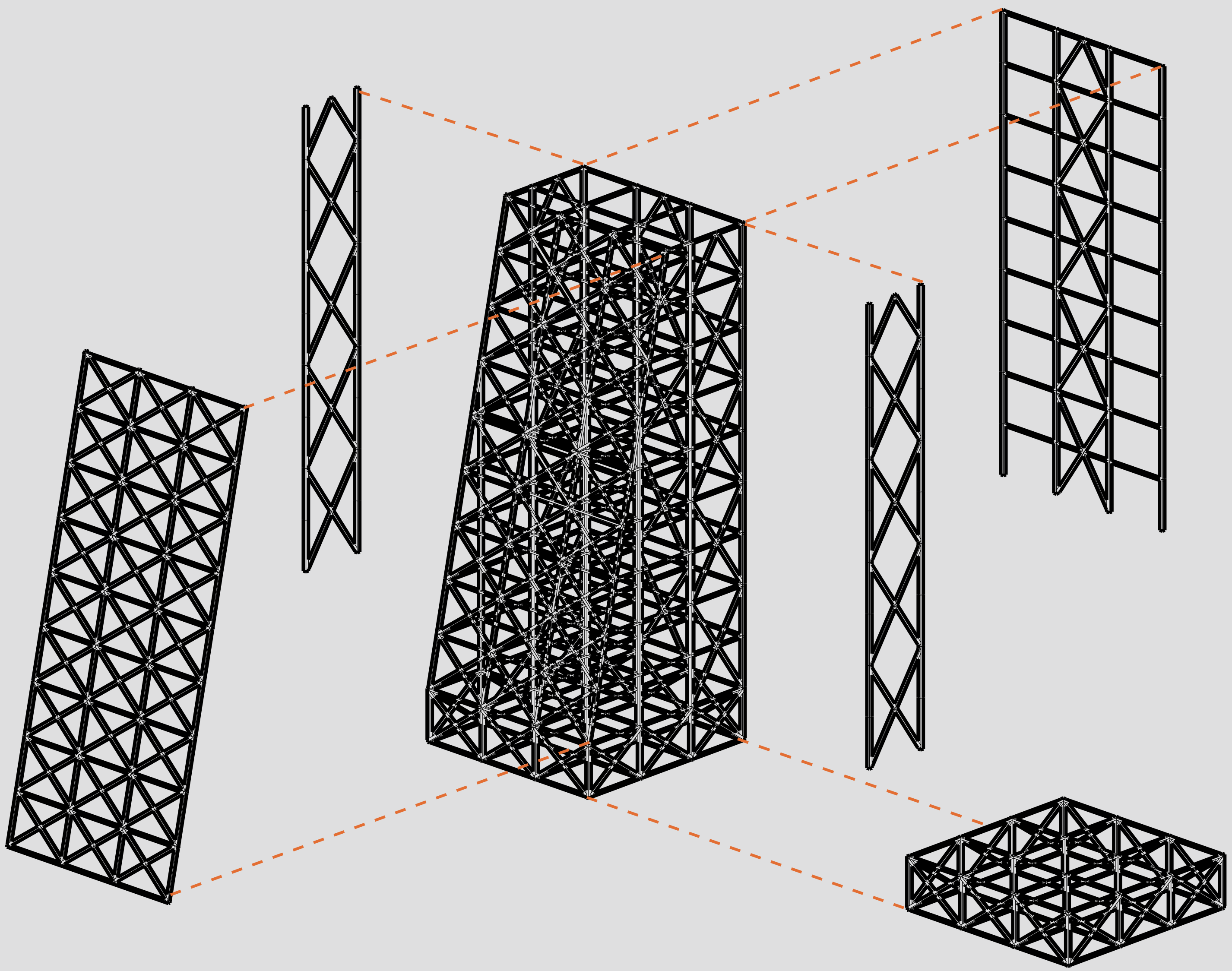
EXISTING

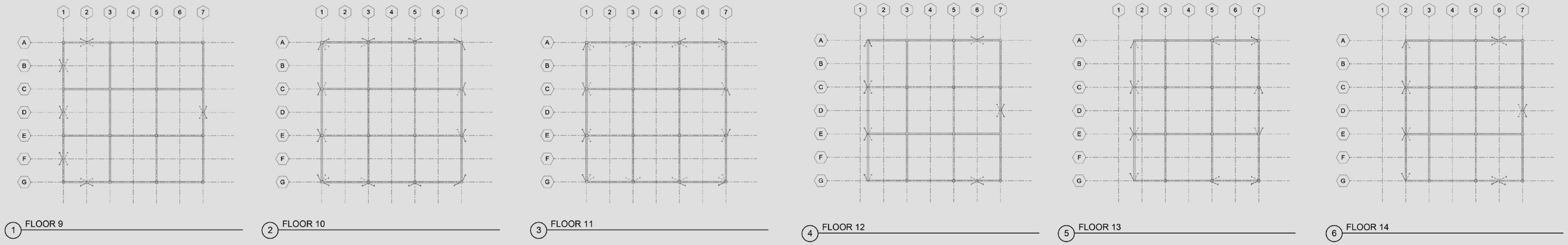
Given construction documents for the existing hospital building, a base ETABS model was generated for analysis. During this phase, dead load was applied to the floors and scaled ground motions were run through the structure. The dominant mode shapes of the model were mainly torsional, due to the irregular brace design.

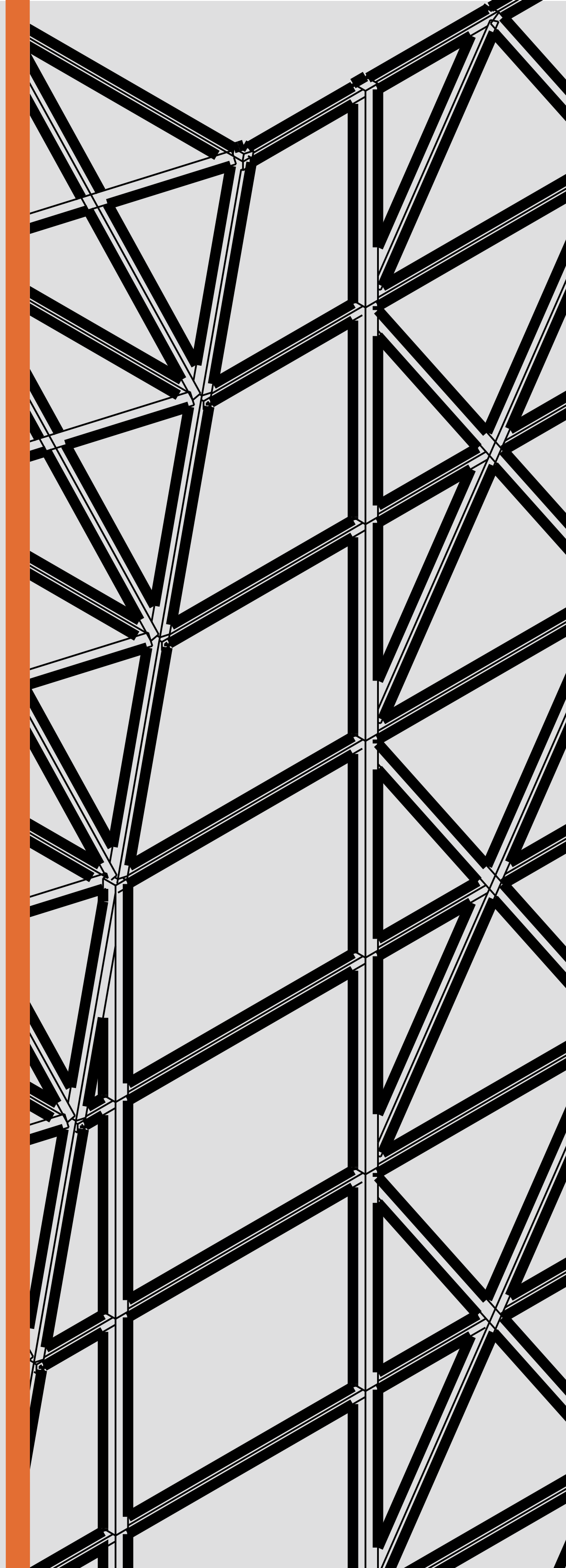
Maximum member forces for the existing structure were compared to hand calculated capacities to determine if any failure occurred. Further outputs of inner-story drift ratios were displayed, where the maximum across all ground motions occurred in the north-south direction between stories 6 and 7.

ADDITION

After a series of iterations to combat the existing irregular design, an extension brace layout was selected. The chosen design incorporated single story X-bracing along the sloping face to match the existing scheme and maintain architectural appeal. In addition, two-story X-bracing was placed at the east view in an effort to eliminate torsional irregularities. Two-story X-bracing was also placed on the north and south faces to provide stiffness in those directions. The final iteration incorporates a belt truss at the tenth story to drag forces from the addition to the existing structure.







Retrofit

RETROFIT

The retrofit scheme of adding braces was selected to combat high displacement ratios and to accommodate the failure of the existing structure with the addition. A series of vertical braces were added from the base to floor 10 on the east face of the building.

REDSEIGN

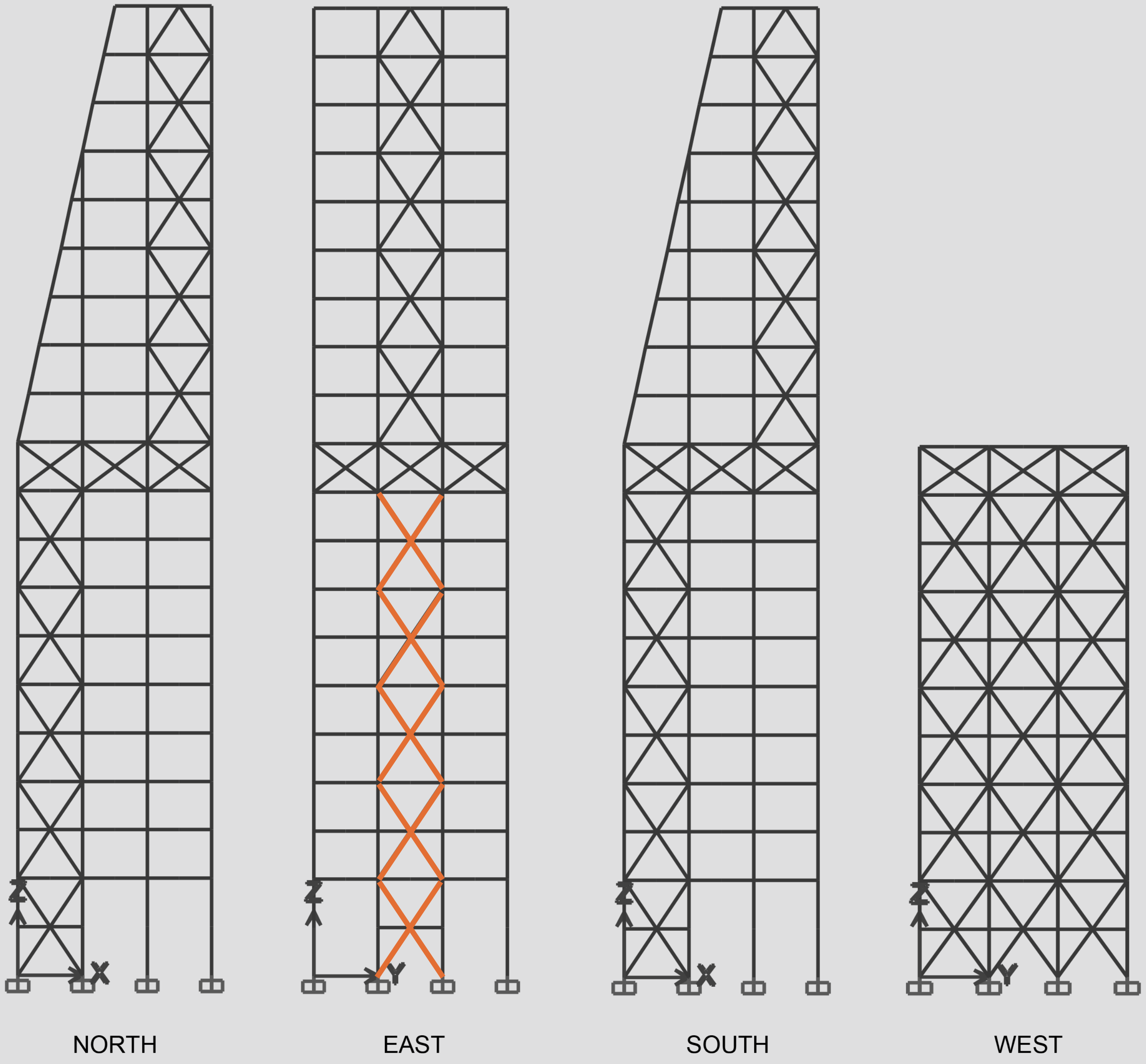
This series of five, two-level braces, in combination with an adjusted bracing layout for the modified addition, proved to allow the structure to perform well in terms of member capacity and drift. An edited scheme for the addition was that of eliminating braces on the outer bays of the east face, to reduce stiffness. Collectively, this final design performed well in all regards.

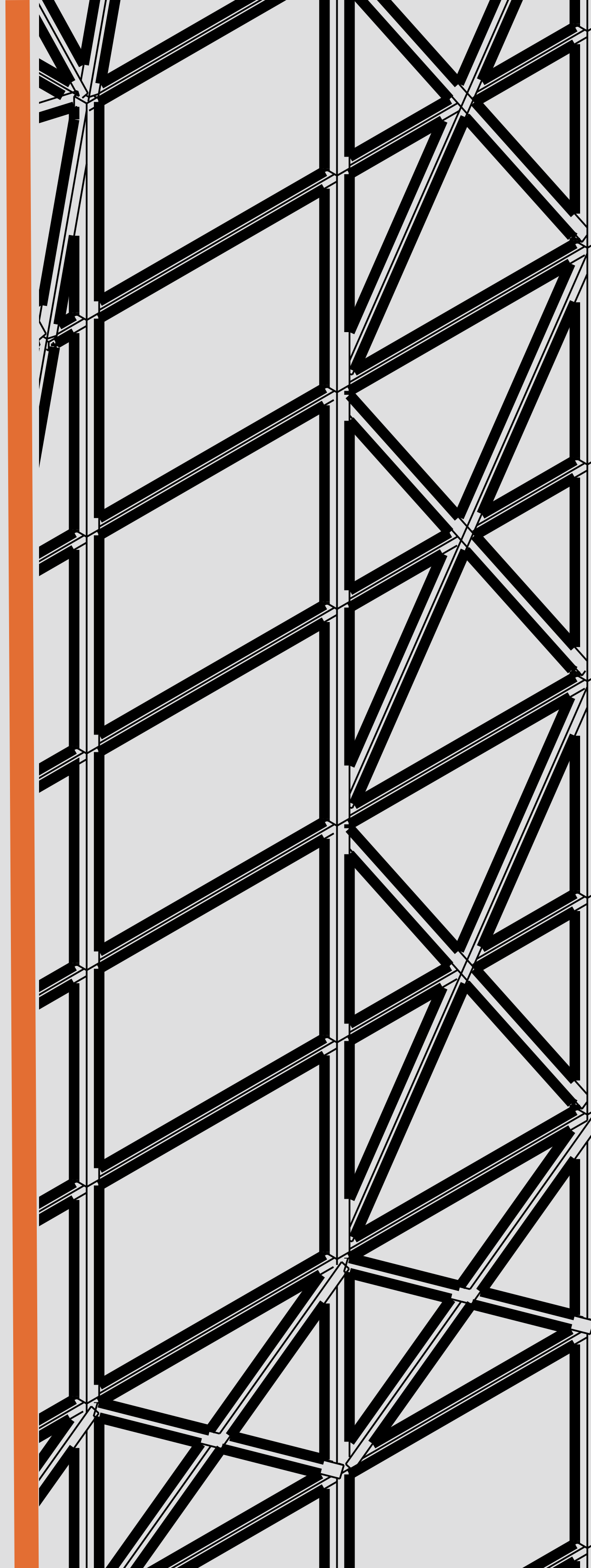
COLLAPSE RISK

The annualized collapse risk (λc) was calculated by combining collapse fragility and the seismic hazard curve resulting in a value of 0.0396%. Assuming a Poisson distribution of the probability of collapse, the 50-year collapse risk (x) was calculated to be 1.96%. This value exceeds ASCE-7 guidelines which set a maximum limit for the collapse risk in 50-years to be 1%. Therefore, a retrofit scheme with a minimum collapse probability reduction factor (m) of 1.9682 is necessary to reduce the 50-year collapse risk of the existing hospital with addition to 1.00%.

FINAL WEIGHT = 0.474 pounds

RENTABLE FLOOR AREA = 2325 in^2





EERI_final_presentation_210415_Seismicdesigncomp