Problem:

Due the COVID-19 pandemic hospitals around the world have needed more equipment and space. In this effort we were tasked with designing a extension of a current hospital, so there are there are specific criteria that shall be met by code for being an essential facility as well criteria that the client would request.

The current hospital existed near the ports of Seattle, so designing in this region will require a little extra work because it is a seismicity prone area but given it's a seismicity prone area the existing structure that needs an addition is old and may not have been designed/built to with stand ground motions that are now required by code.

Preliminary steps to rectify problems:

1. Analysis of the Existing Structure and determination of failure modes
2. Analysis of Addition without retrofit to existing structure
3. Analysis of Addition with retrofit to existing structure.

- During each analysis members were analyzed using wood properties of balsa wood provided by the SLC with the National Design Specification for Wood Construction.

- Member sections where members exceeded demand capacity ratios were assessed to determine if an alternate load path could be created in order to reduce load/stress applied to the member.

ARCHITECTURAL DESIGN

Krill Tower 2.0 incorporates a very intricate design, with a sleek and bold manner of showing. The super bracing was utilized during the retrofit process in order to optimize strength with limited changes to the existing structure. The super bracing also provides the structure a burst of character. Since this structure's shape is so unique, we brainstormed to create an innovative design that has never been seen before by the combination of both super bracing and conventional X bracing.

Balconies are provided of outdoor areas with fresh air and vegetation. And the building materials utilized in construction help meet the LEED Credits desired.

The design of the building is inspired by the Douglas fir, a native tree to the Puget Sound region. The upper floors tapered, and stacked balconies are designed to resemble the layered foliage of the tree. The natural also seemed fitting as the inspiration for the architectural design due to the efforts of the design to reduce the heat island effect.

Building Features

- **19** stories high totaling up to 60 inches tall
- Provides over **2000** square inches of floor area
- System lobby floor height doubled for space

STRUCTURAL DESIGN

Seismic Load Mechanism

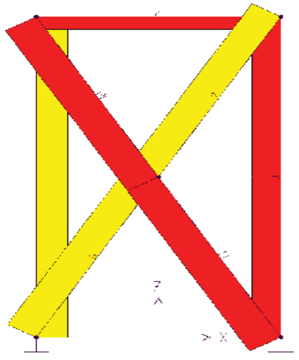
Earthquake forces originate from the fictitious force due to the ground acceleration and the mass source of the building. It acts as a lateral load and the building behaves much like a cantilever beam. In order to resist this lateral load, Krill Tower 2.0 has incorporated two main innovative solutions.

1. Conventional X bracing Design (before retrofit but with addition)

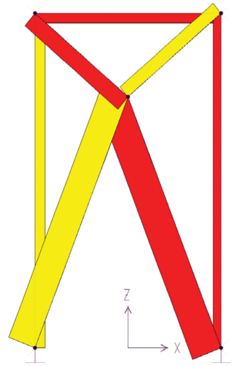
The X bracing utilized was done so in order to make the addition to be ridged. Due to lack of bracing on the East of the existing structure the X- bracing was strategically placed order for the load path to go to the braced side of the exiting structure. The X- bracing was placed in a taper formatted in order to make subtle changes so irregularities in load path will not occur, which may over stress members.

2. Vertical Bracing Design Using Topology Optimization (when retrofitted)

Unlike the conventional X bracing design, Krill Tower 2.0 utilizes the Super Braces which yield a better strength-to-weight ratio (SWR). Compared to the X bracing, Super Braces put less compression force on the outer column which is the most critical one due to its longer length.



X bracing:
SWR = 156



Super Bracing
SWR = 337

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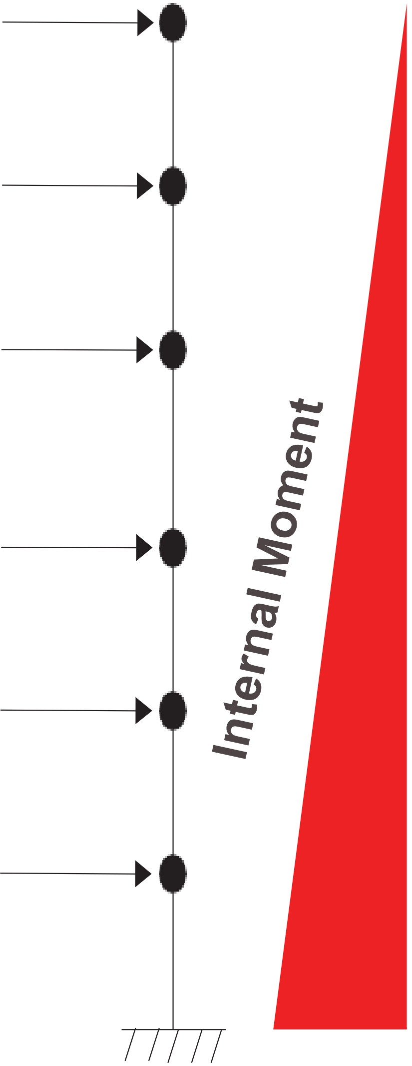
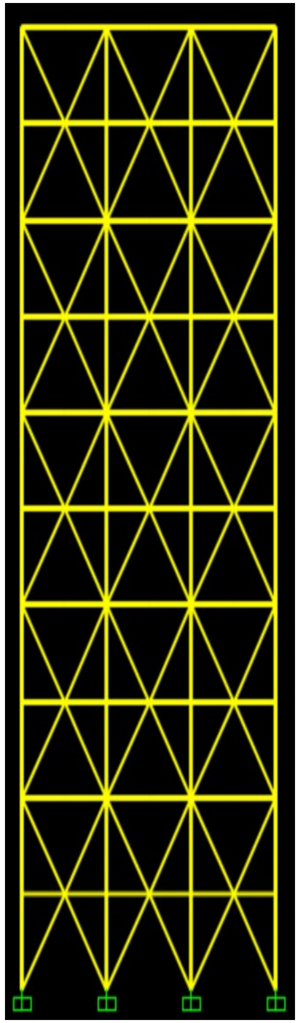
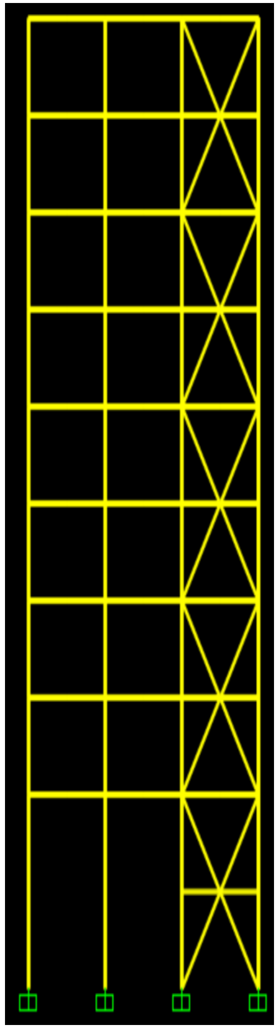
STRUCTURAL DESIGN

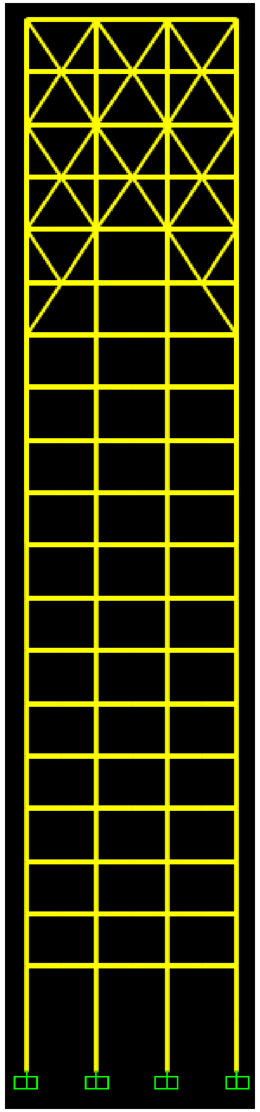




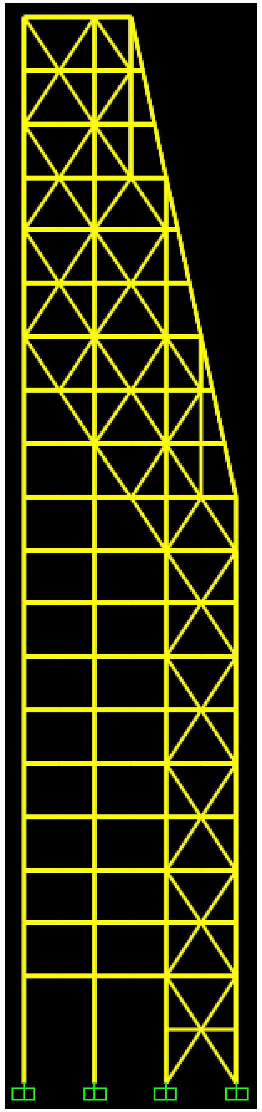
Existing West Elevation



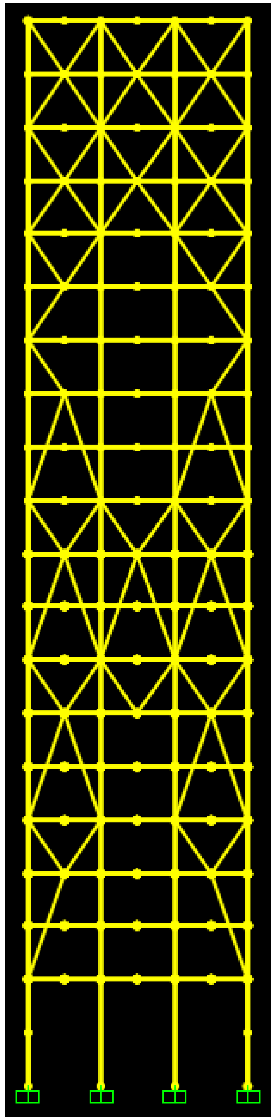
Existing North Elevation



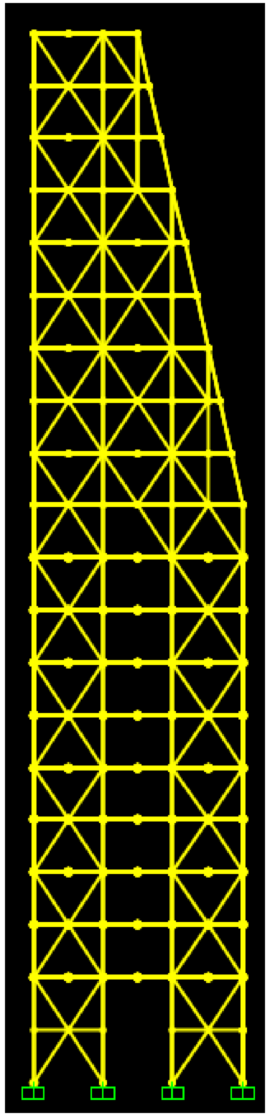
Addition East Elevation



Addition North Elevation



Retrofitted East Elevation



Retrofitted North Elevation

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PREDICTED STRUCTURAL BEHAVIOR

The structure was analyzed using the Time History data provided by the SLC. Uniform loads were applied to the structure to the certain beams using tributary width. Self weight of the structure was also included in the analysis. The results retrieved from the SAP 2000 analysis are shown below.The results after the retrofitting were significantly better than the results of the existing and existing with out the retrofit.

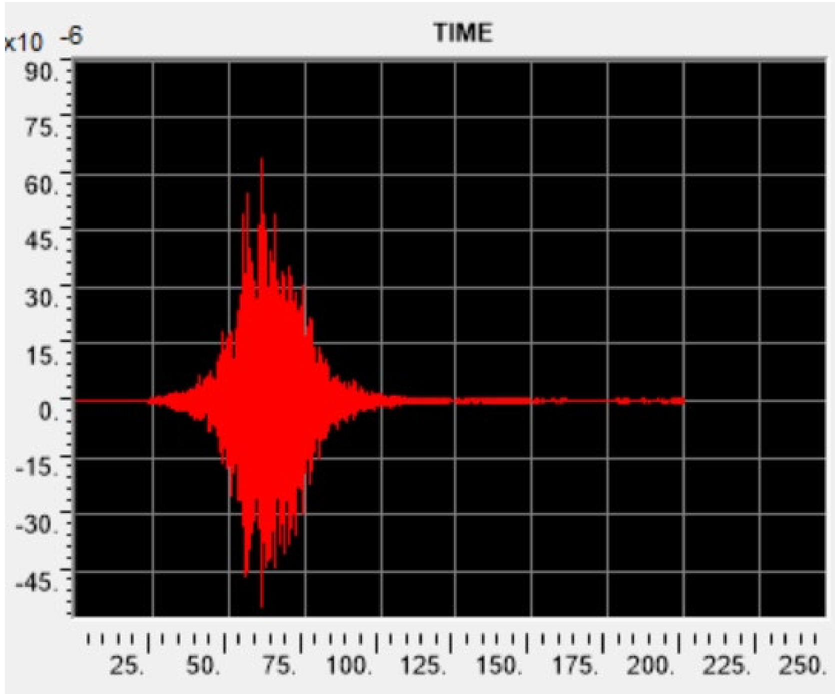

Figure 9.a. Roof Acceleration for TH2 in the N/S direction **-0.000064 in/sec^2**

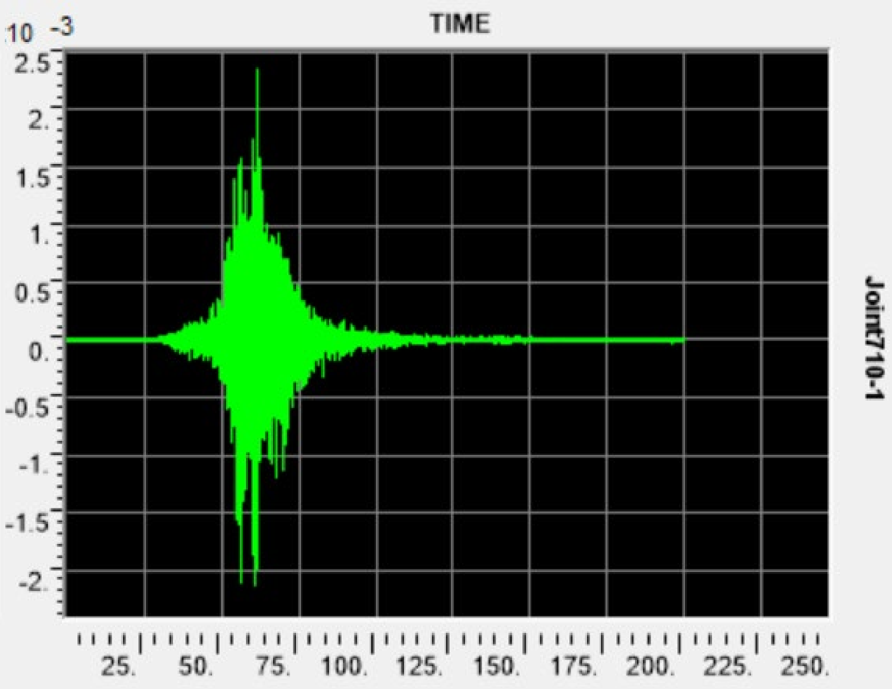

Figure 9.b. Roof Displacement for TH2 in the N/S direction **0.0023 in.**

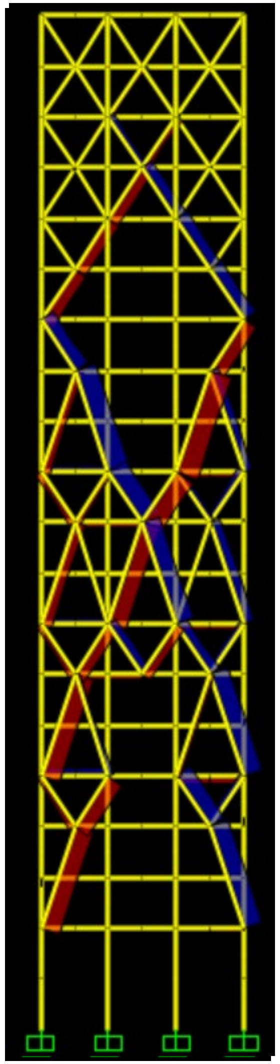

Figure 10.a.
Internal Axial Forces for Retrofitted Structure, East Elevation View

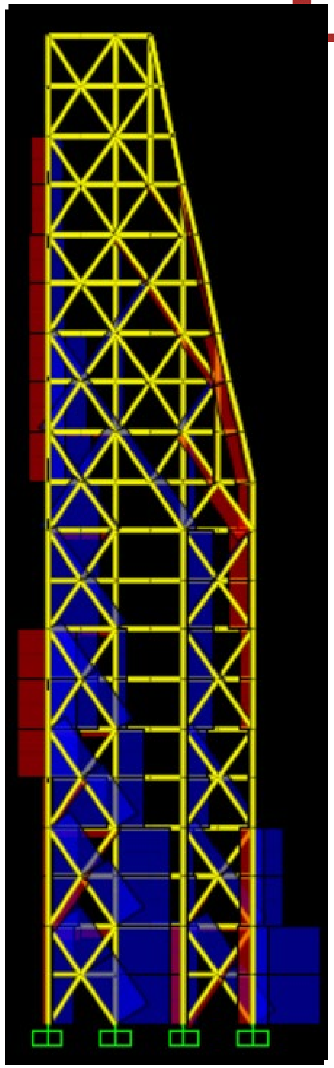

Figure 10.a.
Internal Axial Forces for Retrofitted Structure, North Elevation View