EMERALD HOSPITAL CENTER

University of Illinois at Urbana-Champaign

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Special Thanks To
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GEOTECHNICAL & SEISMICITY EVALUATION

EVALUATION PERFORMED AS PER ASCE 7-16

CATEGORIZATION

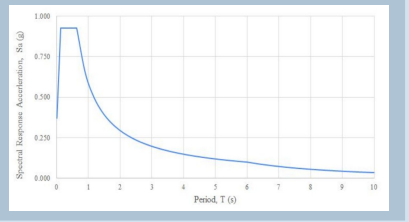
Site Class F
without ground improvement
Seismic Design Category F

Site Class D
with ground improvement
Risk Category IV

SEISMIC RESPONSE SPECTRUM

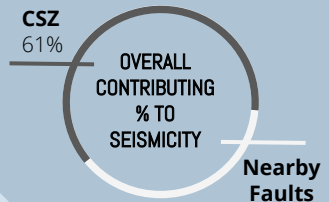
Spectral acceleration

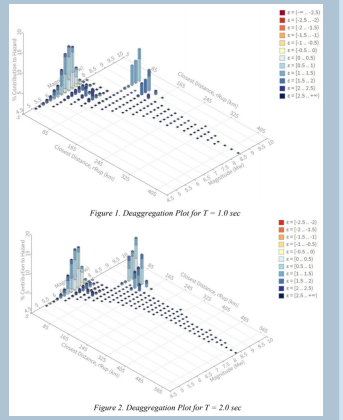
- Existing: 0.587
- Existing w/ Addition: 0.294



SEISMIC DEAGGREGATION

Largest % contribution came from the CSZ for both analyzed periods of 1.0 s and 2.0 s.





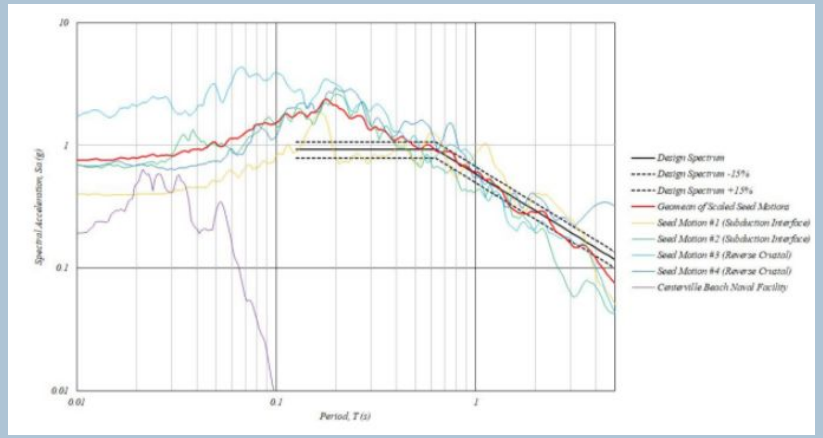
SITE CONDITIONS

Located in the heart of Seattle downtown, the structure sits in highly seismic region whose landscape has been shaped by a history of repeated tectonic activity and glaciation. The soil was found to be susceptible to liquefaction between 10 to 55 ft and 96 to 98.5 ft below grade due to: (1) location below water table, (2) low-density soils, (3) loosely/poorly graded soils. Ground improvement techniques considered: dynamic compaction, compaction grouting, vibroflotation.

SCALED TIME HISTORIES

Seed motion recommendations based on tectonic similarity

- **CSZ:** subduction rupture mechanism
- **Nearby faults:** crustal reverse rupture mechanism
- **Nearby faults w/ pulse:** Cape Mendocino (Centerville Beach Naval Facility)



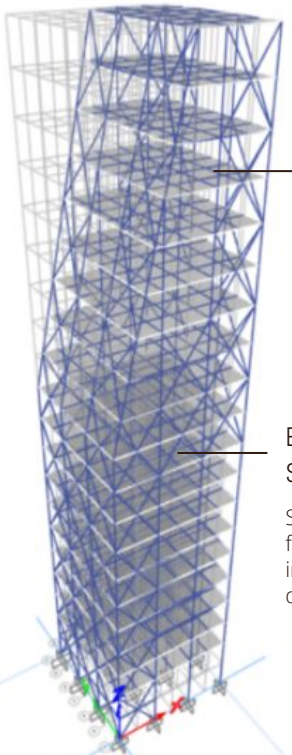
SCALE FACTORS

Seed Motions
#1 - 1.5
#2 - 3
#3 - 1.4
#4 - 0.8

Cape Mendocino - 0.6

EERI Student Leadership Council

INITIAL STRUCTURAL DESIGN CONCEPT



EXISTING W/ ADDITION

Sufficient members, failure in y-direction interstory drift

EXISTING STRUCTURE

Sufficient members, failure in both interstory drift directions

MAX. INTERSTORY DRIFT RATIO	*LARGEST D/C RATIO per MEMBER*
X-DIR. for TH3 4.8% **Y-DIR. For TH3** 26.3%	**BEAM axial** 0.64 **BRACES axial** 0.06 **COLUMNS compression** 0.93

ITERATION PROCESS

Our team decided to design a 19-story structure with tapered west face to avoid pounding with an adjacent structure. During the design process, various types of bracing were considered, however, to honor the existing cross braced system on the west face, braced frames were ultimately chosen. Location of braces were placed to reduce torsional irregularity in the y-direction and to provide a gradual load path from the West to East face braced systems.

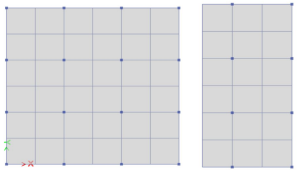
CHOSEN STRUCTURAL DESIGN CONCEPT PRE-RETROFIT

- Optimize floor area to reduce construction impact to hospital function and maximize hospital space capacity and flexibility. (floor plan)
- Braced frame system to work in unison and act symmetrically with existing system. (braced frame schematic)
- Laterally constrain West face to reduce torsional effects in y-direction ground motions and increase system stiffness.

ANALYSIS & PERFORMANCE

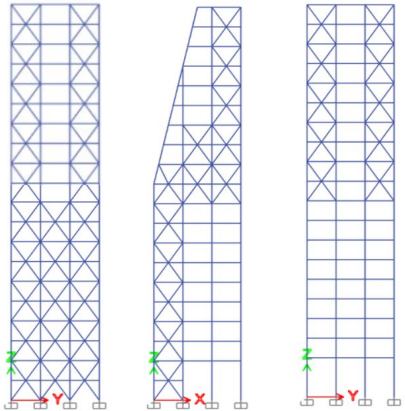
A modal and time history analyses were performed in ETABS to inform the design decisions. It was determined that both the existing structure and existing with the addition had sufficient member design strength, however, failure was seen in the interstory ratio drift checks for both. Excessive drift was the controlling factor for our design with the possibility of a failure mode of first column buckling in the lower stories, as these were the most critical members in the system. Therefore, the future retrofit had to address these main issues of drift, torsion in the y-direction from eccentricities in the system.

TYPICAL FLOOR PLAN



FLOOR 1 TO 11 *ROOF*

WEST NORTH/SOUTH EAST

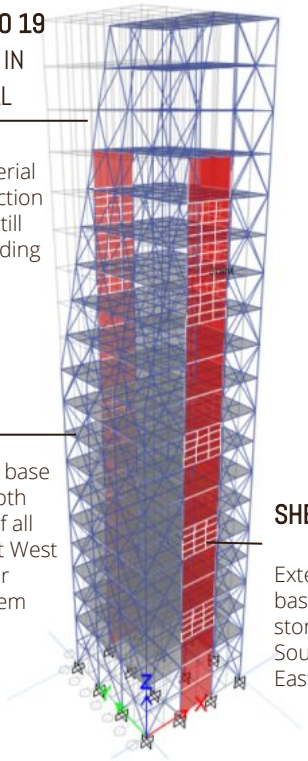


STORY 17 TO 19
REDUCTION IN STRUCTURAL SYSTEMS

Reduce material and construction costs while still meeting building demands

BRACED FRAMES

Extend from base to roof on both outer bays of all faces, except West face to honor existing system



SHEAR WALLS

Extend from base to 17th story on North, South, and East faces

RETROFIT SCHEME

RETROFIT TECHNIQUES CONSIDERED

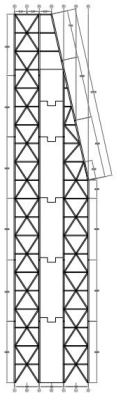
- Addition of structural systems
- Column jacketing

DESIGN

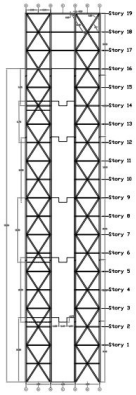
The proposed retrofit scheme uses a combination of exterior cross-braced frames and shear walls to work in conjunction with the existing structural system and keep impact to the existing hospital minimal. Cross-braces on the two outer bays of each face were added/extended up the full height of the structure to work in conjunction with the existing system. To provide additional stiffness and reduce drift, shear walls were added in the middle bays of the North, South, and East face. From modeling the structural response, it was determined that extending all middle bays from the base to the 17th story floor still provided adequate strength and stiffness within the design limits while reducing structure volume and weight.

CONSTRUCTION DOCUMENTS

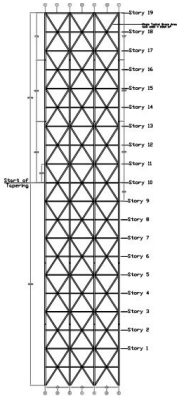
WEST



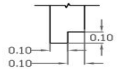
NORTH/SOUTH



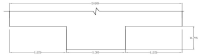
EAST



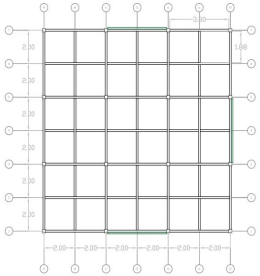
COLUMN NOTCH CONNECTIONS



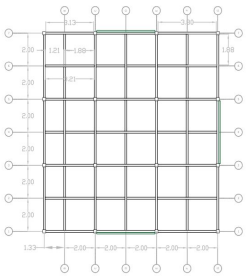
SHEAR WALL T-SHAPE CONNECTIONS



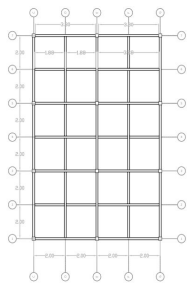
TYPICAL FLOOR 1 to 11



FLOOR 12



FLOOR 17



ANALYSIS AND FINAL RESULTS

MAX. INTERSTORY DRIFT RATIO	*LARGEST D/C RATIO per MEMBER*	*FINAL VOLUME*	*TOTAL WEIGHT*	*TOTAL RENTABLE FLOOR AREA*	*COLLAPSE RISK*	*MINIMUM REDUCTION FACTOR*
X-DIR. for TH3 4.7% **Y-DIR. For TH3** 4.8%	**BEAM shear** 0.43 **BRACES axial** 0.03 **COLUMNS compression** 0.27	563 in^3	2.61 LB	2448 in^2	0.02	1.85

ARCHITECTURAL DESIGN

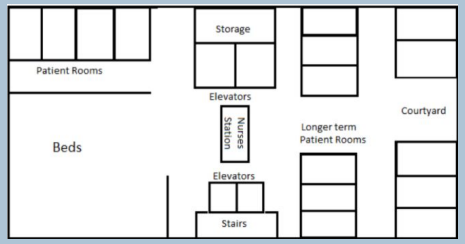
Emerald Hospital Center is inspired by Seattle's moniker, the "Emerald City" and draws from the abundant greenery surrounding the region. The facade features multi-functional properties that are designed both to provide beauty to Seattle's iconic skyline and reduce environmental impact while increasing occupant comfort within the hospital.

See feature descriptions to the right.

INTERIOR LAYOUT

All hallways and corridors were designed to be at least 6 ft wide to comply with social distancing guidelines from COVID-19. Layouts were developed based on high mobility and flexibility to meet rapid changes in demand and capacity levels.

To ensure simple, direct routes, floor components were placed in a circular fashion with nurse stations centrally located in the building with patient/occupant spaces close to the windows to promote a tranquil atmosphere and aid in patient recovery.

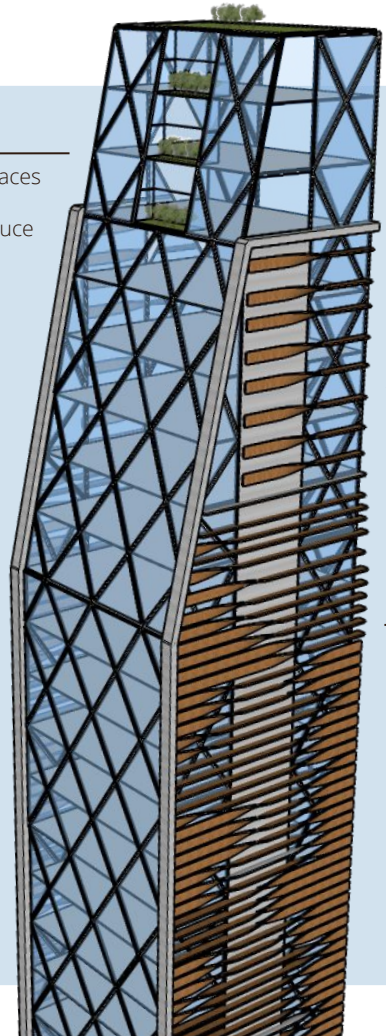


GREEN SPACES

Provide tranquil spaces for occupants and simultaneously reduce heat island effect

RAINWATER HARVESTING SYSTEM

Utilizes Seattle's precipitation levels to collect rainwater and decrease water demand



EXPOSED SYSTEMS

Exposed braced frames allow for increased daylighting and visibility

UNDULATING TIMBER FINS

Allow for natural daylighting to reduce energy costs, while providing occupant privacy and comforting atmosphere

LEED BD+C (Healthcare)
This hospital will aim to achieve
LEED Platinum Certification.