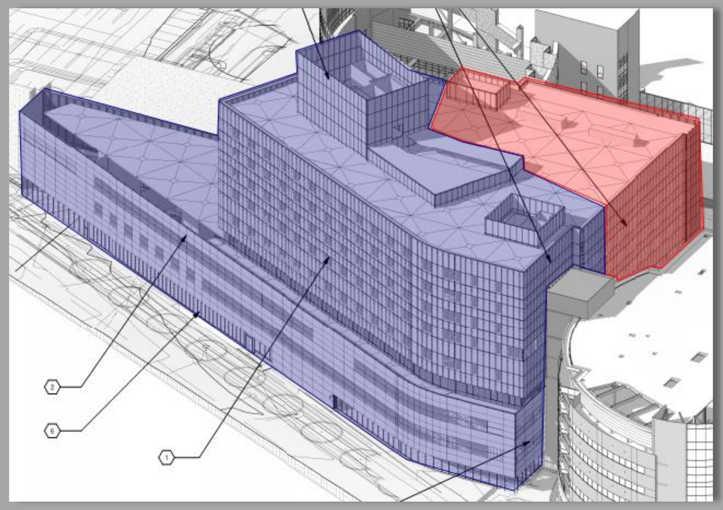


Children's Hospital and Medical Center

Project Overview

Omaha Children's Hospital

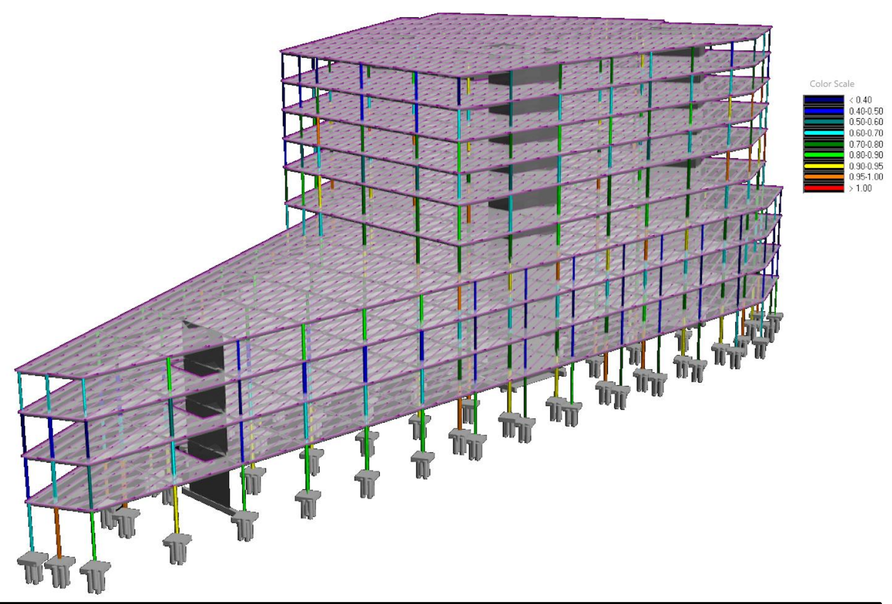
- Building addition is 390,000 square feet
- 3 story podium at 50,000 square feet per floor
- 6 story tower at 35,000 square feet per floor
- Overall project budget is $290 million

Building Systems Designed

- Mechanical, plumbing, fire protection, medical gas
- Electrical, Lighting
- Structural

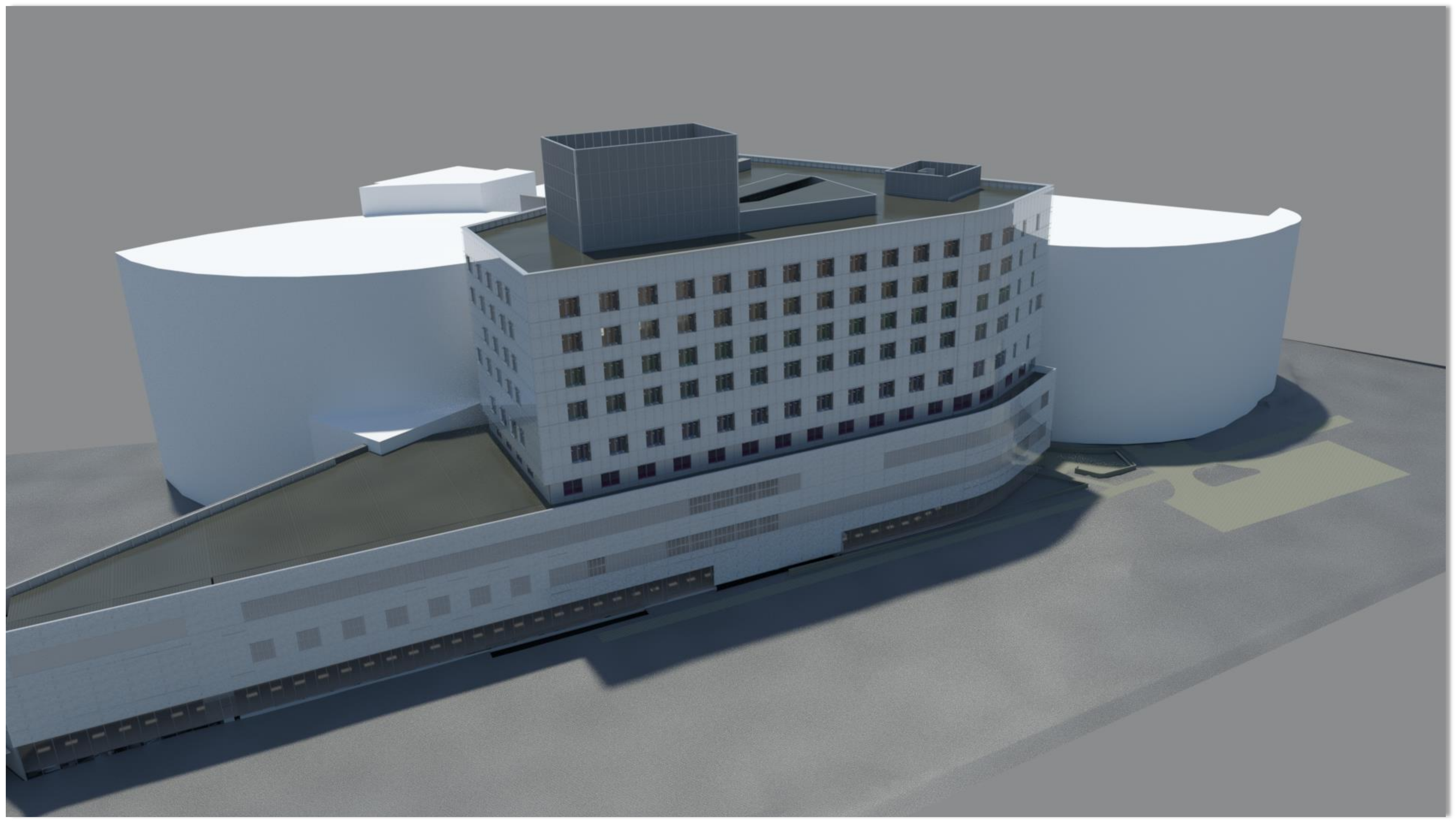
Rooms Designed

- PICU, NICU, HEMONC, CCU
- Patient rooms
- Delivery rooms
- Procedure rooms
- Storage and office space
- Various other room types



Structural Design Highlights:

- Drilled shafts used for foundation design
- Grade beams installed to resist lateral earth pressure
- Main gravity load resisting system comprised of composite steel beams
- Steel deck (3VL20) with 4-inch normal weight concrete accounts for vibration requirements
- Concrete shear walls for elevators and lateral load resisting systems for stair shafts
- Main façade made of unitized curtain walls on every floor



Multidisciplinary Approach

Ceiling Space Competition

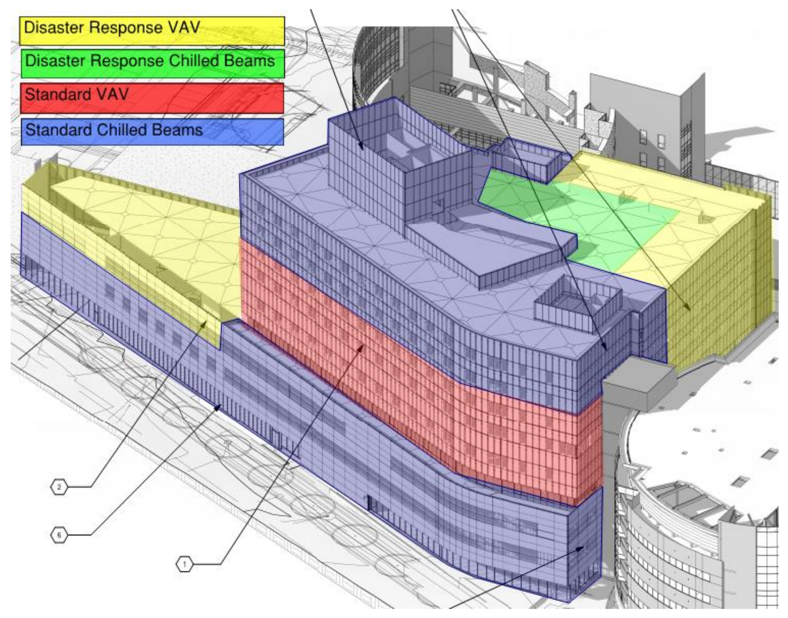
- Structural team minimized beam depths to allow large plenum space for other system designs
- Mechanical team utilized chilled beams with integrated lighting systems to assist in diffuser/lighting coordination in ceiling space
- Minimization of plenum usage provided the potential to reduce floor to floor heights, thus saving money for the owner, if the owner was interested

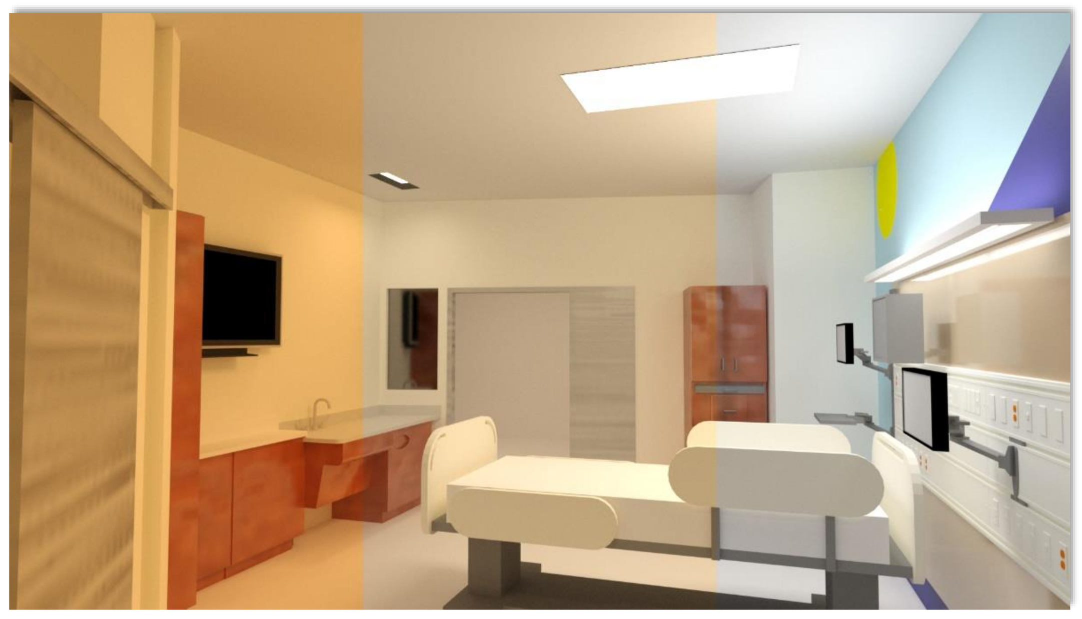
Façade Design

- Windows were tilted in to reduce glare and solar heat gain' on the Northeast and southeast façades
- South and west façade had horizontal and vertical shading devices added

Smart Building Integration

- nLight Eclypse system monitored HVAC and lighting systems
- Public terminals displayed real-time building energy savings





Mechanical Design Highlights:

- Chilled beams utilized where ASHRAE 170 did not prohibit use
- Chilled beams reduced required airflow by 70%
- Energy recovery reduces airflow where code allows
- Reduction in airflow allowed for a large 8,500 square foot mechanical room to be designated as give-back space for the hospital
- Occupancy monitoring and scheduling to reduce temperature setpoints for further increase in energy savings
- Mechanical Design showed a 44% energy savings versus an ASHRAE 90.1 baseline model
- N+1 redundant primary systems allow easy maintenance and safety

Electrical and Lighting Design Highlights:

- Robust redundancy with N+1 backup engine generator system
- Life safety, critical, and equipment branches within the essential electrical system
- Deconfliction of multidiscipline systems with medical headwalls and service columns
- Circadian Rhythm LED lights to help with patient healing
- Wireless patient tablet for integration of lighting and shade control
- RFID tracking system for drug and patient tracking

Public Welfare

Disaster Response Rooms

- Emergency command center
- Conference rooms converted into alternative care suites

Operational Areas on Emergency Power

- Disaster response area consists of one third of hospital capacity
- All procedure rooms throughout the building require emergency power so power is not lost mid-operation

Structural Considerations

- Structural design allows basement to act as storm shelter

Mechanical Considerations

- Ultraviolet germicidal irradiation used for infection control
- Pressurization prevents spread of contaminated air

Electrical Considerations

- Essential electrical system comprised of life safety, critical branch, and equipment branch connected to the backup system

Knowledge Gained

Through collaboration with industry professionals the team gained knowledge in many areas not covered in the school curriculum

- Hospital Design
- Disaster Response Areas
- Smart Building Integration
- Efficient Building Enclosure

The team also gained personal skills that are valuable in both the industry and life in general

- Team Communication
- Discipline Integration
- Time and Stress Management

Knowledge was also gained on the building design process and its phases. These phases included:

- Schematic Design
- Design Development
- Construction Documents

Industry Collaboration

Overall industry involvement with 3 student teams in this project

- 18 licensed professional engineers, 4 engineering interns, 4 professional architects and 2 others served as mentors to the 28 students
- Additionally, 27 licensed professional engineers and 11 engineering interns served as evaluators, evaluating team documents and presentations.

Team-specific industry involvement with the project

- Each discipline (structural, electrical, and mechanical) of the team had a primary and secondary mentor
- Licensed team architect assists with broad building design

Specialty mentor involvement with the project

- Acoustics
- Medical gas
- Low voltage systems
- WELL building design
- Hospital architecture

Abstract

With great pride, engineering student teams have undergone the task of designing the new addition to the Children's Hospital and Medical Center in a city. For this project, careful attention was given to design solutions for the owner's three specific design challenges: a high-performance building enclosure, smart building integration, and disaster response planning. Student design teams placed an emphasis on the development and integration of innovative design solutions, while engaging in robust collaboration and peer review. Students gained experience working in a manner similar to typical building design and construction industry professional. Teams consistently worked together to integrate innovative design solutions. Through this close collaboration with not only team members, but also with a large pool of industry mentors and evaluators, the students gained an unprecedented amount of knowledge in a single academic year. Through this experience, the students gained confidence in their complex designs that pushed the boundaries of what was expected. Owner challenges were met with an excitement to create unique solutions, all while adhering to the budget provided. This project had a strong impact on all members of the design course that will prove beneficial as they soon begin their careers in the architectural engineering industry.

Teams addressed the overall building systems via written submissions communicating the design intent and showing proof of concept, complete with supporting calculations within the outlined scope. All designs complied with code and zoning requirements. The following sections describe some of the key systems integrated across design disciplines as well as lessons learned from deeply engaged professional engineers and faculty.

Project Description

Student teams were to design the Children's Hospital and Medical Center expansion, the Hubbard Center for Children, in a city. This 390,000 square foot addition will focus on providing excellent care to the regional population, while also growing to provide a national presence. This facility will consist of a 6-story tower upon a 3-story ancillary base. The base will be made up of three 50,000 ft^2 floors with a 30,000 ft^2 mechanical floor below grade. The new expansion will connect to the existing hospital facility through this podium base. The tower will be comprised of six 35,000 ft^2 floor plates. The addition includes an expansion of the Neonatal Intensive Care Unit (NICU) and Pediatric Intensive Care Unit (PICU), a new Cardiac Care Center, Hematology-oncology (HEMONC)s, a Fetal Care Center, and other critical spaces essential to a cutting-edge, modern hospital. The tower will also have a dedicated mechanical floor. Additionally, the helipad will be relocated to the top of the new tower. This hospital's prominent location is along the busy road in a cities primary east-west traffic vein. The project budget was $290 million.

The owner tasked design teams with three additional challenges:

1. Designing a high-performance building enclosure
2. Smart building integration
3. Disaster response planning

Teams additionally considered the important aspects of providing healthcare to children and their families to develop individual team goals for this project. The new addition to Children's Hospital is a facility that should make the patients and their families feel comfortable and at ease while creating a platform for excellent care. Because of this, the overarching design goal for this project is to create a healthcare facility able to excel in patient-centered care, provide peace of mind for patients and loved ones, while also instilling joy and wonder through child-friendly design in a pediatric care environment. With these integration challenges in mind, some of the individual teams' design innovations are described here, though throughout this document, more elements of design emerge from individual teams.

High-performance enclosure

The façade is comprised of a rain screen unitized curtain wall with a six-inch air gap on both the podium and tower of the building. White aluminum metal over eight-inch mineral provides insulation. This maintains the building's sleek and sturdy look while not appearing too heavy. The podium's windows form lines that streak across the building, mimicking the traffic of the busy road. The southeast façade windows tilt to the east and the northeast windows are tilted to the north. The tilting of the windows allows the public façade to appear clean and free of exterior shading devices. The mechanical systems benefit greatly from these window tilts because of reduced cooling load, since direct sunlight will not penetrate the least insulated part of the building. Daylighting optimization of the building enclosure reduces energy consumption and supports use of daylighting by staff and patients. Exterior glazing supports considerations for minimizing glare and direct heat, decreasing energy demand.

Disaster response planning

An emergency operations response center is located on lower level 3, and alternative care spaces are located on levels 2, 4, 5, and 6. Lower level 5 and the southwest side of each floor were selected as spaces with increased support for stability during disaster events. The mechanical team separated the southwest side of the building's air handler and connected it to emergency power. This will keep the critical areas pressurized and allow the emergency area to be comfortable and safe for occupants during emergencies. The whole structure is designed to resist seismic forces and a sustained wind speed of 90 mph even though the southwest side of the building is somewhat enclosed by the existing hospital. Concrete shear walls were designed around the egress stair shafts to provide safe shelter during a fire. The receptacles in this area shall be on critical branch power to provide the needs for care in the event of a continued disaster leading to power failure.

Additionally, integration with the mechanical disaster plan is completed by providing ⅓ HVAC demand on the equipment branch connected to the generator source. This connection allows continued HVAC equipment operation during a power outage from a storm. Alternative care sites for examination lights are placed in two locations in each conference room allowing for the treatment of up to 16 additional people at a time in the event of the loss of the procedure rooms and pre- and post- rooms on level 1 and lower level 1.

Smart building integration

The nLight Eclypse building control system allows for the monitoring of HVAC, lighting systems, energy consumption, and room temperatures. It will help with management and maintenance of the mechanical and electrical/lighting systems. Patient room have daylight sensors so lights will dim when enough light is present. Rooms also are equipped with a tablet mounted to headwall that allows access to the internet, video conferencing, lighting, and automatic shade controls. The lighting and shades are controlled through a touch screen wall mounted controller that is Bluetooth enabled, allowing patient to control these from their smart devices without the need to move. Finally, patient tracking through RFID technology will be used to adequately track patients, medication, and status.

Collaboration

Forty-five (45) licensed professional engineers, fifteen (15) engineering interns, four (4) professional architects and two (2) others, sixty-six (66) in total were robustly engaged with twenty-eight (28) students on three teams. The engineers and architects served as mentors or evaluators throughout the two-semester design process. Licensed PEs were integrated into all stages of development. Each team was comprised of students from three disciplines—structural, mechanical, and electrical. For each team, disciplines had both a primary and secondary mentor that were PEs. Each team was also mentored by a licensed architect to assist with the broader picture. In addition to these assigned team mentors, specialty mentors were available to all teams. These additional mentors specialized in acoustics, medical gas, low voltage systems, WELL building design, construction, or hospital architecture. The PE mentors were available for project development collaboration. However, throughout the process, a schematic design presentation, an initial design presentation, and a finalized design development presentation were given by every team. At each of these presentations, over 30 professional engineers volunteered to attend, either in person or remotely, to grade and give feedback on the documents and presentations.

Interaction between students, faculty, and professional engineers

The faculty interacted with students and PEs by providing basic project requirements and general guidelines to enhance innovation. This left most of the specific guidance to industry members with applicable project design experience. To ensure the PEs evaluating documents and presentations were knowledgeable of hospital project design, faculty provided a thorough project description, encompassing the owner-provided project challenges, general project description, and other applicable areas that student project designers were required to meet. Student–industry interaction was also facilitated through the use of multimedia communication methods, such as email, text messaging, in-person meetings, and phone- or videoconferencing. In these interactions, brief questions to lengthy design issues were covered.

Protection of Health, Safety, and the Welfare of the Public

Portions of the building were designed to serve as an emergency command center in the event of a natural disaster. Structural teams designed the alternative care site to withstand an EF4 tornado. Mechanical teams provided additional cooling and heating capacity to the emergency command center to address the increased loads caused by the increase in occupancy during emergencies. In addition to structural challenges, the electrical and mechanical teams provided a plan to operate the building for a minimum of 96-hrs on emergency power, meeting the basic requirements of NFPA 110, FEMA 543, and FGI guidelines.

Day-to-day safety of the patients, staff, and general public is protected by multiple systems within the hospital. Legionella prevention followed ASHRAE Standard 188 and in addition, faucet aerators were selected that prevents the water being retained within the aerator and acting as a potential legionella breeding environment. Emergency lighting systems maintain the lighting levels for safe navigation of the hospital in the event of emergency power loss.

Patient isolation rooms and operating suites were designed to maintain a negative pressure relative to the surrounding spaces. All air handling units serving the hospital spaces utilize a minimum of MERV 13 filters to prevent the circulation of contaminants and utilize ultraviolet lamps to kill mold and bacteria within the airstream.

Multidisciplinary Team Participation

In each team, the three disciplines—structural, mechanical/acoustic, and electrical/lighting—came together to design and discuss innovative technology and solutions to improve the overall design. The mechanical teams worked on HVAC systems, plumbing systems, and medical gas systems. Electrical teams did lighting engineering, electrical system engineering, and data transfer engineering. Structural teams worked on foundation design and all structural systems engineering. Together, teams performed cost analysis and worked on the construction engineering. Some design highlights for each discipline are outlined below.

Structural design highlights:

- Drilled shafts used for foundation design
- Grade beams installed to resist lateral earth pressure
- Main gravity load resisting system comprised of composite steel beams

- Steel deck (3VL20) with 4-inch normal weight concrete to account for vibration requirements
- Concrete shear walls for elevators and stair shafts to serve as lateral load resisting systems
- Main facade made of unitized curtain walls on every floor
- Prefabricated helipad (65' x 65') to accommodate Blackhawk UH-60 per AEI requirements

Electrical and lighting design highlights:

- Robust redundancy with N+1 backup engine generator system
- Life safety, critical, and equipment branches within the essential electrical system
- Deconfliction of multidiscipline systems with medical headwalls and service columns
- Circadian Rhythm LED lights to help with patient healing
- Wireless tablet for integration of lighting and shade control
- RFID tracking system for drug and patient tracking

Mechanical design highlights:

- Chilled beams utilized where ASHRAE 170 did not prohibit to reduce energy consumption
- Chilled beams reduced required airflow by 70%
- Energy recovery reduces airflow where code allows
- Reduction in airflow allowed designation of 8,500 SF mechanical room as give-back space
- Occupancy monitoring and scheduling reduced temperature setpoints to increase savings
- Energy model indicated a 44% energy savings versus an ASHRAE 90.1 baseline model
- N+1 redundant primary systems allow easy maintenance and safety

Other professions involved in project's design

The project included only three disciplines shown above. However, teams were provided with architecture mentors to help students understand the overall building concept. Also, a report from geotechnical engineers was provided for consideration by the structural students who need to understand the nature of the ground and soil on which they designed the foundation.

Knowledge and Skills Gained

With their broad basis of experience, industry mentors provided a rich well of knowledge for students to draw upon and learn from. Through collaboration with these professionals, teams were able to experience professional-level practices about facets of the field not covered in coursework. This project also provided a unique opportunity for students to learn about the codes and standards typically used for hospital design. Allowing teams to learn about advances in healthcare, focus was placed upon designing a facility that placed patient needs and comfort at the forefront of the decision-making process.

The project provided each team with the opportunity to work in a multi-disciplinary collaboration for possibly their first time. To ensure proper team and resource management, the teams used weekly meetings and pre-determined worktimes to collaborate. This resulted in learning how to properly manage a project from start to finish, with a construction document level submittal due at the end of the project.

Being an effective 'influencer' is imperative when competing against other firms for allocation of a project. This practice was similarly applied to this course and project. It was essential for teams to effectively communicate their design intent to the 'client' and perspective audience.

To understand a facility of this caliber, past project research was crucial to learn about healthcare facility design trends. This research led to selection of equipment and systems that are competitive in the healthcare environment. In addition, codes and standards drive design choices, so a developing a deep understanding of the codes and standards related to healthcare design was critical to understanding the choices to be made.