# *U.S. Department of Veterans Affairs (VA) Ambulatory Care Center*

## Project Description

As a capstone exercise, architectural engineering student teams, working with a budget of $86 million, were tasked with completing engineered designs of the structural, mechanical, and electrical systems for the U.S. Department of Veterans Affairs (VA) Ambulatory Care Center in Omaha, NE. The Care Center is a three-story 157,000 SF medical office building that expands upon the existing Omaha VA Medical Center Campus. The building focuses on providing outpatient care through three primary services – a dedicated women's health clinic, a radiology unit, and five ambulatory surgical rooms – and includes several other specialty clinics.

Three teams of engineering students (26 total) addressed unique design challenges with a collaborative approach, fully integrating the structural, mechanical, plumbing, acoustical, fire protection, electrical, telecommunication, and lighting systems. Each team consisted of two mechanical, two or three structural, and four or five electrical engineering students assigned to a mentoring team of professional engineers. The overarching goal of this two-semester immersive activity was to develop excellence in architectural engineering students and prepare them for realistic career experiences by carrying out a fully integrated, multi-disciplinary approach to the planning and design of cutting edge, high-quality, and operational building systems under the guidance of 57 industry volunteers. These volunteers included 51 licensed professional engineers (PEs) and other professionals who acted as either mentors (28 total) or evaluators (29 total) for the following team presentations and deliverables:

- Collaboration Plan (CP)
- Research (R)
- Schematic Design (SD)
- Design Development 1 (DD1)
- Design Development 2 (DD2)
- Design Development 3 (DD3)
- Specifications (SP)

Each team's integrated approach was applied to engineering system decisions throughout preliminary research, schematic design, and design development phases. 3D Autodesk Revit models were created to facilitate interdisciplinary coordination. Engineering designs were developed and detailed to enhance occupant health, safety, and comfort through daylighting, acoustic design, mechanical ventilation for indoor air quality, and controlling structural vibration. By implementing interdisciplinary collaboration and conscientious design choices, teams were able to create cohesive and quality designs that achieved WELL Silver Certification requirements. Design highlights showing extensive consideration of user experience and sustainability are detailed in the sections below.

## Collaboration of Faculty, Students, and Licensed Professional Engineers

Students and their engineering mentors addressed design challenges and developed solutions through extensive use of in-person meetings, phone calls, emails, cloud-storage document sharing, and video conferencing. This allowed for rich collaboration with industry professionals, maximizing access to their valuable time and input. Team members utilized these methods for subdiscipline discussions and seamless discipline integration. The presentation of progress milestones throughout the process were evaluated by licensed professionals both in person and from around the United States using video conferencing.

Over the two semesters the student teams worked with their mentors to develop progress milestone deliverables that included documentation and presentation of a Coordination Plan (CP), Project Research (R), Schematic Design (SD) with an SD progress report, and three Design Development (DD) submissions (two with progress reports). All the submissions and presentations were evaluated with significant verbal and written feedback from the reviewing professionals.

## Integration

Throughout the design of the Omaha VA Ambulatory Care Center, coordination between disciplines was emphasized to ensure a functional and cohesive design for the VA. Design elements that were coordinated include the perimeter structural grade beams with the utility entrances for the electrical and mechanical teams; coordination between all disciplines to support the modular ceiling unit in the operating rooms (ORs); essential electrical system (EES) coordination between the mechanical and electrical teams; structural slab openings coordination between all disciplines; and MEP device coordination for both ceiling and wall mounted elements.

## Electrical

The electrical team focused on designing resilient normal and essential power systems in the Omaha VA Ambulatory Care Center to allow the facility to support veterans for countless decades. To achieve this, the building's electrical system includes a 3000A main switchgear in a main-tie-main configuration. Similarly, (2) 300 kW/375 kVA generators serve the building's essential electrical system (EES). The facility's telecommunications design features a redundant backbone service for further resiliency considerations. Several special systems were also implemented into the design to meet the needs of an outpatient facility. These included a nurse call system, sound masking, audio-visual design, and security systems. Additionally, fire alarm and lightning protection systems were designed to meet code requirements. Lastly, the lighting designed for the facility aimed to support the student's human-centric design goal. A transitional concept was applied, using luminaires and controls to emphasize strong front-end spaces while facilitating relaxing patient care environments. A networked lighting control system was designed to provide flexibility and increased user control for staff and patients LED lighting and automatic lighting controls were specified to meet energy codes and reduce energy usage as part of the projects sustainability design.

## Mechanical

The mechanical team developed a hybrid design that met infection control and resiliency requirements for the VA while implementing innovative all-electric and sustainable systems. The use of a 170,000 SF geothermal bore field provides 460 tons of cooling and 3,200 tons of heating capacity. The facility uses a hybrid AHU-VAV system in ambulatory areas and a DOAS-WSHP system in MOB areas. Supply, return, relief, and exhaust air systems are fully ducted throughout the facility, and HVAC piping design includes condenser water, heating hot water, and chilled water systems. Plumbing equipment includes (2) domestic water heaters, a water softener, and reverse osmosis system; plumbing piping design consisted of domestic, storm, and sanitary systems. Medical gas design - including oxygen, med vac, med air, and nitrogen - supports ambulatory spaces. A wet sprinkler system is used throughout the building, with the exception that critical spaces (such as equipment and electrical/telecom rooms) employ specialty systems. The mechanical team also employed noise control strategies to promote patient privacy and comfort. Mechanical equipment and acoustic accessories, such as wall padding and tiles, were placed to provide treatment to acoustically sensitive areas.

### Structural

The structural team developed innovative design solutions that reduced the construction schedule by implementing modularized design elements while ensuring compliance with the VA resiliency requirements. This was achieved by utilizing a continuous moment frame lateral system that satisfies alternate path requirements in the event of an unanticipated column removal. Modularized beam-to-column moment connections were utilized to improve the speed of construction by reducing on-site welding and improving ease of construction. Moment frames in lieu of braced frames provided the client with programming flexibility that is vital to achieving higher WELL Certifications. Composite steel framing not only addressed vibration due to human footfall but also provided effective mitigation for vibration generated by MEP equipment.

## Protection of Public Health, Safety, and Welfare

Protection of health, safety, and welfare were a priority for the project as a healthcare facility serving a revered population of veterans. As such, the design was human-centric, putting the needs and wants of the patients first, evidenced through a WELL Silver-rated design.

The safety and security measures necessary to this project made clear to students the weight that engineering decisions carry. Public health, safety, and welfare are of utmost concern and must be considered in all design decisions. Since every design decision impacts other facets of the project, interdisciplinary coordination is key.

### Codes and Standards

The health, safety, and welfare of the Omaha VA Ambulatory Care Center requires significant knowledge of healthcare, government, and VA codes and standards. The codes and standards utilized across all disciplines included the IBC 2021, WELL v2, and Facilities Guidelines Institute (FGI) 2022.

For the electrical discipline, NFPA 70, 72, 99, 101, 110, and 780 were referenced throughout the life of the project. Following the VA and their proprietary standards, the VA lighting design manual, VA electrical design manual, VA physical security design manual, VA fire protection design manual, and VA telecommunication design manual were also consulted. A few other standards and recommendations, such as BICSI, IES RP 29-20, and IES RP 10-20 were referenced by the electrical design team.

The mechanical students referenced federal and local codes to complete the design. The International Mechanical Code and Omaha Plumbing Code were enforced. ASHRAE standards 55, 62.1, 90.1, and 170 were also consulted. The VA HVAC design manual, VA plumbing design manual, and VA fire protection design manual were reviewed. Lastly, NFPA 13, 90A, 99, and 101 were utilized to meet applicable design requirements.

The structural students referenced the VA structural design manual, VA physical security and resiliency design requirements, VA handbook H-18-8, and the VA fire protection design manual. ASCE/SEI 7-22, AISC 360, ACI 318-19, and TMS 402/602-22 were also used by the structural students.

### WELL Silver Certification

The WELL Standard defines health-based goals centered around the mental and physical well-being of occupants within the building. For this facility, the students aimed to emphasize occupant health by pursuing WELL Silver Certification. Design interventions for this certification impact the well-being of both the staff and the patients within the facility, including patient care considerations and indoor environmental impacts on staff who are present throughout the day.

Using the students' mechanical and electrical designs along with the facility's architectural features, the students focused exclusively on concepts influenced by engineering systems. Highlights of the students' design interventions include sound masking for patient privacy, circadian lighting for staff circadian entrainment, and individualized thermostat control for spaces throughout the facility. The increased focus on WELL concepts supported the goal of providing a human-centric design for all occupants within the Omaha VA Ambulatory Care Center.

## Resilient Design

The VA has established that all sites owned by the VA must meet minimum design requirements for resiliency. To accommodate the client's needs, the students prioritized resiliency through the incorporation of a ductile structural framing system and redundant mechanical, electrical, and telecommunication systems. The structure addresses progressive collapse requirements through a continuous moment frame system, ensuring an alternate load path in case of unanticipated column removal. Utility services are encased in concrete duct banks to adhere to protective standards, requiring coordination with structural elements to ensure a minimum depth of 5 ft below grade.

The Omaha VA Ambulatory Care Center's backup power and utilities are designed for life and information protection during outages. This includes a main-tie-main configuration, paralleled generators for increased resilience, and standby emergency power. Collaboration between electrical and mechanical teams ensures compliance with the 96-hour emergency power requirement, including fuel storage and transfer equipment. Also included are two telecommunication utility services with redundant backbones to serve information protection. The facility also maintains optimal air conditions with a redundant mechanical system, featuring a geothermal bore field, electric boilers, and a modular heat-recovery chiller. Mechanical systems prioritize resilience, incorporating dual water service connections, water storage tanks, and N+1 redundancy for critical equipment.

## Essential Electrical Power Coordination

To support systems and equipment defined by NFPA 99, the mechanical and electrical teams coordinated the essential power requirements. To maintain ambulatory service functionality, the air handling unit (AHU) serving the OR and the surrounding ambulatory care spaces required essential power. This AHU is connected to a modular chiller, which, in turn, relies on three geothermal pumps for operation. Therefore, during the loss of normal power, essential power is required for the AHU, modular chiller, and three geothermal pumps.

Essential power was also coordinated with the lighting team to ensure sufficient illumination was provided on the paths of egress. Paths of egress were designed to a minimum value of 1 fc at finished floor level to accommodate requirements during normal power conditions as well as loss of normal power. Exit signs were located to direct occupants towards a safe path of exit from the building. To support these devices, emergency luminaires and exit signs are powered by life safety panels on the ground and second level, which serve their associated level and the levels above as permitted by the Facilities Guidelines Institute (FGI).

## Life Safety Coordination

Life safety coordination was incorporated for alarm systems, egress lighting, sprinkler protection, smoke mitigation, and general egress with architectural features.

### Infection Control & Prevention

To support ambulatory care procedures performed in the facility, the mechanical and electrical disciplines coordinated the infection control measures necessary to preserve occupant health and safety. This included the selection and coordination of the OR Cleansuite ceiling unit, specific airside control measures, waterside design measures, and ensuring specification of sealed and gasketed luminaires to prevent further air leakage.

Airside control for the facility included ventilation, pressurization, filtration, humidity, and temperature considerations. For example, the operating suites are maintained between 30% and 60% relative humidity to mitigate conditions for bacteria, viruses, fungi, etc. to grow. They are also conditioned between 66-70°F to maintain a quality environment for surgical operations. Airflow direction is designed to supply clean air close to patients and staff and multiple high-performance filters are used at the air handling units. Airflow pressurization is designed to travel from cleaner to dirtier spaces. Legionella concerns are mitigated by supplying the domestic hot water loop at 140 °F and mixing down to 120 °F at the fixtures. Mechanical equipment controls and sensors monitor and adjust as necessary to ensure proper system function.

## Multidiscipline and/or Allied Profession Participation

For this architectural engineering capstone project, three student design teams (each consisting of eight or nine students from the mechanical, structural, and electrical options) received support and constructive feedback from professional engineers and architectural engineering faculty advisors. Each team was assigned a full set of professional mentors including at least two engineers per structural, mechanical, and electrical discipline, as well as specialty mentors associated with energy, acoustics, fire and life safety, plumbing, and mechanical construction disciplines available to all teams. In all, 28 non-faculty mentors assisted with the project – 27 PEs or SEs and 1 EI.

After each design milestone, teams were required to provide a narrative and drawings and give a presentation showcasing the progress of their designs within each discipline. Another set of professionals participated as evaluators, providing feedback on presentation and document submissions. This group included 23 PEs or SEs and 6 EIs (29 additional volunteers). The evaluators graded the presentations according to a rubric developed in concert with the design professionals and distributed to the students. Follow-up questions and comments were discussed with the student teams, which allowed students the opportunity to defend and improve their design. The presentation and discussion processes were designed to simulate a professional setting.

## Knowledge or Skills Gained

The student participants gained real-world skills because of this collaborative effort. First, using an actual building design project provided an opportunity to consider synthesis and integration outside of a theoretical environment. It gave the students the opportunity to form their own interdisciplinary approach and to witness and learn from people who have made their life's profession on this very basis. By having industry mentors, the students became better prepared to enter the profession with an improved understanding of the skills that a "Complete Engineer" must develop and possess.

Further, professionals gave feedback at periodic phase presentations that challenged the students to accept criticism, learn from it, and continue to improve their design of a "real world" project. Finally, this close relationship illuminated the different opportunities and specializations available to pursue as a career and created potential connections for future employment or collaboration after the students have transitioned into professional engineers. The significant guidance and evaluation of 57 experienced professionals raised the bar with expectations of real, workable solutions to design problems. The value of professional input was made clear from day one, which made students take this investment in their work very seriously.

## ESSENTIAL SKILLS:

- Communication, Written, Verbal & Nonverbal
- Public Speaking
- Critical Thinking
- Interactive Design
- Problem Solving
- Project Management
- Ethics
- Leadership
- Conflict Resolution
- Delegation
- Teamwork
- Accepting Feedback
- Team Building
- Working Collaboratively
- Work Ethic
- Punctuality
- Time Management

## TECHNICAL SKILLS:

### General

- Codes and standards application to building systems.
- Healthcare and VA-specific design guidelines
- Comparative analyses and selection of equipment and devices to meet client needs.

## TECHNICAL SKILLS (continued):

### Electrical

- Utility site coordination
- Building electrical load estimation
- Design of electrical distribution, including normal distribution and an Essential Electrical System
- Telecommunications distribution and design
- Special systems design, including nurse call, sound masking, fire alarm, audio-visual, security, and lightning protection.
- Lighting and daylighting design
- Lighting control systems design

### Mechanical

- Site coordination for a geothermal bore field and building entrance utilities.
- Facility heating and cooling load estimation using Trane Trace700.
- Facility energy modeling and analysis using OpenStudio and EnergyPlus.
- HVAC sizing and distribution (including supply, return, and exhaust duct systems).
- HVAC piping sizing and distribution (including heating water, chilled water, and condenser water systems).
- Plumbing sizing and distribution (including domestic, storm, and sanitary systems).
- Fire protection code review and design.
- Medical gas standard review and design.
- Acoustical design implementation

### Structural

- Tornado wind load provisions
- Deep foundation design
- Earth retention design
- Steel design
- Structural analysis and design software such as RAM and LPile
- MEP anchorage requirements
- Façade connection design and impacts to superstructure.
- Structural connection effects on constructability
- Vibration mitigation design for MEP equipment
- Deep foundation design