Tarrant County College Student Success Center

PROJECT DESCRIPTION

Engineering students in their capstone year were assembled into interdisciplinary teams and assigned to create the fully integrated engineering for the Student Success Center on the Tarrant County College campus in Fort Worth, Texas. The building is a three-story, 153,490 square foot building that contains classrooms, administration spaces, and a large atrium. The budget for this project was $42M to include the base engineering of the building with consideration for human-centric use and the following additional project challenges:

- Resiliency to handle natural disasters
- Emergency planning for utilities
- Overall building performance enhancements

The project described within will demonstrate various engineering innovations developed by three different student engineering teams during their two-semester capstone course. The course is engineered, and the project chosen to simulate a professional-level experience as a team of engineers. Interdisciplinary student engineering teams were guided by 27 mentors—professionals from engineering, architectural, and construction firms, and presented several touchpoint deliverables for evaluation by practicing professionals from across the country as well. Each team presented the deliverables to faculty and 32 professional evaluators from across the engineering and construction industry throughout the United States. Using a strict rubric, teams were evaluated on their collaboration plans; research; schematic engineering (SD); engineering development phases 1, 2, and 3 (DD1, DD2, DD3), and the resulting set of construction documents (CD). Together, 59 professionals contributed a full academic year to aid the students in the important transition from applying coursework knowledge from their educational careers to becoming fully prepared for professional practice.

COLLABORATION OF FACULTY, STUDENTS AND LICENSED PROFESSIONAL ENGINEERS

Before participating, all students were required to take the FE exam before being allowed to enroll in the capstone course. Student engineering teams were then assembled with students from a variety of background knowledge and experience in structural, mechanical, electrical, and acoustical engineering in addition to project management experience. More experienced team members were able to serve as peer mentors. When teams were first formed, each student completed a Clifton Strengths Assessment (Gallup Strengths Finder) which helped establish leadership and identify optimal collaborative roles within the teams. Faculty assigned requirements and engineering process deadlines, assigned student and mentor teams and guided students toward identifying team roles. With great success, student teams engineered innovative engineering by applying lessons learned from their coursework and past internship experiences, engaging in codes and standards research, and receiving ongoing support from professionals, faculty members, and teammates.

Teams utilized multiple professional-level communication tactics to collaborate across and within disciplines and to prepare for efficient and effective communication with their industry mentors. For example, a minimum of once-a-week meetings were had among members of each engineering discipline within a team in addition to a minimum once-a-week meeting across the integrated team. At each internal discipline meeting, discipline-specific topics were discussed, and internal deadlines were set. At these meetings, topics were compiled for discussion with the professional mentors, and meeting minutes were recorded for each of these meetings for easy reference. The meetings between the different disciplines allowed for a discussion of larger, interdisciplinary topics and provided a set place and time for collaboration and coordination, encouraging commitment to deadlines and milestones.

DISCIPLINE-SPECIFIC AND SPECIALTY MENTORS

At the beginning of the two-semester capstone, interdisciplinary student engineering teams were partnered with professional engineers and other mentors from related fields. These 27 mentors collectively volunteered over 2,000 hours dedicated to expanding student and team knowledge and skills. For each team, a set of discipline-specific mentors included two electrical engineers (one team had a third electrical engineering), two structural engineers, and two mechanical engineers. Available to all teams was a set of specialty mentors to assist with acoustics, energy simulation, shading (from lighting/electrical and mechanical disciplines), tornado resilience, mechanical construction, healthy buildings and COVID-19, and codes and regulations regarding fire and life safety.

Communication between student engineering teams and the professional mentors took place during normal class time, scheduled weekly meetings held via Zoom, in-person, or a mix, and through emails as needed. For efficient meetings, students developed agendas, reported on previous action item reports to discuss potential engineering problems, explore solutions, and validate their engineering as they progressed. The structured approach allowed students to be prepared to engage in active dialog with mentors and utilize their time efficiently. Mentors also reviewed practice presentations and engineering details to give valuable feedback prior to deliverable deadlines.

Not only did this experience expose students to and ongoing 10-month, real-world simulation of professional practice, but it developed among them a great support system from faculty, licensed engineers and other professionals, and their future colleagues. Together, they met the goals of the project with unique innovations, great creativity, and high-level professional engineering principles. The relationships and connections developed through this process has had a clear impact on their academic success and created connections and insights they will carry into their professional lives.

An added benefit of the close collaboration and commitment demonstrated to the students by these **59** professional volunteers mirrors the commitment to service and lifelong learning throughout the engineering field and is expected to result in service-minded professionals that give back to educating the engineers of the future. When students were asked to consider the monetary value of the time spent by professionals on this capstone project, they found the salary value to be in excess of $330,000.

PROTECTION OF HEALTH SAFETY AND WELFARE OF THE PUBLIC

Taking a human-centric approach, each team considered how to best engineer a space that considered safety in emergency or disaster situations that also enhances and ensures the physical and mental well-being of building occupants during daily use. They further considered the community at large to engineering a space with enhanced performance through energy efficiency measures and ecologically beneficial elements such as rooftop green spaces and photovoltaics.

CODE COMPLIANCE

Creating a healthy environment begins with engineering sustainable systems that benefit occupants. Throughout the engineering the primary goal was to meet and exceed Tarrant County College District Technical Engineering Guidelines. All plans were compliant with 2015 International Code Council and National Fire Protection Association codes, ASHRAE-90.1 2019, ICC-500, local Fort Worth amendments, and other applicable standards and guidelines such as those provided by IES and ANSI. Additionally, the FEMA P-361 standards were employed to engineering a community safe-room disaster shelter.

SUSTAINABILITY

After evaluation, a team achieved LEED Gold rating with 67 points. This can be attributed to geothermal primary systems, rainwater harvesting, indoor air quality, and daylighting engineering. Their roof integrates plants that require minimal maintenance and are native to the areas and includes an array of photovoltaics over each main wing of the building. These systems lead to a reduction in thermal heat gain at some of the most vulnerable locations of the building.

FIRE SAFETY SYSTEMS

Fire Alarm

The 2015 International Fire Code (IFC) has been used to determine the requirements of the engineering based upon the occupancy Group B that was prescribed from the 2015 International Building Code (IBC). NFPA 72 National Fire Alarm and Signaling Code was also used under sections of the IFC. Section 12.3.2 of NFPA 72 defined the path class as Class B.

A voice/alarm communication system was be implemented as well as the manual pull stations required by IFC Section 907.2.2. Audible and visible device locations are determined by Section 18.4.8 and Section 18.5.5 of NFPA 72, respectively. The voice/alarm system is also the announcement communication system for the building. Emergency voice messages will play over the speakers for fire alarms, active shooters, and extreme weather conditions. This combination system is allowed by Section 907.5.2.2.3 of the IFC, provided the manual fire alarm use takes precedence over any other use. The use of an automatic sprinkler system to initiate the fire alarm system was implemented, but manual fire alarm pull stations are present in locations throughout the building.

Smoke detectors are placed in each classroom as required by the TCCD Guidelines as well as other locations throughout the building as required by the IFC. Smoke detectors have been placed at each elevator lobby as required by NFPA 72 Section 21.3.5 and duct smoke detectors have been placed according to IFC Section 907.2.12.1.2. When the fire alarm is activated and the smoke alarm sounds, strategically placed smoke curtains are lowered to protect the occupants from smoke. Particular mechanical equipment and ductwork penetrations also required duct smoke detectors that relayed to the fire alarm network, allowing shutoff of units. In one engineering, a smoke exhaust system in the atrium expels smoke and utilizes fire shutters to direct smoke away from occupants.

The fire alarm annunciator panel for each team is located within the main vestibule on the ground floor with the fire alarm control panel in the main electrical room within the safe room section of the building for continued functioning during and after a disaster. Along with smoke alarms, carbon monoxide sensors are in rooms adjacent to the generator room.

Fire Sprinkler

An automatic sprinkler system was engineered to include Class III automatic standpipes in each of the three stairwells of the building in accordance with NFPA 14. By having a wet pipe sprinkler system, pressurized water is quickly supplied to put out the fire and provide time for the occupants to safely evacuate the facility. Each standpipe serves a zone no more than 52,000 square feet in total.

Fire Ratings

In more crucial spaces of the building, 1- and 2-hour rated walls are implemented. It was determined that the structure between floors would need to be fire rated. Since the type of construction for a building dictates the fire-resistance rating, construction type IIA was most appropriate due to the total allowable area of a fully sprinklered, multi-story building.

SECURITY

Security systems were commonly engineered to allow for safety, response, and peace of mind to building occupants. Security devices include card readers, security cameras, a gunshot detection system, and panic buttons. Security cameras are placed in the main vestibule, within corridors, at classroom entrances, at emergency phone locations, and at exterior vehicle drop off areas. Wireless emergency notification clocks are installed in the atrium, classrooms, and conference rooms to alert occupants of any security threats or weather warnings. An access control panel is in the main telecommunications room.

MULTIDISCIPLINE AND ALLIED PROFESSION PARTICIPATION

TEAM PRINCIPLES

Once given the scope and details of the project, each team developed principles to guide their development and included ideas such as efficiency, engagement, functionality, and sustainability. Teams even set personal goals to drive their motivation, including unity and innovation. The following are examples of principles teams incorporated in their engineering development processes.

- **Human-centric engineering** to incorporate usability and convenience into the building systems, making them simple to operate and while highly functional per the client's requests.
- **Wellness** through the careful engineering for occupant comfort, enhanced student experience, and a collaborative culture.
- **Responsiveness** to the environment, weather conditions, and building occupancy and use to control the variable systems and allow for peak performance of the building for continuation of task performance.
- **Stewardship** of the earth and the community by being environmentally conscious to minimize environmental impact and maintain a low level of energy consumption while maximizing community use.

ENGINEERING CHALLENGES

The client stated additional engineering challenges that were required for the intended use of this building. Teams had to keep these challenges foremost in all their processes for an integrated engineering that would be 1) resilient to natural disasters of the area; 2) developed emergency planning for continued operation; and 3) enhanced overall building performance by maximizing usability and minimizing energy usage and, other drawbacks. Described here are some of the solutions developed and the results achieved in the final plans.

Resilient to Natural Disasters

Due to the geographical location, it was found that the Student Success Center is located in an EF5 tornadic zone. Earthquakes were also considered in the engineered engineering, since the site is located close to the Balcones Fault and the Mexia Talco Luling fault zones.

All engineering ensured the building would survive an EF-3 tornado completely intact, while also engineering a tornado saferoom to serve the community in the event of an EF-5 tornado. To accommodate this, designs were created as though there were two connected but functionally independent buildings, so the mechanical systems do not experience pressure drops from torn out ductwork and fewer penetrations would need to be protected from projectiles. Additionally, outdoor equipment necessary for the functioning of the building and its systems has been kept to a minimum and the generator housing has been built into the EF5 resilient portion of the building. Moreover, EF5 rated windows were placed throughout the Student Success Center to ensure sufficient occupant safety.

Emergency Planning

In the event of widespread power grid failure, the building is required to function as a community shelter off the grid for up to a week, at different load capacities. Because of this, the implemented mechanical systems must be extremely energy efficient to reduce the amount of energy required to be stored or produced on site. Fire protection and communication systems must remain operational for the whole building. The electrical distribution system is engineered as a microgrid to utilize diesel generators, photovoltaic arrays, and battery storage to supply all building loads with power in the event of an emergency or utility grid failure.

Winter storm Uri in February 2021 exposed massive failures in the Texas power grid that are often seen during summer blackouts. Uri impacted energy generation across all sources (coal, natural gas, nuclear, and wind) managed by the Electric Reliability Council of Texas (ERCOT). Natural gas is the largest energy source for ERCOT, but low temperatures caused generators, pipelines, and wells to freeze, causing a power supply shortage. Windmills in West Texas even froze and failed to produce power. The engineering of the Student Success Center applies strategies that allow the building to function independently of the utility grid at 100% for two days and 20% for an additional five days in the event of a power outage.

Emergency planning for utilities required intentional distribution of power to building loads, assessment of power storage, fuel sources, and load requirements during the summer and winter months. The structure was engineered to handle vibrations and potential seismic events, while preserving the necessary deflection and vibration requirements for the emergency utility equipment.

Building Performance Enhancement

The acoustics of the individual spaces throughout the building were considered as a whole system. Certain areas like the corridors and the atrium were considered areas of high acoustic importance and needed careful attention to meet the RT requirements. These criteria were met through design of acoustic wall paneling, ceiling tiles, and an integrated lighting and acoustics system.

Concrete was used sparingly throughout with steel as a main source of structural material. Mechanical systems were engineered to minimize material and energy use, without sacrificing performance. Rainwater and excess heat are to be reused as much as possible to reduce waste and energy consumption. The electrical distribution system provides renewable energy alternatives in photovoltaic arrays and battery storage. The solar photovoltaic array and green roof work cohesively to increase the efficiency of the array and contribute enough power to cover half of the facility’s energy consumption for a year.

Designs were driven by the goal to achieve both LEED Gold and WELL Gold ratings. The Leadership in Energy and Environmental Engineering (LEED) standard promotes sustainability. In accordance with the client’s sustainability initiatives, teams achieved LEED Gold by means of light, sound, and thermal considerations. WELL V2 Certification considers six engineering principles based on the project being equitable, global, evidence-based, technically robust, customer-focused, and resilient. The main priority of this certification is integration between the functionality of the building and the health of the occupants. The Student Success Center has been engineered with anticipation of achieving a WELL Gold certificate.

INTEGRATION

Throughout the project, engineering components were coordinated with each discipline. These components included the use of two different structural systems, a combined structural and mechanical air distribution system for the large atrium space, the incorporation of piezoelectric material into the stairs, and the functionality of the green roof spaces. The structural systems were separated between the segments of the building which under normal operation are considered a single facility, but during emergencies or after disasters, can serve separately as a community shelter and a safe room. In the large atrium space, the combined mechanical and structural system provides air distribution through diffusers in the voids of multiple built-up columns with HSS members. The roof was designed to have a combined green roof and a photovoltaic array that provides cooling to the panels while partially shading the plants.

Another large area of integration in the building is the safe room located off the atrium. This safe room needed to withstand EF5 tornados while also functioning as a normal space during any other time. Mechanically, an elevated water tank was added to allow for water use in the bathrooms and drinking fountains. Storm louvers were added to the space to allow for proper ventilation. The electrical engineering included an inverter for emergency lighting in the space and a diesel generator for emergency and legally required standby power if the utility were to fail and the rooftop photovoltaic arrays and battery storage could not power the space. The structural engineering allows the safe room to be isolated from the rest of the building in case the rest of the building collapses. The windows were carefully selected to allow for daylight into the safe room to meet the daylight goals throughout the building during normal operation, maintain the performance of the building envelope, as well as being able to provide protection from EF5 wind conditions. Where window and door openings are located, a team included StormDefend impact resistant glass and curtain wall systems and Stormpro and StormDefender impact resistant doors and garage doors.

A key component of HVAC engineering is to minimize noise transferred from equipment through the ducts and walls of the building. This was accomplished with consideration of the duct paths, vibration isolation for equipment, appropriate spacing of the equipment from walls and fenestrations, and use of materials such as acoustic ceiling tile, high STC walls in critical areas, and duct liner.

The acoustics of spaces as a whole were also considered. Certain areas like the corridors and the atrium were considered areas of high acoustic importance, so careful attention was paid to meet the RT requirements. These criteria were met through design of acoustic wall paneling, ceiling tiles, and an integrated lighting and acoustics system. Acoustic panels and vibration isolators are utilized throughout the interior design to prevent noise from becoming an issue in the hallways, particularly in open-to-above portions. More acoustic damping was achieved by integrating lighting with the acoustical panel, and similarly incorporating underfloor ductwork with structural in the atrium.

STRUCTURAL

Gravity System

In order to both engineer for tornado potential and prepare for emergencies with widespread power outages, similar designs were made for two separate sections of the facility, joined by an expansion joint. The engineering consists of a north wing to withstand an EF-3 tornado and act as a community shelter and a south wing to withstand an EF-5 tornado, within which a safe room, the fire safety panels, and the generator and backup electrical systems were all located. Each wing was engineered with different gravity and lateral systems while there was some variability in whether a single or composite foundation system was engineered. Designs for the structural systems are similar to this example, with some variations that result in similar ratings outcomes.

The community shelter, segments A and B, together were engineered as a steel structural system. The composite floor system in this section of the building is composed of 3 ½'' normal-weight concrete on a 20-gauge 2'' metal deck. The columns in the community shelter are W12 sections. The typical column section is W12x50, chosen partially due to the ease of construction. Segment B makes up the three-story atrium, where levels two and three are open areas with no diaphragm. The curtain walls are laterally braced by 16x4x5/8 HSS members with the strong axis framing into the curtain wall.

Lateral System

The lateral system utilized brace frames in segments A and B as they were more efficient in lateral stiffness compared to moment frames. In addition, the brace frames significantly reduced the amount of drift, therefore decreasing the size of the expansion joint. The selection of HSS chevron bracing was used to provide an economical lateral system. Segments C and D together comprise the safe room, engineered as a concrete, cast-in-place system. The safe room segment floor is composed of an 8'' reinforced concrete slab with #5 rebar at 12'' on center each way. The slab is monolithically cast with 30'' deep beams. The beam width varies depending on if it is a purlin or a girder. The concrete beams in segment C are typically sized to 30" deep x 24" wide, the girders at 30''x46'', and the spandrel beams surrounding the perimeter of the safe room are sized at 30''x46". segment C of the safe room is designed to take on significant lateral load to withstand the ultimate wind speed of 250 mph. The concrete bays of the safe room are utilized the as moment frames, which provide a naturally stiff structure to take the lateral load in conjunction with the concrete cores.

Foundation System

The ground floor and foundation of both the north and south wings are made of an 8" normal weight concrete slab with #4 bar placed at 10" on center. This slab is then supported by grade beams ranging from 24" x 42" at the interior to 42" x 42" at the perimeter beams to allow the facade system to bear on it. These grade beams and structural slab bear on top of an 8" void form to account for the expansive soils on the site. The grade beams then frame into pier caps supported by 36" diameter drilled shafts with 16- #10 bar surrounded with #4 spiral reinforcement.

Some unique structural elements teams developed were an angled curtain wall, a depressed slab to accommodate underfloor air distribution in the atrium, a green roof, the cistern foundation, a hanging water tank for the safe room, and a separate structure for the generators.

Tarrant County College Student Success Center

MECHANICAL

The engineering for mechanical systems considered energy use and cost, indoor air quality, acoustics, physical size requirements, longevity, and resiliency. Teams engineered systems that exceeded the ASHRAE 90.1 baseline reduction by 44 to greater than 55%. There was a fair amount of variability in the designs, so two of the most different designs are summarized here.

One mechanical design utilized a primary system to include a geothermal loop field engineered to handle the entire heating load of the building, but not the entire cooling load, connected in parallel with a fluid cooler designed to make up the difference between the cooling load the geothermal loop field can handle. Needed are a total of 89 geothermal bores drilled to 300 feet deep with 20 feet on-center spacing southeast of the structure under the drop off and loading area. Indoor air quality is increased by distributing ventilation air to chilled beams throughout the building using a dedicated outdoor air system (DOAS). Two pipe chilled beams save energy by reducing fan power usually needed to move cool air through the building, while radiative fin tubes are placed along exterior walls and in perimeter zones for heat distribution. In classrooms, chilled beams were designed to use 2-3 times the outdoor air requirements to improve indoor air quality. Since the atrium is a large space with high heat gain and infiltration rates, chilled beams are not ideal, so an underfloor air distribution system was engineered to supply air directly to the occupants for better thermal comfort and energy reduction. The energy consumed by the mechanical system is reduced by 44% when compared to the ASHRAE 90.1 baseline model.

The plumbing system used heat rejected by the chiller to heat domestic water using a heat pump water heater providing enough to fulfil the needs of the entire facility. Rainwater collected from the roof and the cistern room located on the first floor since Fort Worth receives an average of 33.5 inches of rain per year. This can provide up to 600,000 gallons per year to be cleaned and recycled, and able to completely meet the flushing demands of the facility. This can save Tarrant County College over $2,000 per year on their water bill.

Another mechanical team focused on increasing the energy performance and sustainability of the building by using a 3-pipe heat recovery variable refrigerant flow (VRF) system as the secondary system of choice for the conditioning of the building. This system reduced overall energy consumption, provided tighter temperature control within zones, and increased the acoustical performance of classrooms and offices. Water cooled condensers were connect the refrigerant loop to a condenser water loop, to provide heat rejection and add to the VRF system. These condensers are much more efficient than their air-cooled counterparts due to the use of a 285-ton, 700 gpm cooling tower and condenser boilers. When used in conjunction, these systems substantially reduce the energy consumption of the primary mechanical systems. Their solution to the 3-story atrium space was to install displacement ventilation diffusers to increase indoor air quality of the space while connecting the air supply back to the building condenser water loop. The diffusers are nestled within the wooden structural columns, providing an interesting integration point with the structural system, and hiding the ductwork that is needed to supply the diffusers with air. The energy consumed by the mechanical system is reduced by 55% when compared to the ASHRAE 90.1 baseline model.

ELECTRICAL

The electrical engineering designs consist of power, lighting, and special systems engineering.

Power Systems

Teams engineered various main electrical systems such as a 2500 A, 480Y/277V microgrid distribution system to allow all sources of energy generation to be connected to the same bus and distributed to all building loads in normal and off-grid modes. In that system, for renewable and off-grid energy, a 344 kW photovoltaic array and a 390 kW battery storage system were designed along with three (3) 750 kW and one (1) 350 kW diesel generator to provide power at 100% for and at 20% for an additional five days in the event of a natural disaster or utility outage. Another team with a similar primary system included a photovoltaic (PV) system incorporated into the green roof design that will produce an average of 632,000 kWh per year. One team's multiple forms of redundancy ensure continuous power, with the building electrical system sized at 2000A and configured as main-tie-main connection, with three (3) 600 kW generators located in the dedicated generator segment of the building and a photovoltaic array and piezoelectric energy harvesters to fulfill the client desire to incorporate renewables into their campus.

Lighting Design

Lighting designs were very creative and incorporated daylighting for wellness and energy efficiency. This is shown in various concepts such as layering lighting, mimicking light breaking through a canopy and through the atrium complimenting architectural features to make the space inviting and invigorating for occupants. LED fixtures and programmed control sequences reduce lighting loads while responding to occupancy conditions. In addition, 67% spatial daylight autonomy was achieved in occupied spaces from windows, solar tubes, and skylights to improve occupant experience. Daylighting was also incorporated to promote improved learning environments, with windows installed in learning spaces and shading devices to help mitigate glare.

Special Systems

Building special systems included telecommunications, fire protection, audio/visual, security, and lightning protection. Each system is connected to the main distribution frame (MDF), which was connected to the campus fiber network. Equipment rooms (ERs) are connected to an uninterruptible power supply (UPS) to increase the reliability of the building communications systems. Classrooms were also equipped with speakers, control stations, multiple displays, and cameras to better accommodate virtual collaboration, and increase presentation quality through the audio/visual designs. Additionally, a team included a Prevectron 3® active air terminal because, as described on its brochure and specs, it is the preferential point of impact for lightning discharge and provides the entire structure with maximum protection, further meeting the natural disaster resiliency and emergency planning client challenges.

KNOWLEDGE OR SKILLS GAINED

Through this academic year, students were able to apply coursework knowledge to a real-world challenge and grow in measurable and unmeasurable ways. Technical knowledge was applied, and new skills developed from experience. Additionally, having a deeply involved industry mentorship program helped students develop essential professional skills to prepare them to work in teams, stay organized and efficient, and become impactful engineers in their professional journey

SOFT SKILLS

Essential skills, often referred to as “soft skills” were developed and honed through this rigorous academic-year activity. Communication, organization, critical thinking, teamwork and professionalism are requirements for professional engineers to make impactful contributions to the built environment.

Collaboration began with individual assessments using the Gallup Clifton Strengths Finder. This helped establish chains of command and develop conflict resolution plans, so students maximized the benefits of weekly meetings. Through multiple avenues of communication within teams and with industry mentors, professional etiquette, including punctuality was required. Organization was kept through meeting agendas, minutes, and a shared file access system with an established filing structure.

Students honed professional skills through many presentations with appropriate business professional attire required. Quality of work and of the presentations was ensured through robust feedback from industry professionals evaluating each deliverable touchpoint presentation by a strict rubric. Learning to accept criticism and grow from it generated highly professional work and prepared students to enter a world of collaborative engineering teamwork.

<u>Mechanical</u>

- Geothermal design, underfloor air distribution, and chilled beam systems
- ventilation practices
- Multi-entrance plumbing design
- ASHRAE 15 Refrigerant Design
- Primary and secondary system design and selection
- Plumbing and fire protection systems design
- Acoustical analysis

<u>Electrical</u>

- Power systems and distribution design
- Emergency power back-up
- Renewable, sustainable, and on-site generation
- Lighting design
- Daylighting analysis and design
- Telecommunications, fire alarm, security, and audio/visual infrastructure
- Lightning protection system

<u>Structural</u>

- Gravity, lateral, and foundation system selection and design
- Foundation load transfer, structural redundancy, and system evaluation
- Steel, concrete, timber, and masonry design
- Impact-resistance per ICC-500 and FEMA P-361
- Safe room design

<u>Software</u>

Revit/BIM 360, AutoCAD, L-Pile, RAM Structural System, Bluebeam Revu, Enercalc, MasonryIQ, RISA Systems, Trane Trace 700, GSHP Geothermal, Climate Consultant, VA Design, SKM Powertools, 3ds Max, Rhino 3D, SAM, Enscape, Excel