


ENGAGE. ENRICH. INSPIRE.

NCEES
advancing licensure for engineers and surveyors

2015 NCEES ENGINEERING AWARD

Connecting Professional Practice and Education

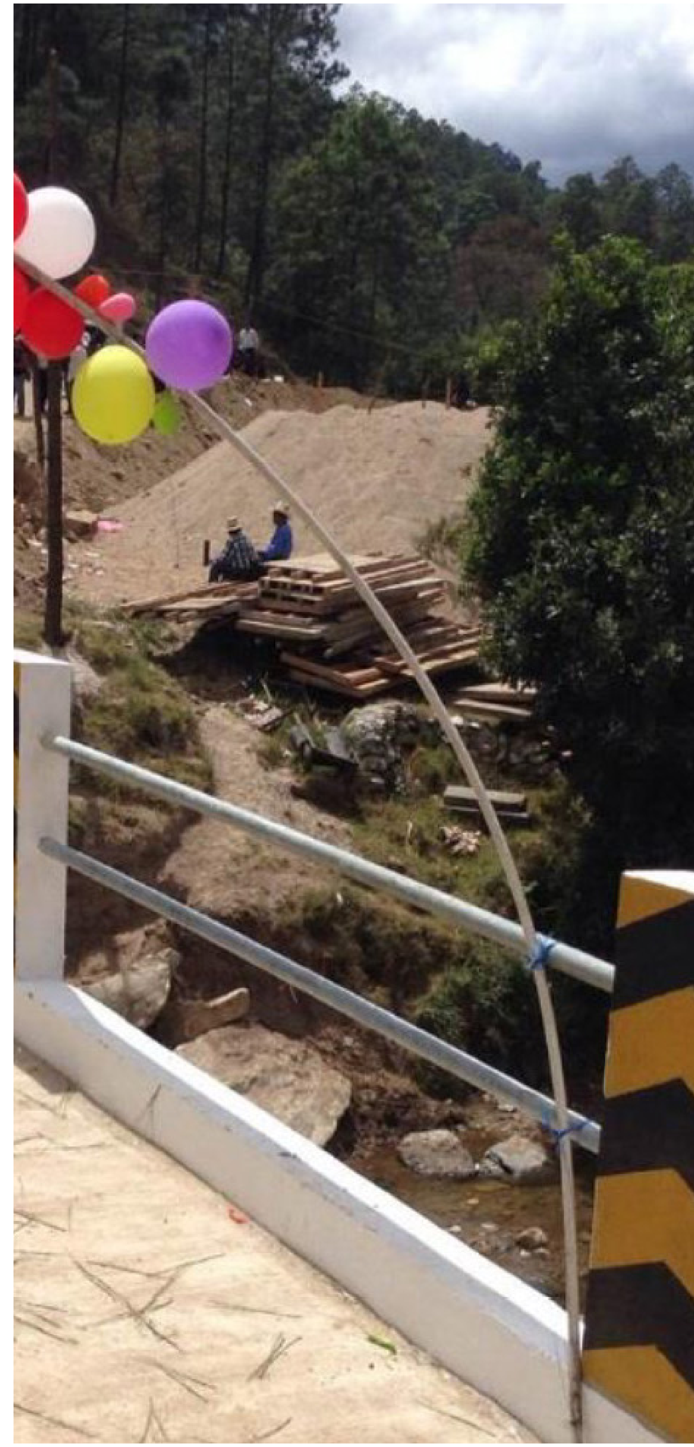


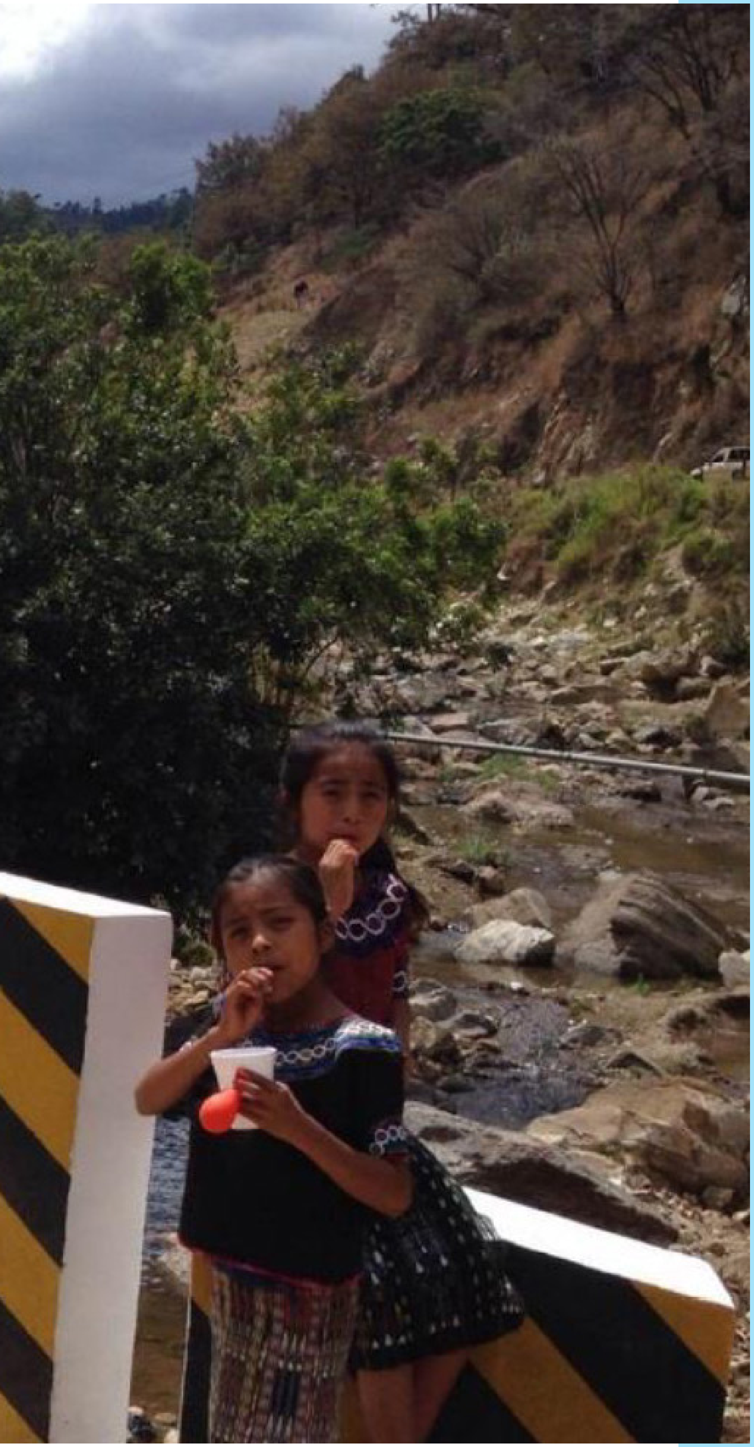
ENGAGE. **ENRICH.**

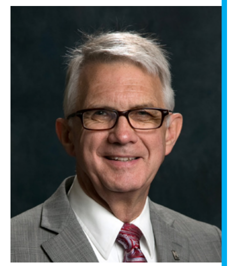
2015 NCEES ENGINEERING AWARD

CONTENTS

INSPIRE.





PRESIDENT'S **MESSAGE**

The NCEES Engineering Award was launched in 2009 to celebrate engineering programs bringing students and professional engineers together to work on collaborative projects. Advancing licensure for engineers is a top priority for NCEES, and bringing these two groups together helps ensure success for all involved. The projects afford students the opportunity to take learning outside of the classroom and apply it to real-world issues. In turn, this increases students' knowledge of engineering principles.

Engineering reaches all parts of our lives. By highlighting this, the projects show students how working with licensed professional engineers protects the public's health, safety, and welfare. Students not only work with professional engineers, but they also collaborate with their peers, faculty, other engineering disciplines, and other professions to enrich their experience.

We at NCEES thank the students, faculty, and practitioners who participated in this year's projects. We appreciate and applaud their efforts to connect professional practice and education. We give special thanks to the jury members for giving their time and expertise to support this initiative.

NCEES has published this book to recognize the 2015 winners. We hope these successful projects will encourage other engineering programs to develop collaborations with the professional engineering community and continue to engage, enrich, and inspire all who are involved.

Michael Conzett, P.E.
2015–16 NCEES President

2015 NCEES ENGINEERING AWARD JURY

Jury members from each of the four NCEES geographical zones were chosen to represent state licensing boards, academia, and professional engineering societies.

Michelle Roddenberry, Ph.D., P.E., Jury Chair
Florida Board of Professional Engineers

Richard (Dick) Hayter, P.E.
Kansas State Board of Technical Professions

Bradley Aldrich, P.E.
Vermont Board of Professional Engineering

Neil Norman, P.E., C.Eng.
Washington State Board of Registration for Professional Engineers and Land Surveyors

Hesham El-Rewini, Ph.D., P.E.
Dean, University of North Dakota College of Engineering and Mines

Steven Schreiner, Ph.D., P.E.
Dean, The College of New Jersey School of Engineering

Ronald Welch, Ph.D., P.E., COL (Retired)
Dean, The Citadel School of Engineering

Amy Moll, Ph.D.
Dean, Boise State University College of Engineering

Wallace Fowler, Ph.D.
ABET

Michael Smith, D.Eng.
DiscoverE Diversity Council

Robert Green, P.E., F.NSPE
National Society of Professional Engineers

ABOUT **THE AWARD**

The NCEES Engineering Award was established to promote understanding of the value of licensure and to encourage collaboration between the engineering profession and education.

Academic programs accredited by the Engineering Accreditation Commission of ABET were invited to submit projects that demonstrate a meaningful partnership between professional practice and education. The competition was open to programs from all engineering disciplines.

Projects did not have to offer academic credit, but they were required to meet other eligibility requirements. The projects had to be in progress or completed by March 16, 2015. If a project had been entered in a previous award cycle, the engineering program was required to explain how the project had been further developed since the previous submission.

The 2015 NCEES Engineering Award jury met in Clemson, South Carolina, on June 2, 2015, to conduct a blind judging of the 31 entries. Each submission consisted of a display board, abstract, and project description. These materials were sent electronically for the jury to review prior to the judging and were also available at the judging.

The jury considered the following criteria in its deliberations:

- Successful collaboration of faculty, students, and licensed professional engineers
- Protection of public health, safety, and/or welfare
- Multidiscipline and/or allied profession participation
- Knowledge or skills gained
- Effectiveness of display board, abstract, and project description

The jury selected the Marquette University Department of Civil, Construction, and Environmental Engineering to receive the $25,000 grand prize. The jury chose five additional winners to each receive $7,500 awards.

2015 NCEES ENGINEERING AWARD

$25,000 GRAND PRIZE WINNER

MARQUETTE UNIVERSITY

Department of Civil, Construction, and Environmental Engineering

Sechum Vehicle Bridge

$25,000 GRAND PRIZE

MARQUETTE UNIVERSITY

Department of Civil, Construction, and Environmental Engineering

Sechum Vehicle Bridge

PARTICIPANTS

Students

Stefanie Berg
Rachel Beyer
Phillip Gessler
Nick Haraus
David Iovinelli
Sarah Knox
Tim Lewis
Molly McMahon
Elyse O'Callaghan
Allie Othman
Liam Sawyer
Jake Scheuller
Caroline Villa
Samantha Wagner
Kelsey Welch

Faculty

Mark Federle, Ph.D., P.E.

Professional Engineers

Steve Berg, P.E.
Libby Cavanaugh, P.E.
Carrie Groll, P.E.
Robert Merkle, P.E.
Mike Paddock, P.E.
Dan Salazar, P.E.
Max Schmiege, P.E.

Mentors

Benjie Hayek
Neil Hayek
Cathy Paddock

Jury Comments

"This project had a tremendous positive effect on the people of the community."

"This project represents a clear demonstration of how engineers improve the quality of life for people."

"There was great collaboration among students, faculty, and professional engineers."

ABSTRACT

The Sechum Vehicular Bridge is a student-led project encompassing the design and construction of a vehicular bridge over the Rio Pasaguay in Guatemala. Located near the rural Mayan community of Sechum, the project directly impacts approximately 1,300 people in three rural communities seeking safe, reliable crossing of the Rio Pasaguay to access education, markets, and health care. This particular project was presented by the mayor and hospital of the municipality as a highly critical project, as six women had recently died in childbirth because they could not reach the hospital. The project was also heavily advocated for by the primary teachers of the impacted communities, as their graduates were unable to further their studies at the junior high and high schools located in the nearby city because they could not cross the river. The community described the project as “breaking the barrier”—the barrier to higher education, medical care, and economic prosperity. These passionate stories reinforced to the team the positive change that engineering projects can have on the health, safety, and welfare of the public.

The team consisted of four senior undergraduate students in the civil engineering discipline, with mentorship from eight professional engineers and specific technical backgrounds to support each discipline on the project. The project team met weekly, so students could interact with their professional engineering mentors on a regular basis. An additional 11 engineering students, along with more than 100 community volunteers, helped with the construction of the bridge, which was completed in February 2015.

The project began with a team investigating and collecting information at the proposed site location. Topographical survey points were collected and soil samples brought back for analysis. The design phase consisted of determining the structure type, crossing location, and appropriate bridge dimensions according to standard United States professional engineering practice. Main design concentrations included hydraulic modeling of the river, structural analysis to select and detail the bridge type, transportation analysis to determine roadway geometry, and construction engineering to schedule and estimate the entire building process. Professional mentors ensured each step was done properly and that design specifications met professional industry standards.

The project provided an excellent real-life example to the team and allowed them to gain many important skills. The team learned that considering sustainability during the practice of engineering is important, especially in developing countries where resources are so scarce. Team members also learned how to communicate with a variety of stakeholders, including the end users, government officials, themselves, and the general public. This project provided an excellent forum for professional engineers to work with engineering students and demonstrate the value of continuous learning.

Finally, the students and professionals alike were reminded by this project how engineering can make a real difference in the world. The project team realized their obligation to use their skills to improve the lives of those who are in most need.

$25,000 GRAND PRIZE

MARQUETTE UNIVERSITY

Department of Civil, Construction, and Environmental Engineering

Sechum Vehicle Bridge

PERSPECTIVES ON

Protection of public health, safety, and welfare

Prior to the project completion, when the river was low, community members jumped from rock to rock or drove four-wheel-drive vehicles to cross the river. When the river rose due to rain, community members could not cross safely. Due to Guatemala's rainy season, this meant the community lost reliable access for nearly six months each year. While the directly impacted communities had access to alternative routes, these routes were circuitous and arduous, adding a difficult two to three hours of hiking through the mountains to reach Highway 2. The trip was nearly impossible with a heavy pack of supplies or a sick community member.

This particular project was presented by the mayor and the municipal hospital as a highly critical project because six women recently died in childbirth when they could not reach the hospital in time. Primary teachers in the impacted communities were strong project advocates. The primary teachers were concerned for their students because when river levels prevented students from reaching school, classes were often canceled. The teachers were concerned for older students seeking secondary education in the nearby city; they had watched former students brave waist-deep rushing water in order to reach their high schools. Alternatively, if students made it to school, they often came back to a swollen river, making it impossible for them to return home. As a result of the dangerous and unpredictable conditions, many parents refused to send their children to secondary schools.

Knowledge and skills gained

The student team learned to do a topographic survey using locally available equipment, such as a clinometer, tape, and compass. The team learned the value of having a well thought out data-gathering plan to ensure that all information was gathered in one site visit and how data was critical to design development.

The student team dug several test pits and collected soil samples for analysis. Rock samples were also collected and brought back to the university lab for testing. The students saw firsthand the critical importance of geotechnical data in identifying acceptable foundation alternatives when a deep pile alternative was deemed unconstructable.

The team completed a hydrological analysis using the program TR-55 and drawing input data from topographical maps and regional rainfall data. With water volumes for 100-year storms identified, the team completed a hydraulic analysis using the program HEC-RAS in conjunction with survey data to model current river conditions and river conditions at the bridge site alternatives. With this analysis, the team identified that a 45-foot deck span was reasonable at all location alternatives and established a high water elevation at each of those locations.

The bridge was designed using AASHTO (American Association of State Highway and Transportation Officials) design standards. A key decision was the selection of the design vehicle. The students learned that the design needs to accommodate future loadings that might be realized instead of the lighter loads that currently pass through the river. Since the team was designing and constructing the bridge, a design build delivery was utilized. The formwork needed to construct the project needed to be designed using locally available materials. No cranes or other heavy machinery were available, so the design needed to ensure the project was buildable using locally available equipment and materials. For example, the concrete was mixed using a 1/6 cubic yard mixer resulting in maximum pours available to the team at 20 cubic yards each day.

The team considered three different location alternatives and five superstructure alternatives. Each alternative was taken to 30 percent design. Decision matrices were developed to compare the transportation and superstructure alternatives. The location alternatives were analyzed on a comparative basis in categories of safety, geometry (horizontal and vertical), estimated cost, and sustainability. The superstructure alternatives were analyzed in categories of cost, constructability, durability, maintenance, function, and serviceability. Based on these matrices, a location was determined, and the concrete T-beam was identified as the preferred superstructure. The project

alternatives and recommendations were presented to the community, along with the advantages and disadvantages of each alternative. The community concurred with the preferred alternative, and the project moved into the final design phase.

Multidiscipline or allied profession participation

The scope of the project included site survey, materials testing, hydrologic and hydraulic analysis, geotechnical analysis, roadway realignment geometric analysis and design, bridge sub- and superstructure design, retaining wall design, estimating, scheduling, life-cycle cost analysis, and sustainability. Outside of engineering, the team looked to lab technicians, contractors, and masons for technical support. The team relied on interpreters and a Latin American history professor to understand the language and historical context of the communities in which they worked. Additional support and collaboration came from mentors well versed in contract law and fundraising to ensure the project could become a reality.

$25,000 GRAND PRIZE

MARQUETTE UNIVERSITY

Department of Civil, Construction, and Environmental Engineering

Sechum Vehicle Bridge

POINTS OF VIEW

Mark Federle, Ph.D., P.E.
Faculty advisor

What value does a real-world project bring to the students?
The impact of the environment, the location, and the decisions that have to be made to implement a design allows students to take classroom experiences and see that not everything will be perfect, or exactly the way it was drawn or calculated, once you are in the field. There is not the opportunity to say, "Wait, let me run back to a computer and make my revisions."

How do you decide which projects to work on?
We specifically work in Guatemala. This allows familiarity with material procurement and travel/accommodations. Then, the local municipality helps prioritize and partially funds the projects.

How did this project prepare students for professional practice?
It showed students how to complete a design under the supervision of highly qualified, highly motivated engineers while learning to serve others.

What was the biggest challenge on this project?
What is normally a five-week project was planned and built in three weeks. We had to stay focused and move the project forward each day.

What advice do you have for other programs wanting to add similar collaborative projects to their curriculum?
Find great mentors, particularly those that help in the design and those that travel with the team. Our mentors were fantastic in helping the students learn while they designed and learn while they constructed a bridge that will make a difference in the lives of thousands. Celebrate your successes after your work hard!

How does Marquette University plan to use its $25,000 prize?
We will build more bridges in Guatemala and perhaps also a school.

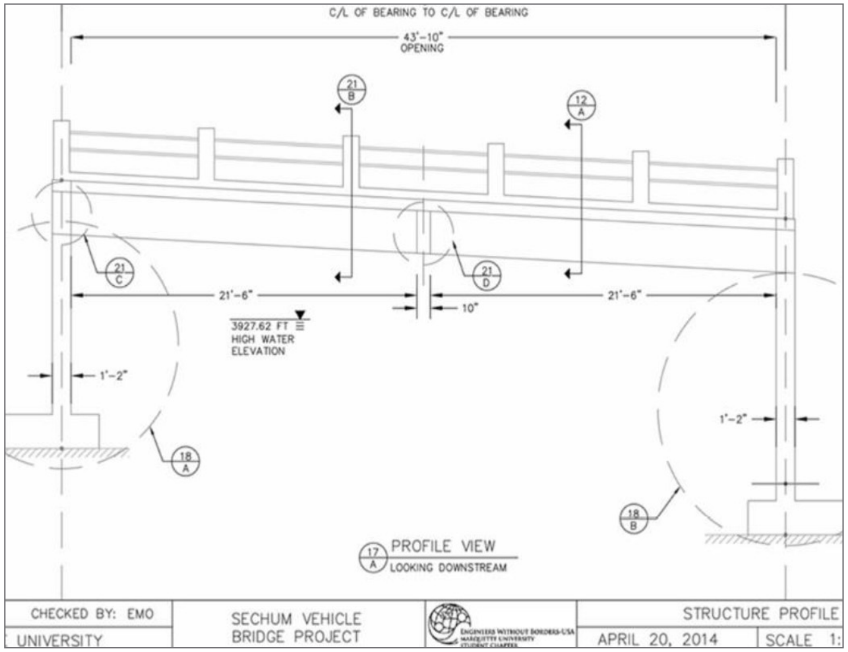
Elyse O'Callaghan, E.I.T.
Student

What did you like best about participating in this project?
I thoroughly enjoyed the fact that our project was community driven. The community members asked us for a bridge because they needed safe passage and all of the health, education, and economic security that came with it. Knowing that my team and I were an integral part of that solution, while a bit frightening, was also exhilarating. I wanted to become an engineer so I would have the skills to provide critical public services, and this project was a wonderful realization of that dream.

What did you learn?
I worked on small portions of large, real-life engineering projects through internships and worked on engineering problems and small-scale projects in school, but having the opportunity to take a project that impacted real people from inception to construction with the collaboration and support of professors and professionals was the most substantial experience of my undergraduate education.

Education in the workplace through internships was limited to billable hours and advice as necessary from professional coworkers; while that taught me a great deal about the world of professional engineering, the Sechum Vehicle Bridge project experience took such workplace encounters to a new level. Instead of being a small worker in a larger project, we as students were placed at the head of the project to learn by doing. Instead of conversations with coworkers to pick up snippets of advice as necessary, we had extensive interactions with professionals to discuss nearly every element of the project. As a result, the depth of experience I gained by applying classroom concepts within the context of this project was unparalleled in my undergraduate education.

How did the participation of professional engineers improve the experience?
The professional engineers were critical to the success of this project because they provided us with their expertise throughout the various phases and portions of the project. Because of this, they taught us through their example and their expectations how to work as professionals. Rather than working in the context of grades and rubrics, we worked in the context of due diligence, project delivery excellence, and meeting client needs.



What do you think the engineers learned from working with students on this project?

I think the professionals enjoyed working on this project as much as we did for similar reasons, such as taking a project from inception to construction, but beyond that, I think they enjoyed working with enthusiastic students. They were critical to the success of our project, and we were eager to listen to them and learn from them. I know I've always enjoyed working with underclassmen who look up to me and want to learn from my experience, and I think the professional engineers on our project had a similar experience.

Tim Lewis
Student

What did you like best about participating in this project?

I most enjoyed working together with a developing community to help them achieve a higher quality of life through improved infrastructure, while also developing my own technical abilities to solve advanced engineering challenges.

What did you learn?

My technical abilities expanded dramatically over the course of the immersive design process because the design was not just an exercise, it was a demanding engineering design. I learned a tremendous amount about both the structural engineering tasks that were required of me as well as how to operate, coordinate, and collaborate efficiently on a team of engineers working towards the same project goals. This required teamwork, utilization of professional consultation, and diligence in delivering a high-quality end product because the ultimate users of the infrastructure deserved the most thorough engineering solutions.

How did the participation of professional engineers improve the experience?

With participation of professional engineers, this project was able to adhere to a rigorous standard that held student designers accountable for decisions, justification, and documentation for all design solutions. Because this project was far more than an academic exercise, in that it was to intended to be a lasting piece of heavy civil infrastructure, having professional consultation advanced the quality of the design immensely. By working with engineers who had built similar projects in the past, we combined knowledge recently acquired as students in the classroom with the practical knowledge of the professionals, adding significant value to the success of the project.

With the intersection of professional consultation with the students' academic approach, the design outcome benefits from the students' quest to understand engineering concepts and the professionals' goals of transferring best practices to the next generation of engineers. By being

MARQUETTE UNIVERSITY

Department of Civil, Construction, and Environmental Engineering

Sechum Vehicle Bridge

POINTS OF VIEW

advised in this manner, the students can soon become professionals themselves to continue passing along this high quality standard, which aims to deliver quality engineering solutions that suit the particular needs of a population in need.

What do you think the engineers learned from working with students on this project?

I think that the engineers gained a rewarding experience where their years of experience added significant value to the ultimate quality of the design, while simultaneously enhancing the learning experience of the students. By involving themselves and lending their industry standards to the project, professionals are providing an educational opportunity to students while also positively affecting the final design outcome of the engineering solution.

Professional engineers might also learn new problem-solving approaches. Some of the problems faced in development engineering projects cannot be solved in the traditional ways common in United States professional practice. Development engineering projects can challenge a professional engineer to think outside the box along with their student team and come to a rewarding solution that delivers a higher quality of life to the users of the infrastructure.

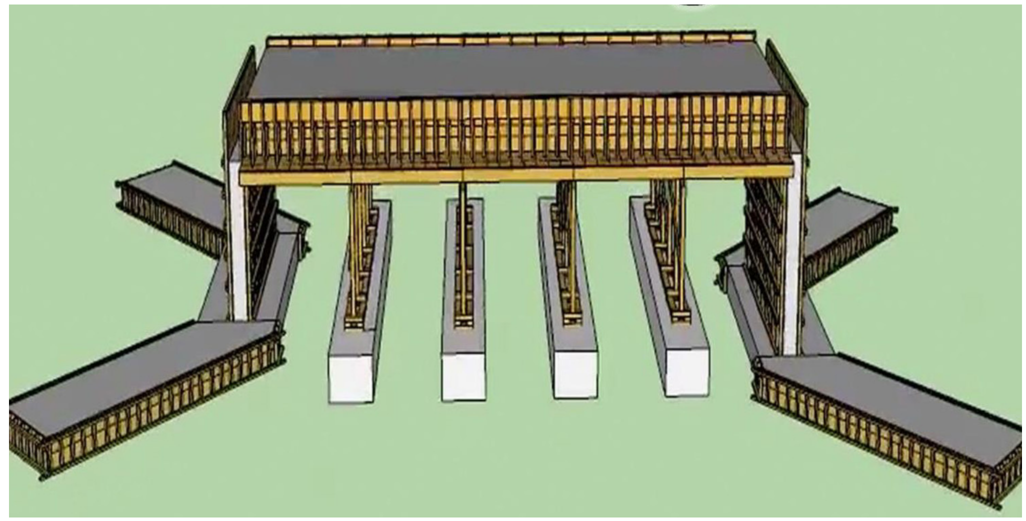
Michael Paddock, P.E., P.S.
Practitioner—civil engineer and surveyor

Why did you get involved with Marquette University's project?

I have been working with Marquette for the past 12 years on senior design projects that have been constructed in Guatemala. This project was identified by the local Guatemalan community as a high priority for the past several years, and it was a great project opportunity for the team. The student team approached me and requested mentorship, so of course, I had to say yes.

How did you assist the students in the Sechume Vehicle Bridge project?

As a mentor of students, it is important to guide instead of direct the student team. The learning process is a very important part of the project.



I provided overall mentorship for the project and managed the mentoring team during the design. I was also the engineer in responsible charge for the project and took responsibility for the design of the bridge.

During construction, I mentored the student team, who organized the schedule, materials, and labor. I also was the engineer in responsible charge for the construction of the project and took responsibility for the constructed bridge.

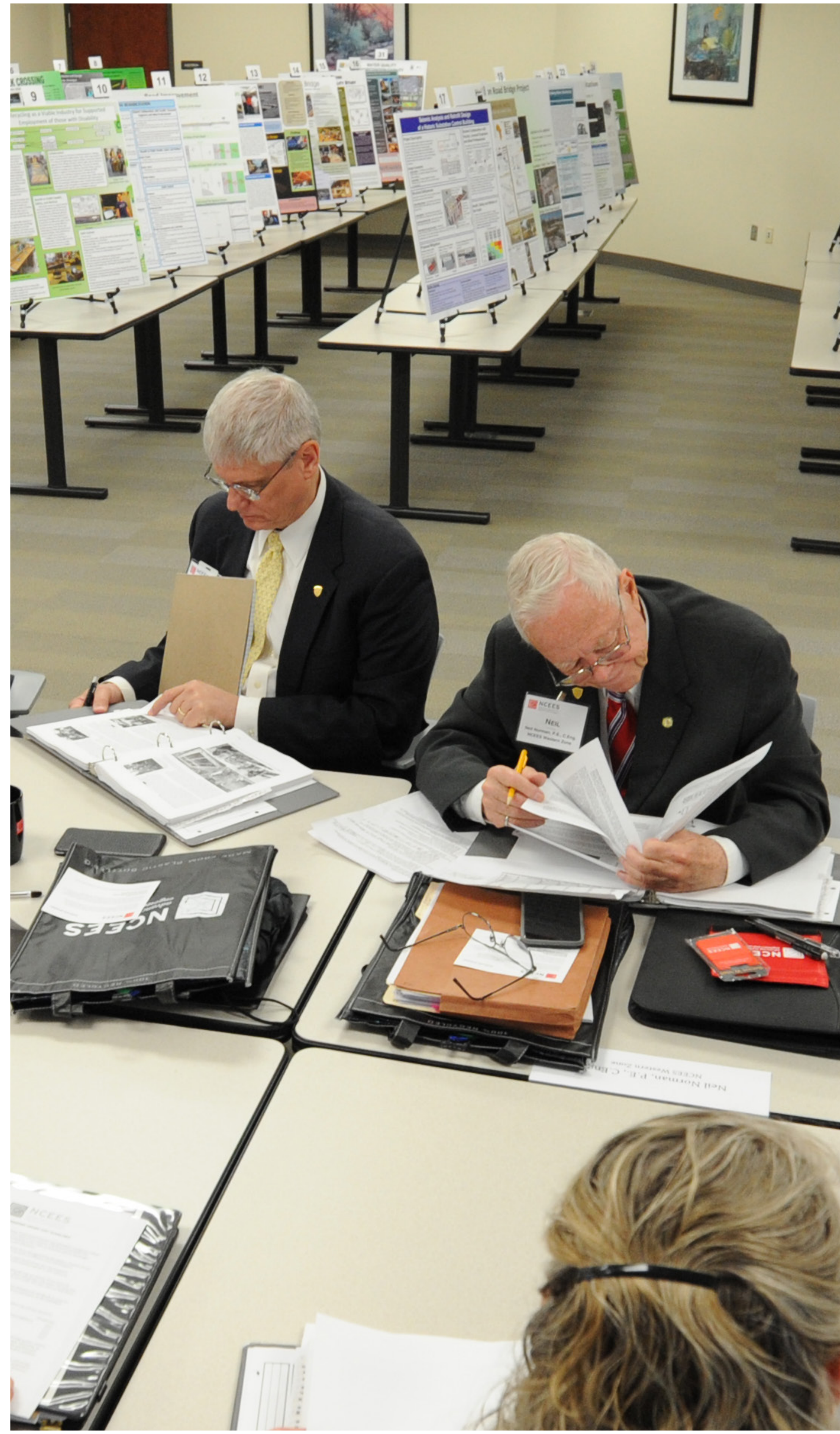
What did you learn from working with the students?

Students have so much energy that it is always a fantastic experience!

What did you want students to take away from working with professional practitioners?

I wish I had the opportunity to plan, design, and build a project at such an young age. I hope the students have come to appreciate all the facets of an engineering project, including the importance of financing and community relations.




Ronald Welch, Ph.D., P.E., COL (Retired)
The Citadel
Robert Green, P.E., F.NSPE
NSPE
Michael Smith, D.Eng.
Discover Diversity Council

NCEES

2015 NCEES
ENGINEERING AWARD
$7,500 WINNERS

THE CITADEL

Department of Civil and Environmental Engineering

Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church

GEORGE MASON UNIVERISTY

Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering

Water Supply, Distribution, and Storage Sabana Grande, Nicaragua

SEATTLE UNIVERSITY

Department of Civil and Environmental Engineering

Seismic Analysis and Retrofit Design of a Historic Substation Control Building

UNIVERSITY OF ARKANSAS AT LITTLE ROCK

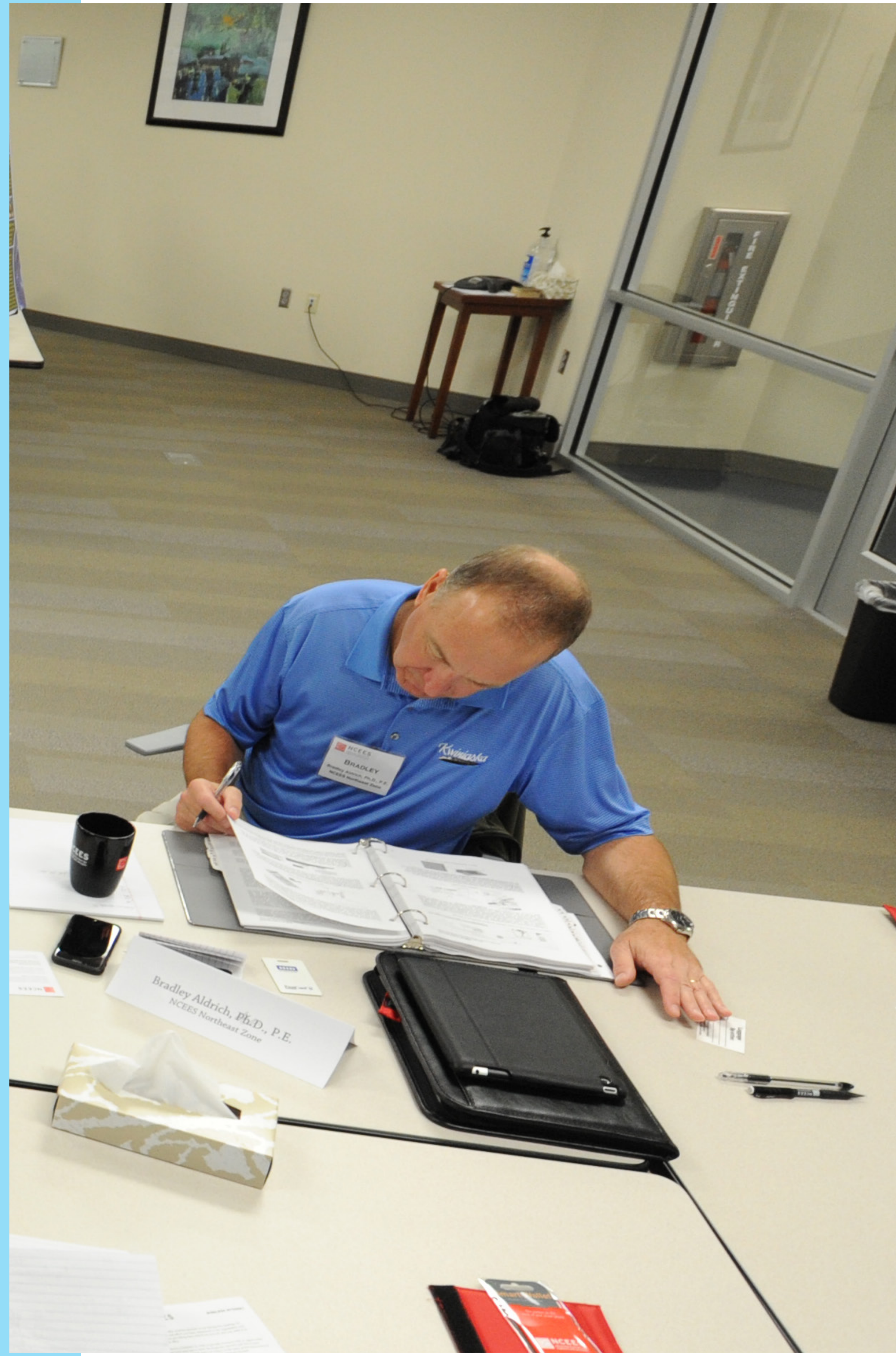
Department of Construction Management and Civil and Construction Engineering

American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

UNIVERSITY OF NEBRASKA-LINCOLN

Charles W. Durham School of Architectural Engineering and Construction

Multidisciplinary Vertical Farm Design

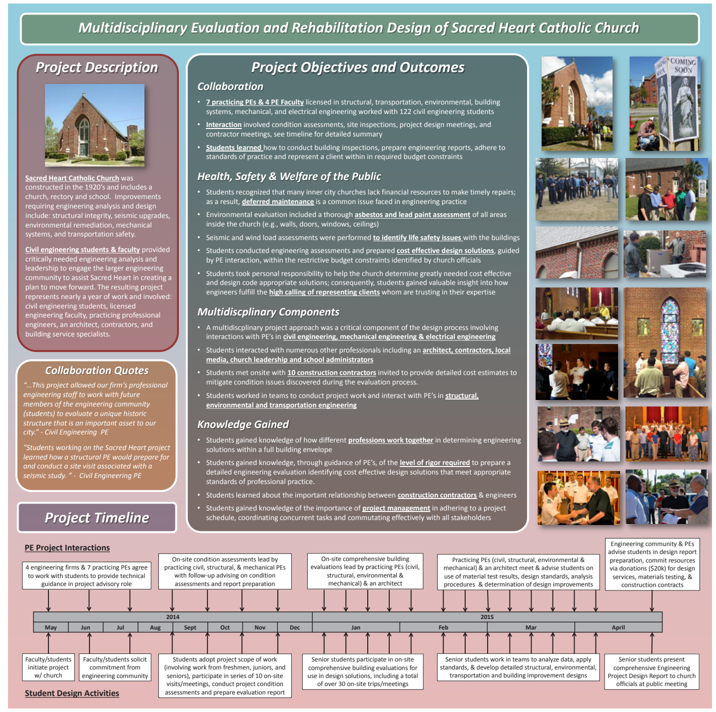


$7,500 AWARD

THE CITADEL

Department of Civil and Environmental Engineering

Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church



PARTICIPANTS

Students

Mason Ackerman
William Alexander
Zachary Appleby
Joshua Apsitis
Ulysses Avgeros
Cody Baird
Jake Bakley
Stephen Balentine
Vanessa Ballard
James Bath
Aaron Beck
Christopher Bellanova
Cameron Blanchard
Taylor Bostwick
Kyle Bowerman
Allen Boyd
Jordan Buster
Dane Butler
Trenton Butler
James Carraway
William Caughman
Michael Chan
Kenneth Chappell
Ahman Lemus Chavez
Jared Chrysostom
Stephen Cleary
Carli Cline
Christopher Cook
Joseph Cook
Taylor Cothran
Samuel Cowart
Charles Cox
Gregory Craft
Aaron Crosby
Austin Currie
Marlay Dantzier
Eddie Davis
Stephen Donaldson
Zachary Eulo
Ross Evans
Grant Eversmann
James Farmer
Erik Fender
Joshua Fiddie
Noah Flowe
Cody Floyd
Richard Foster
Grayson Gasque
Jeremy Gibbons
Alexander Green
Louis Guess
Benjamin Hall
Jason Hatch
Andrew Hensley
Logan Hester
Victor Hill
Cauley Hobson
Patrick Horgan
Abigail Humpston
James Howlin
Cody Jones
Eric Jones
Hunter Kennedy
Robert King
Braxton Kirby
Colt Kirkpatrick
Kashmeir Kirkpatrick
Eric Ladson
William Landreth
Aaron LeBrun
John Lee
William Lewis
Richard Linton
Cameron Lutes
Jack Marquez
Benjamin Martin
Harley Martin
Nicholas Mathwig
Daniel McCullough
Michael McGaffic
Randy Medders
John Millane
Christopher Miller
Davis Mixon
James Munson
Sabrina Necelis
Mark Neitzel
Richard Newman
Kelbey Oakes
Wesley Oellerich
Samuel Partyka
Jacob Payne
Zachary Peters
Andrew Phillips
Mark Rupinski
Justice Sanders
Henry Schweers
Justin Shinta
Charles Smith
Daniel Smith
Collin Sponable
Nicolas Stoker
Donnie Stroman
Ryan Templet
Aaron Terrill
Richard Thompson
Shannon Todd
Aaron Tribbett
George Turner
Justin Turner
Julian Vandamme
Phillip VanderWerf
Robert Wiegand

Faculty

Kevin Bower, Ph.D., P.E.
Ken Brannan, Ph.D., P.E.
Jeff Davis, Ph.D., P.E.
Timothy Mays, Ph.D., P.E.
Mary K. Watson, Ph.D., E.I.

Professional Engineers

Chuck Black, P.E.
Scott Cowen, P.E.
Richard Garcia, P.E.
John Greenan, P.E.
Rich Hamlin, P.E.
Al Schweickhardt, P.E.
Malena M. Yablinsky, P.E.

Additional Participants

Scott Harvey, AIA
Jim Killingsworth, CHMM
Eddie Polk, roofing expert
Rick Salmon, windows expert
Father Dennis Willey
Various representatives from 10 contractors and subcontractors

Jury Comments

"Strong proposal steeped in structural engineering and design principles"

"The collaboration between professional engineers and students led to a significant, practical design experience."

ABSTRACT

Approximately 122 students and four licensed faculty from a college in the southeastern United States worked together with seven practicing professional engineers, one architect, 10 contractors, and several other professionals to solve a major community problem common to many cities. Students recognized that several churches located near their inner-city campus were neglected, and upon further research, they learned that most inner-city churches lack the financial resources to make timely repairs. As a result, deferred maintenance becomes the norm rather than the exception, which leads to higher repair bills when a future crisis occurs (e.g., leaking roof, termite damage, heating and air issues). Most inner-city churches cannot afford evaluation studies to outline the need and cost of maintenance, repair, and rehabilitation options in order to meet current building code regulations. Parishioners and church staff typically lack the skill set to evaluate what needs to be done and to prioritize these needs. Inner-city churches often have long histories of individuals doing a variety of undocumented repairs without continuity between volunteers or consideration of building code requirements. Thus, church structures become a confusion of materials, designs, installations, and maintenance approaches.

In May 2014, students and faculty at the College reached out to the pastor of Sacred Heart Catholic Church and learned, as expected, that his parish had serious maintenance issues. To complicate matters, Sacred Heart Catholic Church is located in a high seismic and high wind area, making the building vulnerable to natural disasters. This document summarizes activities conducted by the civil and environmental engineering (CEE) department at the College related to evaluation and rehabilitation of Sacred Heart Catholic Church from May 2014 until April 2015.

In summary, all freshmen, all seniors, and key juniors in CEE at the College participated in the multidisciplinary evaluation and rehabilitation design of a historic, yet somewhat dilapidated, urban church near their campus. Students worked under the constant supervision of outside practicing engineers and licensed faculty members to perform a myriad of evaluation, design, fundraising, simple construction, and construction cost estimating activities for Sacred Heart Catholic Church. Key services performed by the students included a complete building envelope evaluation (structural, architectural, environmental, mechanical, electrical, plumbing), seismic and hurricane structural and nonstructural assessments, and rehabilitation design and cost estimations for all deficiencies noted during the evaluations. A final deliverable was presented to the church pastor on April 21, 2015.

$7,500 AWARD

THE CITADEL

Department of Civil and Environmental Engineering

Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church

PERSPECTIVES ON

Collaboration of faculty, students, and licensed professional engineers

During the entire one year over which the project has taken place, there has been constant collaboration of licensed faculty (4), students (approximately 122), and professional engineers (7). The evaluation and rehabilitation design of Sacred Heart Catholic Church involved over 30 total faculty/student/professional engineer visits that included field trips, meetings with contractors, meetings with church staff, and other critical data-gathering sessions. Involved professional engineers participated in field trips with students and data-gathering sessions, which allowed them to guide students in hands-on, experiential learning. Furthermore, professional engineers and faculty worked closely with students as they developed a master report for the pastor of Sacred Heart Catholic Church.

The three main lessons the students learned from the project were (a) how to write a practical engineering report that references current codes and standards, (b) how to perform a building inspection, and (c) how to think and solve problems quickly in the field. For example, students were amazed by how quickly one licensed engineer was able to identify a cut brace deficiency in the church attic.

Knowledge and skills gained

A conclusion made almost each week by the students was that the knowledge and skills gained by working directly with licensed engineers and contractors was invaluable. Many students stated that they learned more in the field than they did the same week in course lectures.

The full building envelope evaluations, which involved architecture, structural engineering, environmental engineering, mechanical engineering, and electrical engineering, showcased how all disciplines must work together to ensure a successful project.

Although the students indicated that evaluation techniques (e.g., field measurements) were a primary and necessary civil engineering skill learned during this project (and not specifically taught in the traditional

curriculum), a survey at the end of the project revealed that report writing may have been the most significant skill learned. Licensed engineers stressed that professional report writing is paramount to the practicing engineer and an important aspect of daily activities. The final product developed by the students was nothing like an academic lab report. At project completion, the students delivered a comprehensive 100-page report to the church pastor.

The licensed engineers working with the students on the project taught the students correct formatting for laying out reports and appropriate methods to address a particular client's concerns.

Finally, project management played a major role in the entire project. Students actually participated in all of the building evaluations. In fact, at times, the structural, seismic, and wind assessments were led as much by the students as the licensed engineers. However, during the building systems (electrical and mechanical) and architectural assessments, students played the role of project managers as they scheduled and met the other discipline leaders onsite since they were unqualified to perform the assessments themselves. Similarly, after the mitigation designs were developed, students played the role of project manager with all the contractors. Each contractor was contacted by students and met on site to ensure that the contractors' cost estimates to fix deficiencies were in line with the expected amount of work.

$7,500 AWARD

GEORGE MASON UNIVERSITY

Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering

Water Supply, Distribution, and Storage Sabana Grande, Nicaragua

PARTICIPANTS

Students

Jennifer Arias
Abigail Armuth
Rony Avalos
Rob Burkhart
James Craighead
Chris Dolan
Chris Evans
Jordi Fabian
Lindsey Keller
Seth Lawler
Santosh Neupan
John O'Brien
Micah Poole
Josh Powell
Yalda Rahimi
Osualdo Ramos
Kathryn Snyder
Ashley Timms

Faculty

Liza Durant, Ph.D.
Deborah Goodings, Ph.D., P.Eng.
Laura Kosoglu, Ph.D.

Professional Engineers

Liz Anderson, E.I.T.
Carmen Bere, E.I.T.
David Binning, P.E.
Gabe Stone Breaker, E.I.T.
Matthew Doyle, P.E.
Tala Eisawi, E.I.T.
Felicia Glapion, P.E.
Satha Mathavan, E.I.T.
Sean O'Bannon, E.I.T.
Katty Overcash, E.I.T.
Kenex Sevilla, E.I.T.
Michael Shular, E.I.T.
Chris Triolo, P.E.
Katie Winters, E.I.T.

Additional Participants

Kristin Amaya, admin
Nicole Jerome, admin
Amy Mackintosh, admin
Craig Rice, water lab
Michael Ridden, solar
Raiel Sevilla, engineering student
Joanna Vivanco, soils lab

Jury Comments

"The students did a great job mobilizing this community."

"Access to clean water is a worldwide problem. The team created a replicable solution that can be used around the world."

"This project not only serves those who will now have access to clean water, but it will tell a valuable story to those considering entering the engineering profession."

ABSTRACT

Engineers for International Development (EfID) is a rapidly growing student-directed, nonprofit organization that fundraises, designs, and constructs innovative systems for communities with critical infrastructure needs. It is an organization with a foundation based on the support of student volunteers, faculty, and allied licensed professionals.

The project described herein is EfID's largest project to date, took place in Sabana Grande, Nicaragua, and was completed in two separate phases in 2013 and 2014. Phase I required installation of a 200-foot-deep well for drinking water; a water pump; a pressure tank and switch; an 800-watt, 12-volt solar-powered array; and 1,500 linear feet of PVC piping and fittings. Multiple water stations or kiosks were installed at strategic locations, as well as a security fence, which ensured the safety of the community and equipment. Phase II involved the extension of a water distribution system to each individual house in the community and installation of a 10,000-liter water storage tank. Students worked side by side with the faculty and volunteer professional engineers throughout each phase to ensure all design calculations were correct.

The Sabana Grande community was selected to receive EfID support after three students and one licensed professional engineer (P.E.) conducted a trip that would give them the opportunity to interact with the community and its leaders, with the goal of establishing a needs assessment. Sabana Grande is one of many communities that lacks infrastructure to distribute or store clean water. During the assessment trip, the team tested the two wells that served as the primary source for water in the community, to include drinking, cooking, and cleaning. Testing revealed that the water contained pathogens such as, bacteria, viruses, and protozoans. In addition to the poor quality of water, many members of the community, consisting of about 30 homes, 150 people, and a local elementary school, were located more than 1 to 2 kilometers from the wells, requiring significant time to gather water and haul it back to homes and the school for consumption. As a result of this assessment trip, EfID identified a critical need for a water distribution system to protect the health, safety, and welfare of the members in the community.

Since the first assessment trip in January 2013, as many as 40 students and 14 licensed engineers and faculty have contributed to this project and, as promoted by EfID, have been under the guidance of a practicing licensed professional in civil engineering. The students have held weekly project meetings lasting several hours with P.E.s or engineers in training (E.I.T) in attendance. During the assessment and implementation trips to the field communities, the teams are small in size and include a professional engineer as a member of the team.

With the help of community members, undergraduate students, and licensed engineers, the Sabana Grande project was successfully completed in two separate implementation trips. This achievement required years of planning and design time and a total of 20 travel days in Nicaragua.

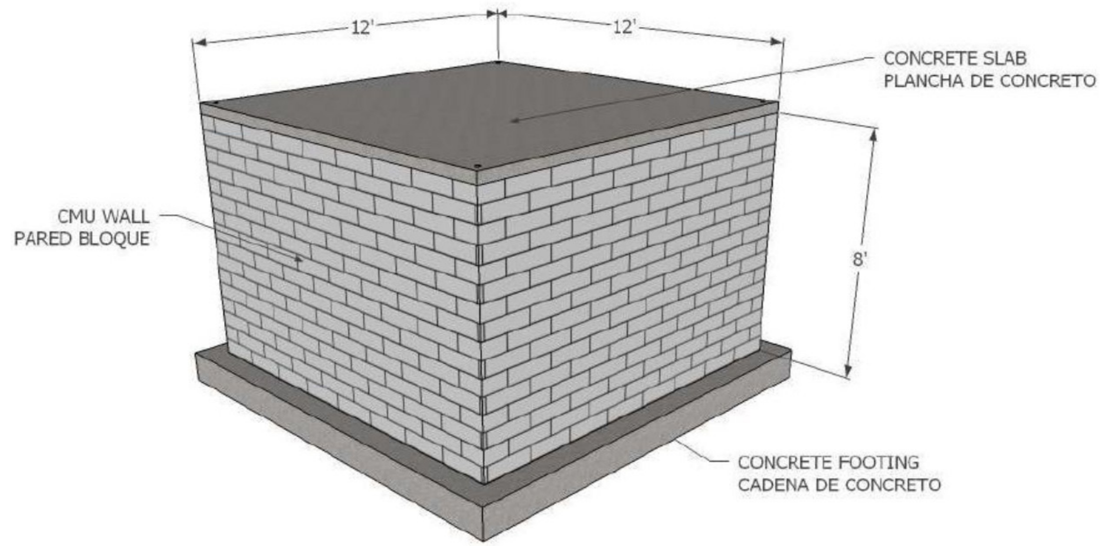
$7,500 AWARD

GEORGE MASON UNIVERSITY

Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering

Water Supply, Distribution, and Storage Sabana Grande, Nicaragua

PERSPECTIVES ON



Collaboration of faculty, students, and licensed professional engineers

EfID members conducted extensive research with professional engineers during the assessment trip to further enhance their design for the Sabana Grande community. The data consisted of GPS and elevation coordinates, as well as survey analysis for every household regarding daily water consumption. Based on the data collected, students and faculty designed for future development of homes in the community, as well as water demand growth. As part of the research and planning process, professional engineers, faculty, and students assembled a replica of the system and began testing to avoid delays in the field. With the forward thinking by the engineers, the Sabana Grande project was completed and improved in 20 short travel days.

Knowledge and skills gained

The knowledge gained through this incredible experience ranges from field experience to cultural learning for not only the students but the professionals as well. The students improved their understanding of surveying analysis while working alongside professional engineers, who taught them beyond what the classroom could offer. The students also gained knowledge in water resource engineering by understanding the fundamental importance of having the correct pressure set for a water distribution system.

As the students' knowledge increased, their skills to improvise improved. While working in a foreign country, there are always obstacles that cannot be accounted for until they have happened. The students and professionals made a design with certain materials, but unfortunately, the only hardware store was located in a small remote town of Condega, Nicaragua. The store contained only commonly used items. Regrettably, some parts required for the water distribution system were irregular to the store and needed to be transported in from the next largest city, Esteli, Nicaragua. The team learned to improvise their design with the materials the store contained rather than to postpone building and fall behind schedule. The skills to improvise and make decisions were a vital part of working in a field that most students had not experienced.

The student volunteers and professional engineer's knowledge did not stop with engineering skills, but also expanded to cultural knowledge. Everyone realized the importance of having a strong unified community. The 150 members in the community taught all the travelers that it is the basic fundamental to a happy life when people are able to come together and help one another. To keep the water system healthy, a water committee and community members were trained on how to take care of the system. The committee came to an agreement to incorporate a savings system of 50 cordobas (1 USD) a month to provide maintenance funds for the system. Should the equipment require repair, the community would have the money to sustain the water distribution system that will continue to improve the health and welfare of the entire

community. It is evident how important a sense of community is to survive in underprivileged countries.

The significance of communication with the community positively impacted the students and facilitated the understanding that although a perfect design may be constructed, if it does not meet the community's needs, it is a worthless effort. There was no better feeling than when members of the community thanked the EfID team for their hard work in taking the time to improve their quality of life. The lessons these students learned from this project and the Sabana Grande community is something they will carry with them and appreciate for a long time to come; in doing so, they will continue to realize that, as engineers, they have a responsibility to society and even into the future will be unable to overlook a community's declining public welfare.

$7,500 AWARD

SEATTLE UNIVERSITY

Department of Civil and Environmental Engineering

Seismic Analysis and Retrofit Design of a Historic Substation Control Building

PARTICIPANTS

Students

John Anderson
Randal Anton
Keisuke Massey
Garrett Skelton

Faculty

Katherine Kuder, Ph.D., P.E.
Jhon Paul Smith, Ph.D., P.E.
Nirmala Gnanapragasam, Ph.D., P.E.

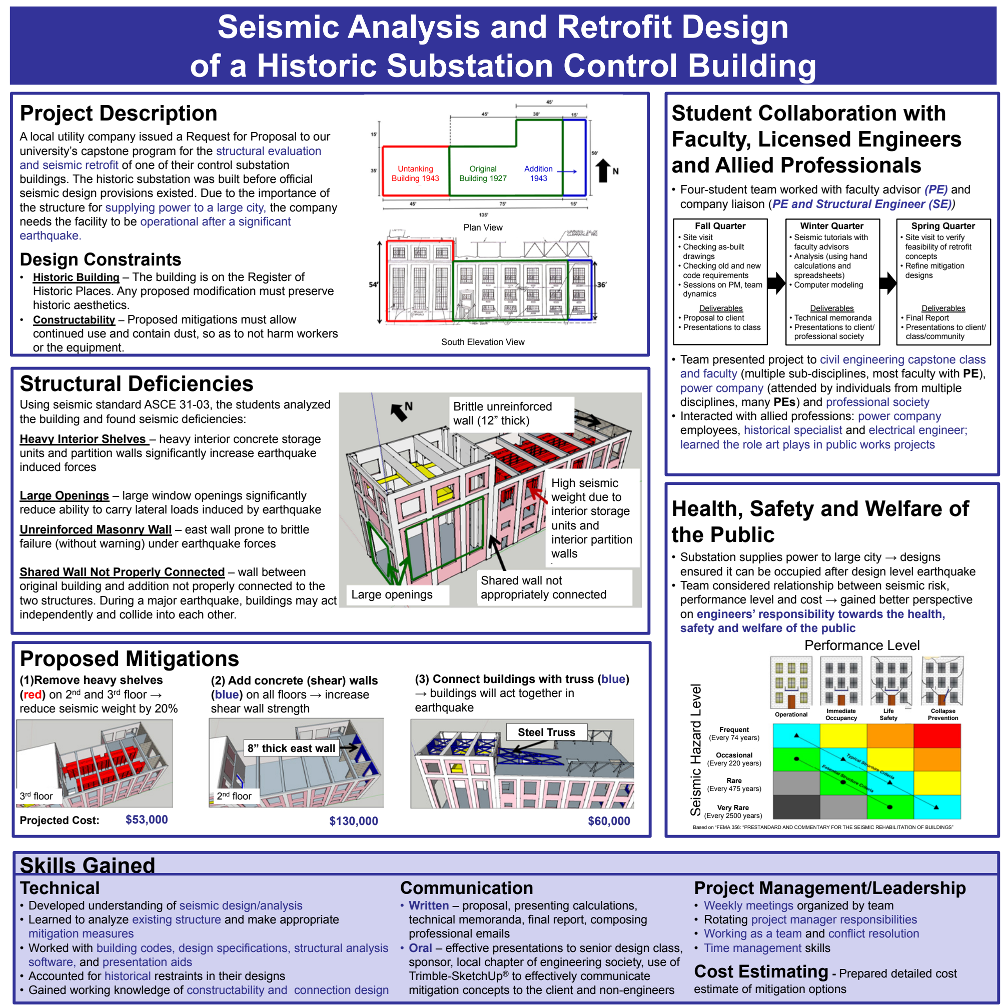
Professional Engineers

Robert Cochran, P.E., S.E.,
Seattle City Light

Jury Comments

"The collaboration between students and professional engineers led to a significant, practical design experience."

"The project involved interactions with and consideration of other disciplines such as the utility company, a historical specialist, and an electrical engineer. It also benefitted from the involvement between students and professional engineers."



ABSTRACT

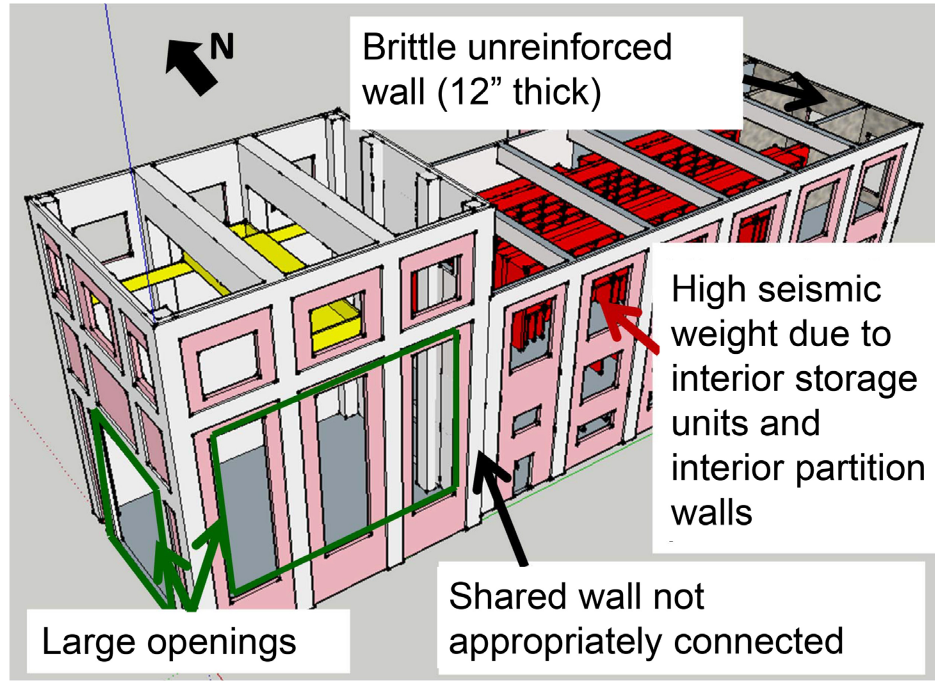
A local utility company issued a request for proposal to our university's capstone program for the structural evaluation and seismic retrofit of one of their substation control buildings, which was built before official seismic design provisions existed. Due to the importance of the structure for supplying power to a large city, the company needs the facility to be operational after a major earthquake.

The original building was constructed in 1927, with major structural additions made in 1943. It is a three-story reinforced concrete structure of approximately 13,000 square feet. The utility company imposed the following design constraints: the building must remain functional in the event of a major earthquake; due to the operational importance of the structure, any proposed mitigations must allow continued use and contain dust, so as to not harm workers or the equipment; because the building is a historic landmark, any proposed changes need to preserve the aethetics of the original builidng.

Based on the design constraints, the team determined the performance level of the building to be "immediate occupancy" per design code, which ensures employee safety and uninterrupted power supply to the city following an earthquake. Considering the relationship between seismic risk, performance level, and cost helped the students gain a better perspective on engineers' responsibility to consider the health, safety, and welfare of the public in this project.

The team used a two-tiered process specified by the American Society of Civil Engineers Standard for Seismic Evaluation for Existing Buildings (ASCE 31-03) to perform the seismic assessment of the substation control building. A site visit by the team followed by analysis revealed that (a) the building has a high seismic weight due to interior storage concrete shelves and partition walls, (b) the building has unreinforced walls, which may fail in a brittle manner without warning, and (c) the original building and the addition lack appropriate connections enabling the two structures to act independently during a major earthquake.

The team recommended three mitigations: (1) removing the interior shelves and partition walls to reduce the weight and, therefore, the inertial forces caused by an earthquake, (2) adding reinforced concrete walls (referred to as shear walls) to strengthen the building, and (3) connecting the original building and the addition with a steel truss at the roof level so that both the structures act together in an earthquake. The projected costs for these mitigations were $53,000, $130,000, and $60,000.



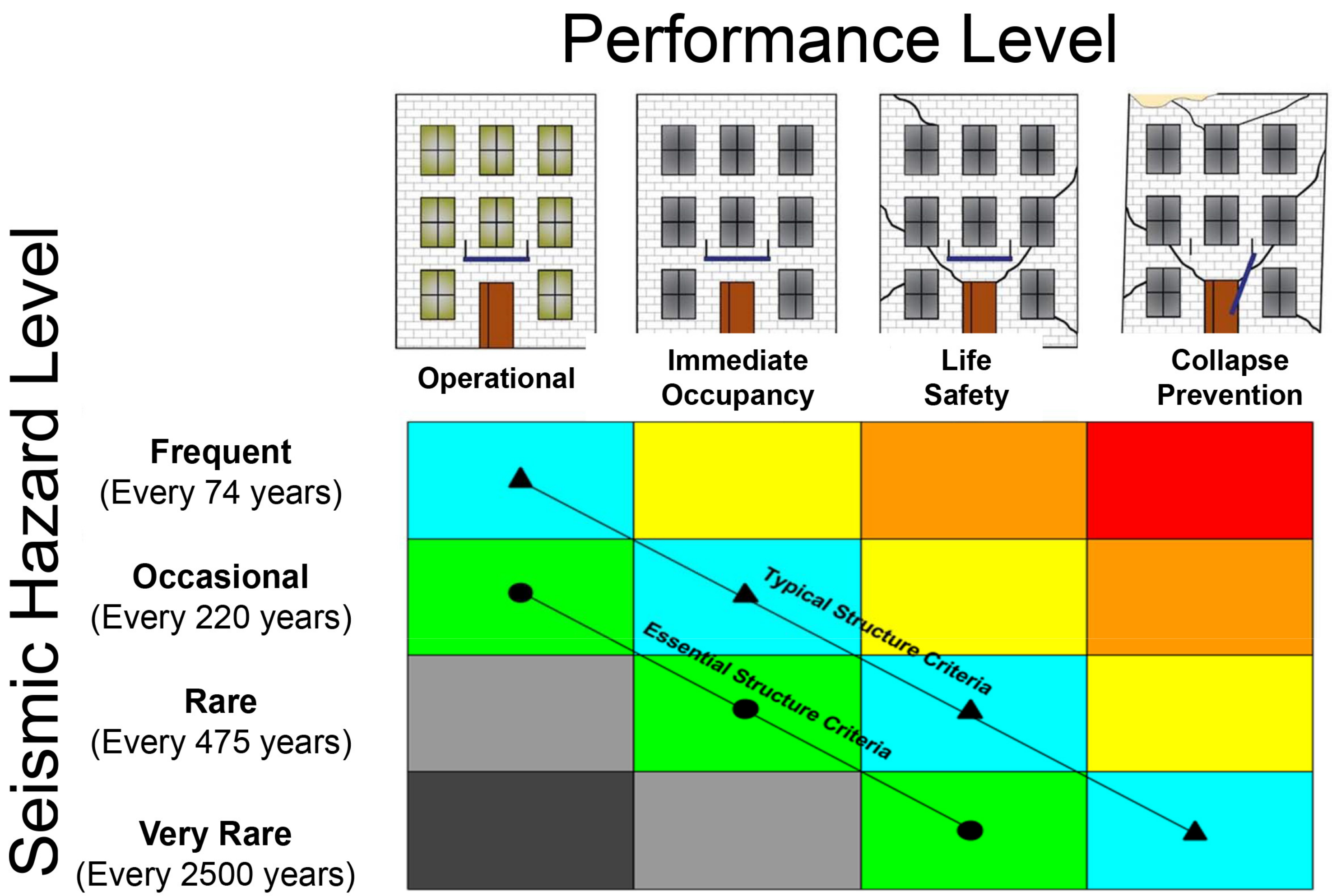
Four students were assigned to this project and worked under the guidance of a faculty advisor who is a licensed professional engineer (P.E.) and a licensed professional and structural engineer (P.E. and S.E.) from the sponsoring company. As part of the capstone course, students completed (1) a written proposal during the fall quarter, (2) the major analysis and design work during the winter, and (3) a final report and presentation in the spring quarter. Project highlights included site visits; professional presentations to their class, the project sponsor, and an outside professional chapter; working with a historical specialist and electrical engineers from the utility company; and learning about the role art plays in public works projects. The team also learned to use Trimble SketchUp® to effectively convey their mitigation concepts to the client and non-engineers. The project culminated in an oral and poster presentation event to the university and local engineering community. Throughout the year, students developed important technical, communication, project management, and cost estimating skills to help prepare them for their future careers as practicing engineers.

$7,500 AWARD

SEATTLE UNIVERSITY

Department of Civil and Environmental Engineering

Seismic Analysis and Retrofit Design of a Historic Substation Control Building



Based on "FEMA 356: "PRESTANDARD AND COMMENTARY FOR THE SEISMIC REHABILITATION OF BUILDINGS"

PERSPECTIVES ON

Multidiscipline or allied profession participation

The project included opportunities for the students to interact with other disciplines and licensed P.E.s.

During the site visit, the design team interacted with utility company workers and P.E.s to learn about the site. They also presented their proposal (late fall), preliminary design concepts (early spring), and final recommendations (late spring) at the utility company to an audience that included staff at the substation control building, project managers, and P.E.s.

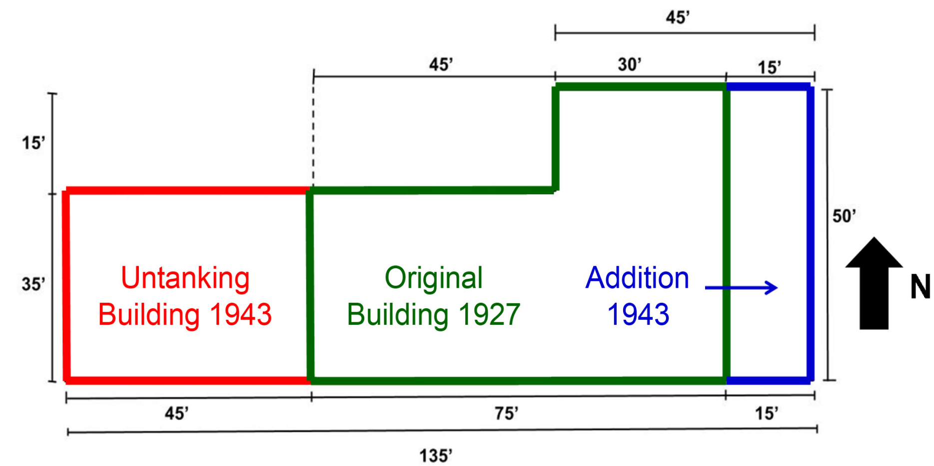
The substation control building is a historical landmark. During the winter quarter, the students met a historical specialist, who works at the utility company. They learned about the company's historic management plan and that the aesthetics are to be preserved. In the spring, they met again with the specialist to make sure that the proposed mitigation schemes did not significantly affect the historical appearance of the building.

The substation control building houses important electrical equipment. To help the team better understand this equipment and the operation of the facility, they met with an electrical engineer from the utility company.

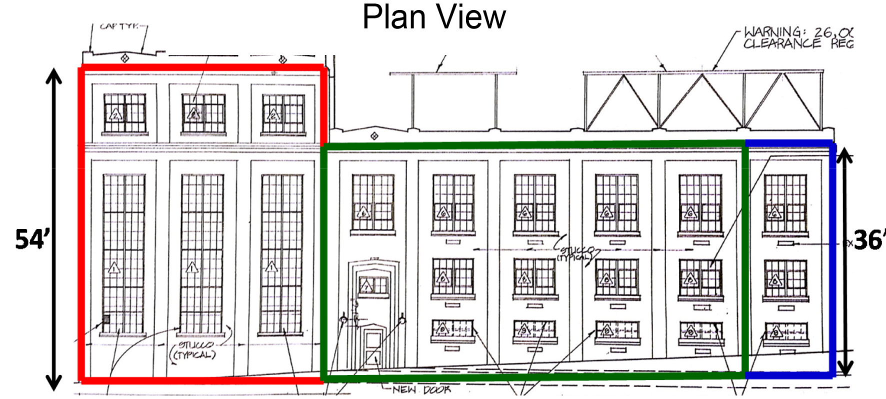
The substation control building has an art budget to contribute to the aesthetics of the neighborhood. The building is painted pink and cultural images are projected through the windows at night. During their facility tour, the team learned about the inclusion of art in public works projects. Their final mitigations had to preserve the art features of the building.

Protection of public health, safety, and welfare

The substation supplies power to a large city; therefore, ensuring it can be occupied after a design level earthquake protects public health, safety, and welfare. For a typical structure, the structure must remain operational after frequent earthquake events and must not collapse after very rare earthquakes. Essential facilities have more stringent design criteria. Because the substation serves a large city, the utility company considers it critical for it to remain operational after a design level earthquake. The team determined that the performance level of the building should, therefore, be immediate occupancy, ensuring that employees are safe and that power can still be supplied to a large city. Considering the relationship between seismic risk, performance level, and cost helped the students gain a better perspective on engineers' responsibility to consider the health, safety, and welfare of the public in this project.



Plan View



South Elevation View

$7,500 AWARD

UNIVERSITY OF ARKANSAS AT LITTLE ROCK

Department of Construction Management and Civil and Construction Engineering

American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

PARTICIPANTS

Students

Sarah E. Brown
Joshua M. Hendricks
Angela B. Matika
Whitney Montague
Esteban R. Rodriguez
Essie C. Whitmore

Faculty

Hollis G. Bray, D.Eng, P.E., C.P.C., Associate Professor

Nickolas S. Jovanovic, Ph.D., P.E., Associate Professor

Professional Engineers

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Michael A. Callahan, P.E., SECB, Cromwell Architects Engineers

Joe H. Hilliard, P.E., SECB, Cromwell Architects Engineers

Paul Timko, P.E., Cromwell Architects Engineers

Additional Participants

Larry M. Newkirk, AC, Cromwell Architects Engineers

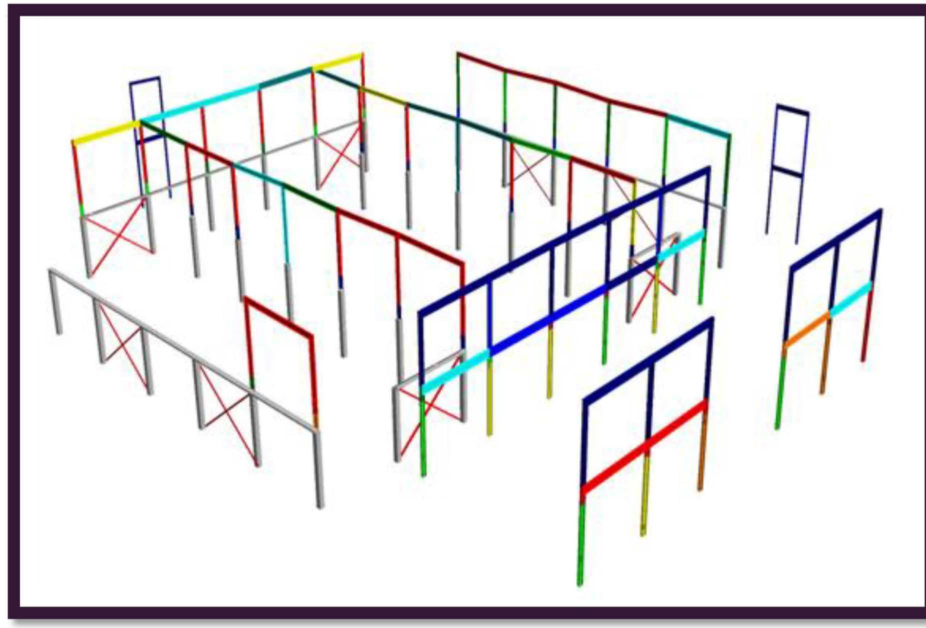
Jury Comments

"The wide participation of students, faculty, and professional engineers made this project a success."

"This was a great project that also included a freshman component, which could possibly lead to greater retention."

"The project enabled many students to assess the structure and get exposed to structural rehabilitation."

ABSTRACT



This study presents a conceptual seismic retrofit design to limit structural damage to the state Red Cross headquarters, an essential services facility vulnerable to seismic forces from earthquakes originating within the New Madrid Seismic Zone (NMSZ). The NMSZ is the most seismically active area of the United States east of the Rocky Mountains, experiencing more than 150 earthquakes annually (MDNR, 2014). Most of these events are small, but there is a 10 percent chance of a magnitude 7.5–8.0 earthquake occurring in the NMSZ within the next 50 years (Gomberg, 2007). An event of this magnitude would result in numerous injuries and deaths and substantial structural damage to older buildings constructed prior to development of modern seismic design guidelines.

A team of six senior civil and construction engineering students worked with advisors from structural engineering, general contracting, and steel fabrication firms to identify a cost-effective approach to strengthen the structural framework of the Red Cross facility. The Red Cross headquarters provides immediate emergency care after disasters, 24 hours a day, 365 days of the year. The facility consists of two functionally connected but structurally independent buildings: a two-story building with a first-story concrete tilt-up framework and a second-story steel framework and an L-shaped, one-story concrete tilt-up addition. Constructed prior to the adoption of modern seismic design requirements, both structures were built without consideration for seismic forces.

The objective of the seismic retrofit design was to allow for immediate occupancy following an earthquake and, failing that, provide enhanced control to minimize damage and allow a swift reopening of the facility. The challenge was to achieve the desired performance level with minimum cost and disruption to Red Cross operations.

RAM Structural Systems software was used to model the facility and assess the susceptibility of the existing structural framework to seismic failure. Laterally loaded models were used to identify a conceptual seismic retrofit design. Steel ordinary concentrically braced frames were selected for the retrofit of the two-story building based on ASCE 7-10 guidelines. Three options for placement of the frames were simulated in RAM Structural Systems. The final selection was based on seismic resistance, constructability, cost, and facility operation concerns. The selected conceptual design incorporates five steel X-brace frames. Special considerations regarding foundation concerns warranting further study were noted. The cost for implementation of the retrofit was estimated to be approximately $380,000, and the construction timetable was 111 workdays.

The L-shaped addition was determined to be susceptible to seismic forces due to the irregularity of its floorplan. Reinforcement of corners and connections and placement of interior seismic frames were proposed to alleviate stress concentrations under seismic loading.

Through this study, a conceptual seismic retrofit design for improving performance under seismic loads and protecting operations at the Red Cross facility was identified. The proposed steel ordinary concentrically braced frames are relatively inexpensive to design and implement and provide a safe lateral force resisting system for older structures such as the Red Cross facility.

Gomberg, J., and Schweig, E. (2007). *Earthquake Hazard in the Heart of the Homeland* (No. 2006-3125).

Missouri Department of Natural Resources, 2014. The New Madrid Seismic Zone. Missouri Geological Survey fact sheet number 26. (http://dnr.mo.gov/pubs/pub2465.pdf).

$7,500 AWARD

UNIVERSITY OF ARKANSAS AT LITTLE ROCK

Department of Construction Management and Civil and Construction Engineering

American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

PERSPECTIVES ON

Collaboration of faculty, students, and licensed professional engineers

During the fall 2014 semester, the student team was enrolled in CNMG 4185 Professional Engineering Seminar. This class meet twice weekly to work on this design project. The class was led by their faculty advisor, who is the civil and construction engineering program coordinator and a licensed engineer. The faculty advisor provided guidance with respect to development of a scope of work, establishment of goals and deadlines, and identification of research resources.

In the spring 2015 semester, the students enrolled in CNMG 4285 Civil and Construction Engineering Design Project. The student team met twice weekly with a university faculty member, who is a licensed engineer. This faculty advisor helped the student team strengthen its skills with respect, quality, and productivity improvement, implementing a bi-weekly project reporting system.

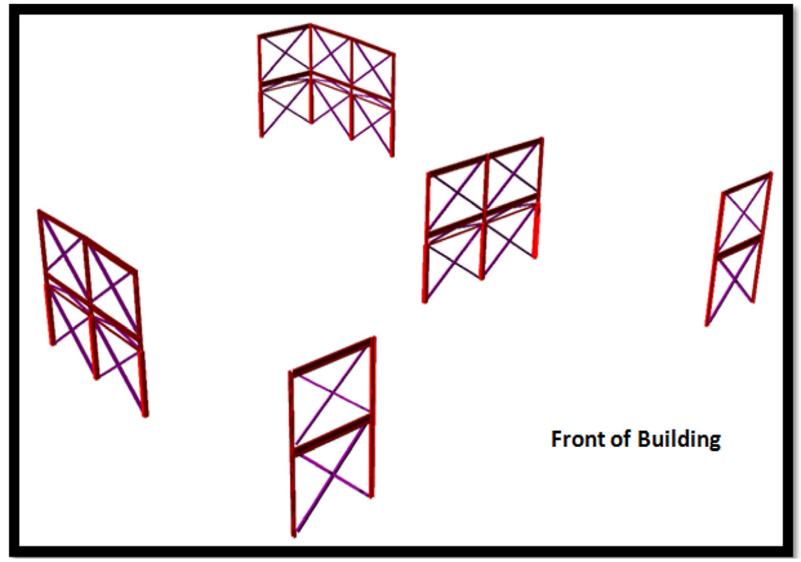
Throughout the school year, the students met every other week with an advisory team of licensed engineers and construction managers representing two firms. The engineers are formally trained structural engineers. The advisory team provided technical training and guidance with respect to use of the RAM Structural modeling suite, seismic design methodology, and structural analysis. The advisory team also provided technical review and guidance throughout the design process.

The advisory team provided multiple opportunities for students to meet with them on an individual basis to provide more targeted assistance on technical matters such as analysis of pseudo flexible diaphragms and detailed design of concentric braces.

Deliverables that the students provided to the faculty advisors and the advisory team included:

- mid-point presentation and report (December 3, 2014);
- powerpoint presentation on interim report (December 23, 2014);
- final report, first draft (April 1, 2015);
- final report, second draft (April 15, 2015);
- project presentation (April 24, 2015); and
- final report, final draft (April 29, 2015).

Faculty advisors and the advisory team provided students with feedback and additional guidance based on these deliverables.



Multidiscipline or allied profession participation

After the park board approved the Multidiscipline and allied profession participation was required to develop the conceptual seismic retrofit design. The proposed design of the steel ordinary concentrically braced frames used structural engineering methodology based on geotechnical considerations. The construction schedule and cost estimates were developed based on construction management considerations.


Red Cross

$7,500 AWARD

UNIVERSITY OF ARKANSAS AT LITTLE ROCK

Department of Construction Management and Civil and Construction Engineering

American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

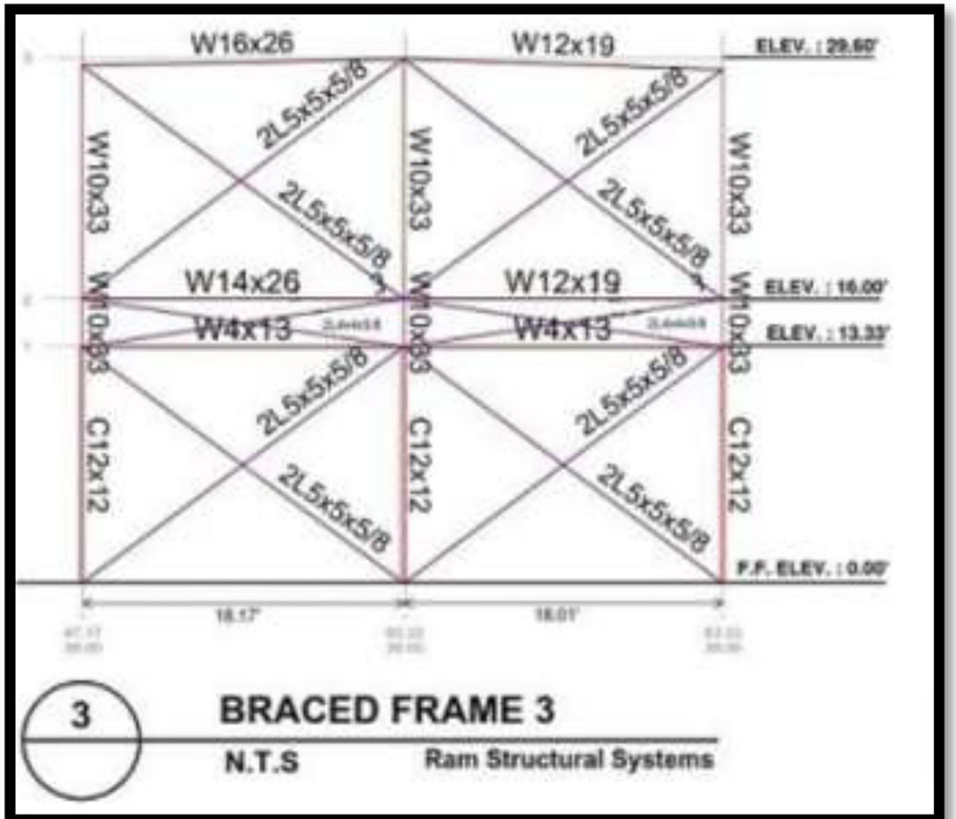


Figure 3: OCBF X bracing Configuration

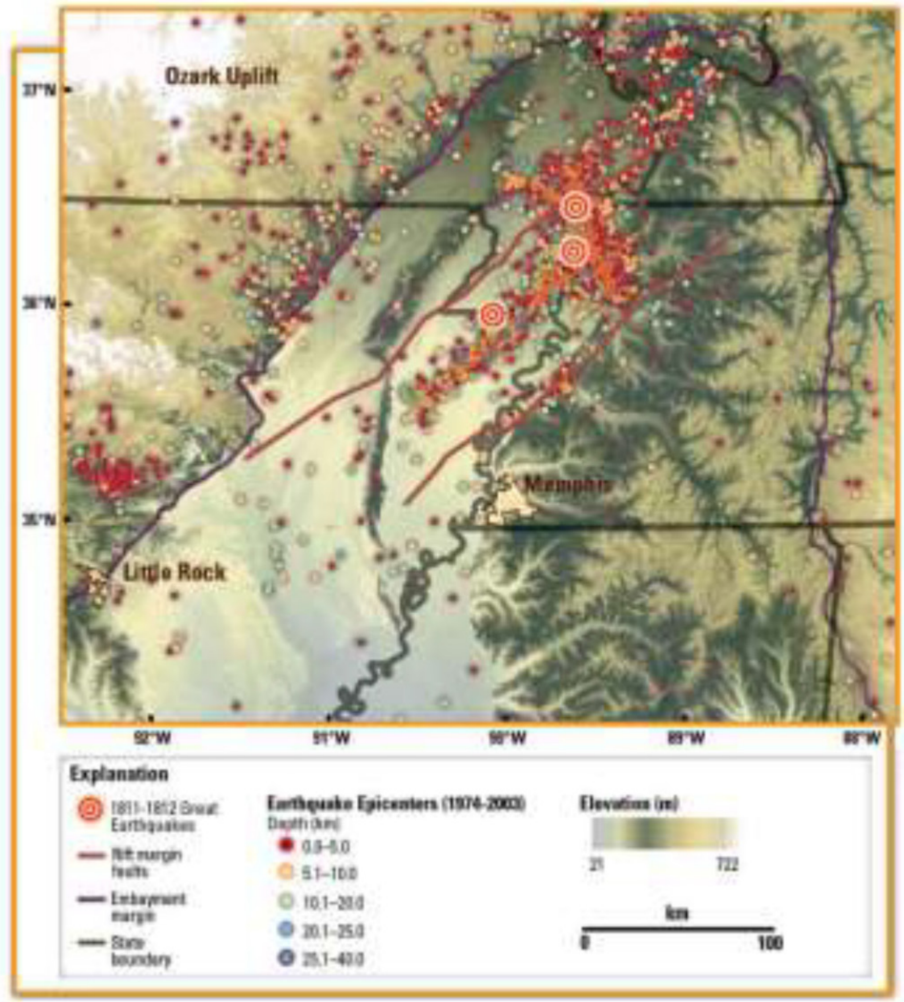


Figure 4: Earthquake Activity in the New Madrid Seismic Zone (Contributors, 2011)

The students identified viable retrofit options based on guidance provided in ASCE 7-10: Minimum Design Loads for Buildings and Other Structures and constructability considerations. ASCE 7-10 provides a matrix for determining suitable seismic force resisting systems based in part on the Seismic Design Category (SDC). The SDC represents seismic risk based on occupancy and post-earthquake use, the severity of ground shaking, and other earthquake effects the structure may experience. There are six categories, ranging from A (minimal risk) to F (highest seismic risk). The student team determined the appropriate SDC category using methodology outlined in Chapter 11, Seismic Design Criteria, of the ASCE 7-10. Geotechnical considerations included site soil classification and determination of ground motion parameters. The student team reviewed soils reports and consulted with the advisory team to identify soil class. The ground motion parameters were determined using U.S. Geological Survey design maps. This online tool allows the user to get site-specific geotechnical information based on building code, soil classification, building occupancy and use, and altitude and latitude coordinates. Based on these geotechnical considerations, the student team identified the Red Cross facility as a Seismic Design Category D classification, indicating a need for relatively high strength options.

The student team used structural engineering principles to design and assess the OCBF system. An X-bracing configuration was selected as it requires limited demolition and comparatively simple construction. Additional structural engineering considerations included preliminary connection designs for the OCBF bracing. Although connection design was beyond the scope of this project, the students determined that a design was necessary to realistically estimate material and fabrication costs. The students identified known reactions for one OCBF bracing. Using these computations, a licensed civil engineer on staff at a local steel fabrication shop developed preliminary connection designs for the student team.

Following analysis and verification of the conceptual seismic retrofit design, the student team developed a cost estimate and a construction schedule for implementation.

Students consulted with experienced construction managers from a local general contracting firm. The industry advisors provided guidance with respect to required tasks, phasing, and estimation.

The student team developed the model representations of the Red Cross facility based on architectural drawings showing column and beam layout, room dimensions and usage, roof construction, and structural details.

$7,500 AWARD

UNIVERSITY OF NEBRASKA–LINCOLN

Charles W. Durham School of Architectural Engineering and Construction

Multidisciplinary Vertical Farm Design

PARTICIPANTS

Students

Brianna Brass
Kate Fickle
Alycia Noble
Andrew Reinke
Sara Robbins
Linsey Rohe
Adam Steinbach
Wyatt Suddarth
Josh Wilson
Geof Wright

Faculty

Moe Alahmad, Ph.D., P.E.
Stuart Bernstein, Ph.D.
Ece Erdogmus, Ph.D., P.E.
Terence Foster, Ph.D., P.E.
Gary Krause, Ph.D., P.E.
Clarence Waters, Ph.D., P.E.

Professional Engineers and Engineer Interns

Denise Allacher, P.E.
Dave Carey, P.E.
Todd Feldman, S.E.
Steve Gollehon, E.I.
Ryan Goughnour, E.I.
Dan Hahn, P.E.
Joe Hazel, P.E.
Brendan Headley, E.I.
Craig Johnson, P.E.
Drew Johnson, P.E.
Kyle Kauzlarich, E.I.
Brian Kolm, P.E.
Gary Lange, P.E.
Andy Lang, P.E.
Todd Mack, P.E.
Tim Morrison, E.I.
Brandon Rich, P.E.
Ben Ries, P.E.
Alexander Skillman, P.E.
Kevin Wenninghoff, E.I.
Andrew Wilson, P.E.
Jim Zavadil, P.E.

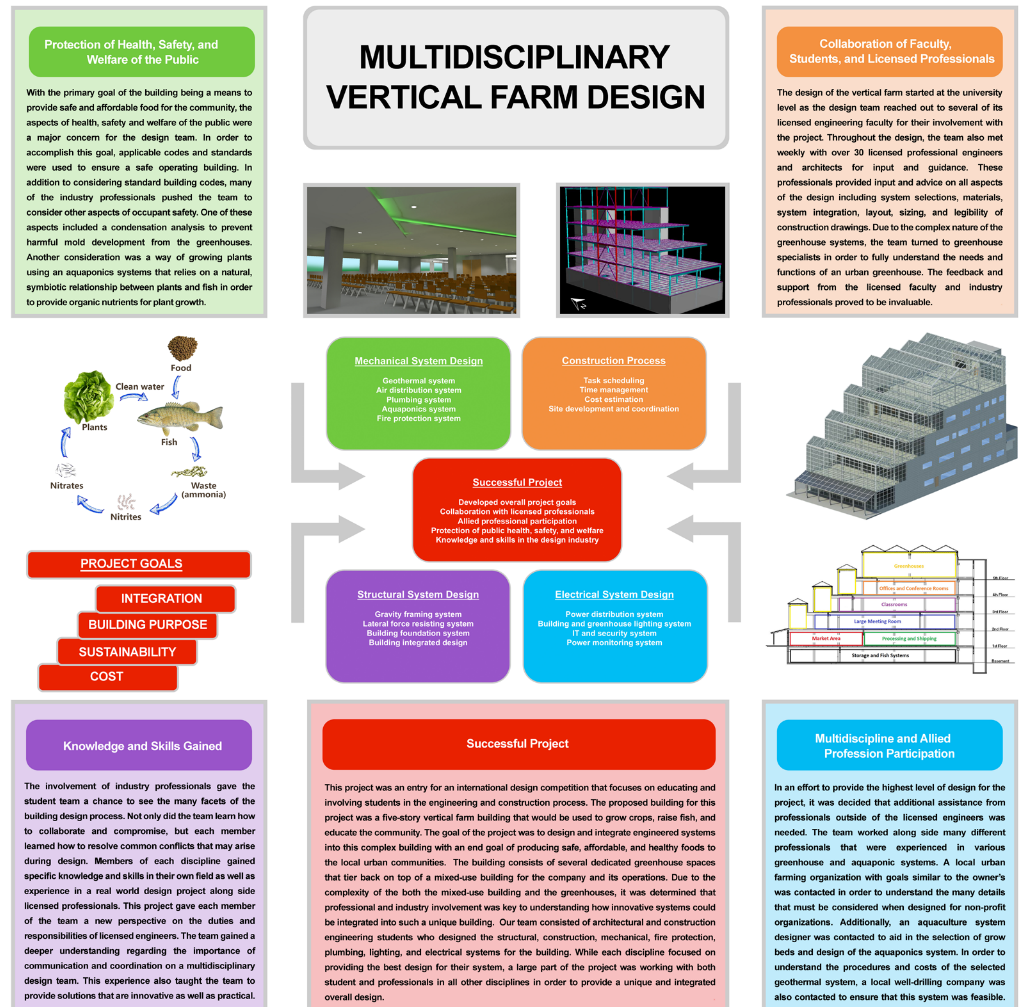
Additional Participants

Stephen Corson, greenhouse design consultant
Jason Danaher, aquatic system designer
Matt DeBoer, architect
Gregg Fripp, educational urban farmer
Shane Keplinger, architect
Jake Redeker, drilling representative
Nichole Schultes, architect
Vanessa Schutte, architect
Allen Washatko, architect

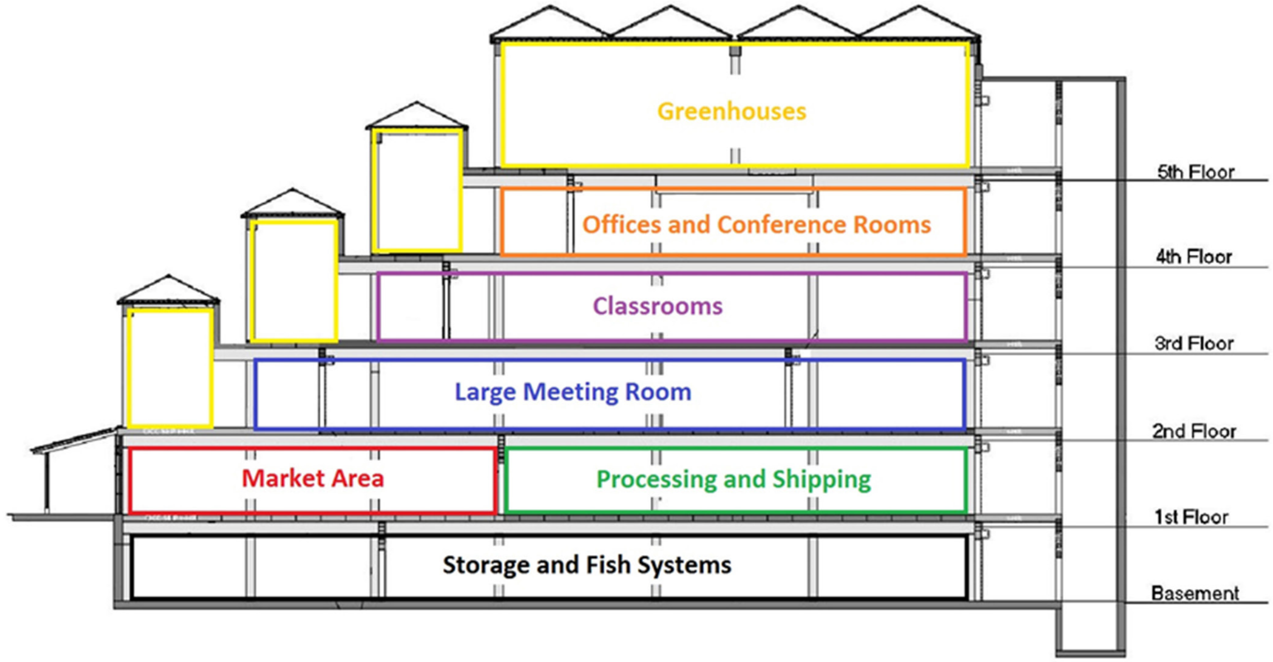
Jury Comments

"A very well thought out design that addresses the majority of design challenges in a vertical farm"

"Great job at addressing a complex problem"



ABSTRACT



An interdisciplinary team of seven graduate students preparing to be construction, electrical, structural, and mechanical engineers was challenged to design a high-performance building for an international team design competition. The building was to be an urban vertical farm for a nonprofit organization that desires to educate the community about urban farming. The main objectives of the competition were the development and integration of innovative and original design solutions. These criteria, along with the goals of the company, lead to team mantra of "Innovation through Integration" by using the goals of integration, building purpose, sustainability, and cost. Based on these goals, the team was able to develop a design that expanded on the existing urban farming and sustainability practices already used by the client. This is seen in the continued use of solar power and aquaponic systems, and it is also in the new solid-oxide fuel cell and geothermal systems that serve the building.

Over the course of this project, 35 licensed professional engineers and architects from industry, licensed professors from the university, and other allied professionals met with students to review design narratives and construction-type documents and to listen to oral presentations reviewing the design and major considerations in the project. Licensed professionals met with the students outside of the scheduled class times to mentor students in practical and safe design methods for the chosen systems. All students involved in the project have taken the Fundamentals of Engineering exam, will be completing an EAC/ABET-accredited degree, will work under licensed engineers following graduation, and plan to pursue professional licensure for themselves.

The sustainable, vertical farm systems were designed to meet current building standard codes, LEED requirements, and state- and city-specific codes. This was in keeping with the project goals and with the knowledge that poorly designed buildings could result in harm to the client and community. It also provided the opportunity to experience the process of researching and understanding location-specific legislation that would affect the design and construction of a real-life facility.

This project offered many learning opportunities for the students. Due to the unique spaces of this building, the team gained knowledge on a wide variety of topics on not only the building system design process but also the interactions between building systems and the design of unique systems, such as the aquaponics and greenhouse systems. In addition to system design, the students were also able to see firsthand the way licensed engineers approach and think through unique design challenges, experience the necessary collaboration between disciplines in building design, and communicate their design both verbally and through written documents.

$7,500 AWARD

UNIVERSITY OF NEBRASKA–LINCOLN

Charles W. Durham School of Architectural Engineering and Construction

Multidisciplinary Vertical Farm Design

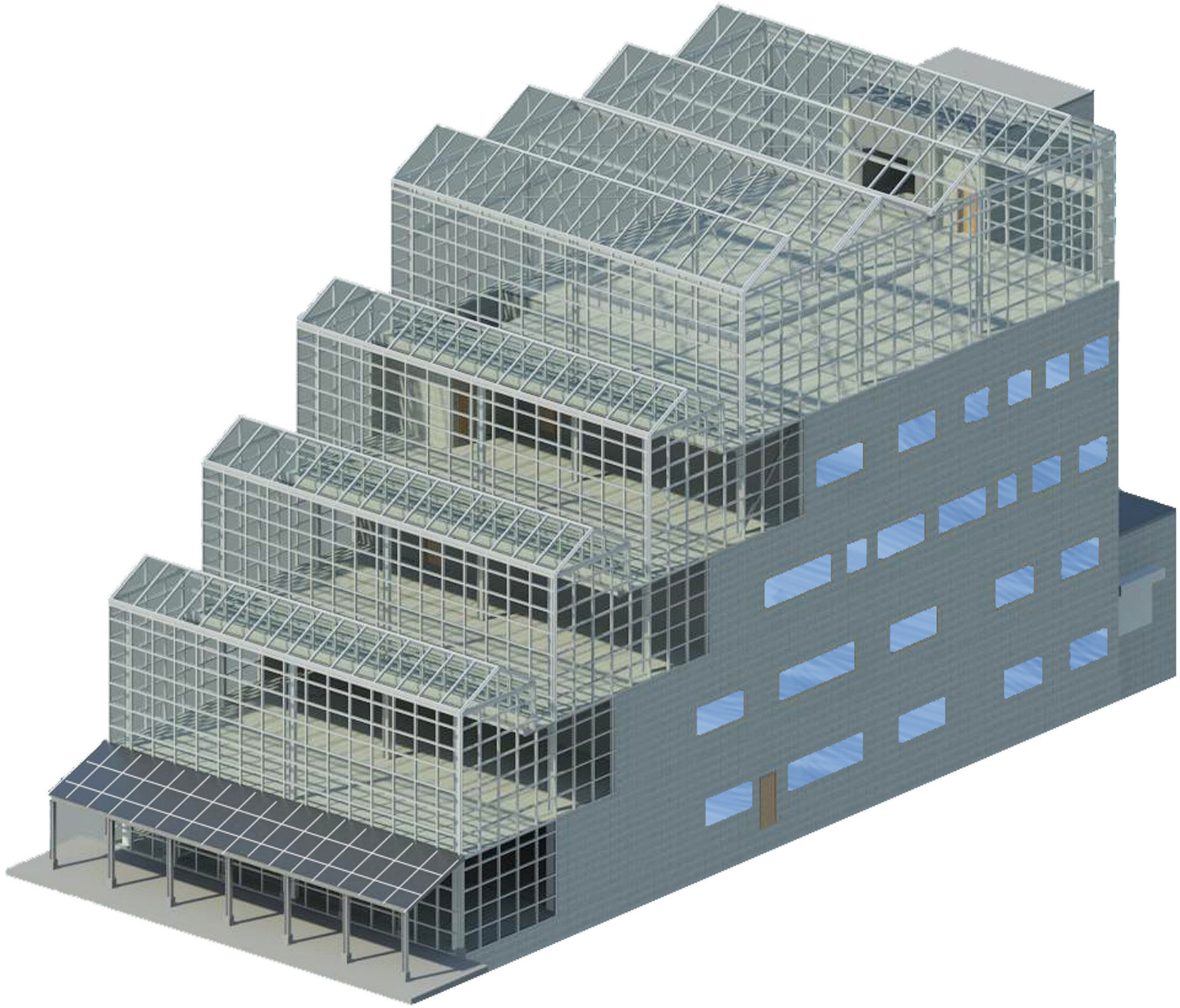
PERSPECTIVES ON

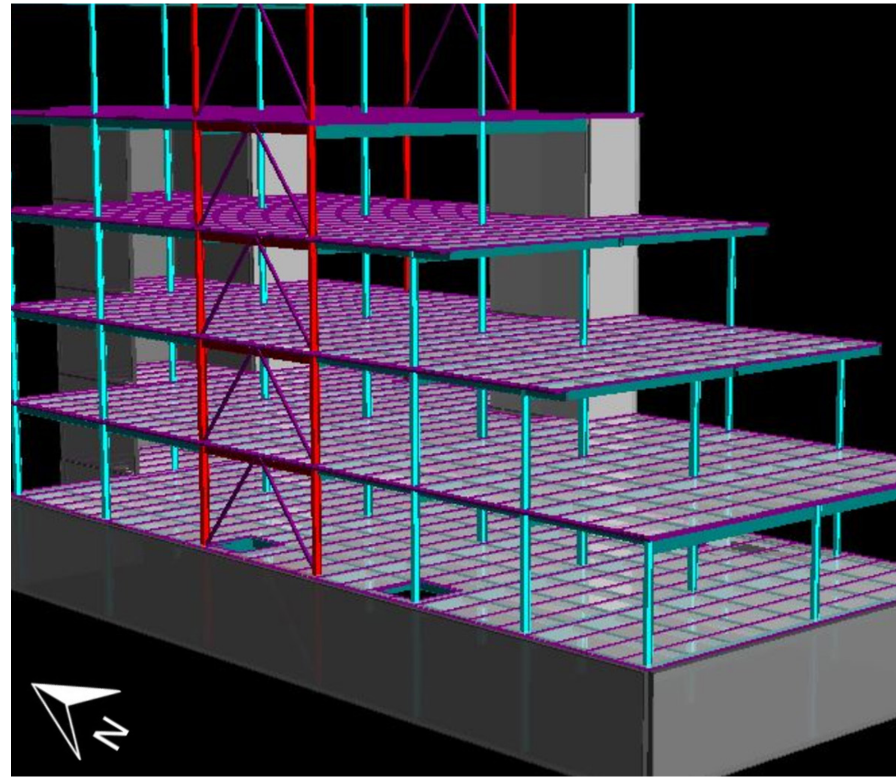
Collaboration of faculty, students, and licensed professional engineers

Through the duration of this design project, the interdisciplinary team benefitted tremendously from the interaction with industry professionals. A professor at the university, who is also a licensed electrical engineer, facilitated class periods where the team was able to discuss design with professors who had obtained professional licensing in their respective disciplines and with industry professionals through design presentations. Through this, the team was exposed to more than 30 local licensed professional engineers and licensed architects. In addition to these facilitated sessions, the team contacted specialized professionals for design questions and feedback.

Protection of public health, safety, and welfare

The existing construction practices and When designing a building project, the public health, safety, and welfare is of the utmost importance. Since employees, volunteers, and the public will occupy the nonprofit organization's building, an important





aspect of the project was making sure that it would be safe for those inhabitants. In order to accomplish this goal, the team relied on building codes that are established to ensure safe buildings are designed. It was also vital for the public operation of a nonprofit organization to carefully manage resources and funding involved with the design. Through cost analysis, a hybrid heating system was designed for the greenhouses that saved 40 percent on initial project cost when compared to a baseline greenhouse heating system. Payment options and purchasing plans were also investigated for the solid-oxide fuel cells to minimize the financial impact of expensive on-site power generation equipment on the small nonprofit operation.

In addition to these codes, the team considered other aspects of occupant safety. One instance of this was the team's consideration of condensation in the building, which can cause mold growth and material damage but is not specifically addressed in any of the building codes. A condensation analysis was completed and insulation solutions evaluated for the greenhouse floor system to ensure the mixed-use spaces below would not experience condensation on the structural ceiling, which would result in dripping ceilings and mold, which can be harmful to occupants.

In addition to ensuring public safety, the project aims to benefit the public health by teaching the public about urban farming practices. The building being designed will produce healthy food and enable others within the community to do the same in order to make eating healthy more accessible to all. The team expanded on the emphasis on education that the client has by designing the aquaponics system with two grow bed types to allow for a first-hand look at how different systems operate. Additionally, an energy monitoring system was implemented in the building that allows the occupants to see the energy consumption of the building, which can be used to educate the public about power use in buildings and in food production.

2015
PARTICIPANTS

California Polytechnic State University
Department of Architectural Engineering
Linking Multidisciplinary Learning and Practice: the Samé Polytechnic College Master Plan and Schematic Design

California State University, Los Angeles
Department of Civil Engineering
Sawpit Debris Dam Seismic Rehabilitation Project

The Citadel
Department of Civil and Environmental Engineering
Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church

Clarkson University
Department of Electrical and Computer Engineering
REVISED: Recycling as a Viable Industry for Supported Employment of Those with Disability

Cleveland State University
Department of Mechanical Engineering
Design of an Engine Air Particle Separators for Unmanned Aerial Vehicles

Cleveland State University
Department of Civil and Environmental Engineering
Heinton Road Bridge Rehabilitation

Cleveland State University
Department of Civil and Environmental Engineering
Kolbe Road Improvements

Cleveland State University
Department of Civil and Environmental Engineering
Newport Harbor Project

Cleveland State University
Department of Civil and Environmental Engineering
Randal Street Rehabilitation

Cleveland State University
Department of Civil and Environmental Engineering
Walker Road Park Pedestrian Bridge

George Mason University
Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering
Water Supply, Distribution, and Storage Sabana Grande, Nicaragua

Marquette University
Department of Civil, Construction, and Environmental Engineering
Sechume Vehicle Bridge

North Carolina State University
UNC/NCSU Joint Department of Biomedical Engineering
The Saga Drainage System

Ohio University
Department of Mechanical Engineering
Sustainable Cement Mixer Creates Jobs to Build a Stronger Haiti

Portland State University
Department of Civil and Environmental Engineering
Water Quality Bioretention Facility

Rose-Hulman Institute of Technology
Department of Civil Engineering
Infrastructure Improvements for Two Communities in the Dominican Republic

Santa Clara University
School of Engineering
Satellite Mission Control

Seattle University
Department of Civil and Environmental Engineering
Design Considerations for the Replacement of a County Bridge

Seattle University
Department of Civil and Environmental Engineering
Faculty—Licensed Professional Engineering Partnership in an Introductory Freshman Course

Seattle University
Department of Civil and Environmental Engineering
Seismic Analysis and Retrofit Design of a Historic Substation Control Building

Univeristy of Alaska Anchorage
College of Engineering
Jewel Lake Road, Strawberry to 88th Avenue Reconstruction

University of Alaska Anchorage
College of Engineering
Penguin Creek Crossing

University of Alaska Anchorage
College of Engineering
Raspberry Road Rehabilitation, Jewel Lake Road to Minnesota Drive

University of Alaska Anchorage
Department of Civil Engineering
Eagle River Wastewater Treatment Facility Headworks Upgrade

University of Alaska Anchorage
Department of Civil Engineering
Hydro Powered Fish Waste Disposal System

University of Arkansas at Little Rock
Department of Construction Management and Civil and Construction Engineering
American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

University of Colorado Boulder
Environmental Engineering Department
On-site Sodium Hypochlorite Generation for Drinking Water Disinfection

University of Colorado Denver
Department of Civil Engineering
Amache Internment Camp Preservation

Univeristy of Kansas
Department of Civil, Environmental, and Architectural Engineering
1905 Historic Pratt Truss Rehabilitation

University of Nebraska—Lincoln
Charles W. Durham School of Architectural Engineering and Construction
Multidisciplinary Vertical Farm Design

University of Portland
Shiley School of Engineering
Engineering Sustainable Water Through Education in Rural Guatemala

PREVIOUS **WINNERS**

2014

GRAND PRIZE

Seattle University
Department of Electrical and Computer Engineering
Microgrid System for a Wind and Solar Farm Located in Rural Kenya

ADDITIONAL AWARDS

The Citadel
Department of Civil and Environmental Engineering
Wave Dissipation System

North Carolina State University
UNC/NCSU Joint Department of Biomedical Engineering
Creating a Better Way to Locate Vasculature for Intravenous Therapy

Seattle University
Department of Civil and Environmental Engineering
Historic Landmark Incline Lift Structural Evaluation and Retrofit

University of Evansville
College of Engineering and Computer Science
Fairfield Reservoir and Dam

University of Notre Dame
Department of Civil and Environmental Engineering and Earth Sciences
Innovative Housing Solutions for Post-Quake Haiti

2013

GRAND PRIZE

Cleveland State University

Civil and Environmental Engineering Department
Design, Funding, and Construction of the August Pine Ridge School/Hurricane Shelter in Belize

ADDITIONAL AWARDS

Northern Arizona University

Department of Civil Engineering, Construction Management, and Environmental Engineering
Paper Pulp Sludge Characteristics and Applications

Seattle University

Department of Civil and Environmental Engineering
Design Options for a Creek Crossing for a Utility Company

Seattle University

Department of Civil and Environmental Engineering
Structural Evaluation and Retrofit of a Warehouse

University of Nevada, Reno

Department of Civil and Environmental Engineering
Capstone Design Project—SouthEast Connector

University of Texas at El Paso

Department of Civil Engineering
Multidisciplinary Design of a Sustainable, Environmentally Friendly, and Affordable House

2012

GRAND PRIZE

Florida Atlantic University

Department of Civil, Environmental, and Geomatics Engineering
Dania Beach Nanofiltration Plant Expansion

ADDITIONAL AWARDS

Oklahoma State University

School of Civil and Environmental Engineering
Roadway and Water Feature Design at the Botanic Garden

Seattle University

Department of Civil and Environmental Engineering
Design of an Orphanage, Learning and Community Center in Ethiopia

Seattle University

Department of Civil and Environmental Engineering
Historic Dam Guard Rail and Vehicle Barrier Retrofit for Public Safety

University of Texas at El Paso

Department of Civil Engineering
Multidisciplinary SMART Design of Fire Station 513

Valparaiso University

College of Engineering
Maji for Masaera—Rehabilitation of a Man-Made Irrigation Canal

PREVIOUS **WINNERS**

2011

GRAND PRIZE

University of New Mexico
Department of Civil Engineering
Integrated Infrastructure Improvements for a Youth Scout Ranch

ADDITIONAL AWARDS

California State University, Los Angeles
Department of Civil Engineering
Connecting Professional Practice and Education through a Civil Engineering Capstone Project: Mud Flow Barrier

Lawrence Technological University
Department of Civil Engineering
Civil Engineering Capstone Project Recovery Park

Seattle University
Department of Civil and Environmental Engineering
Flood Control Channel Design for a River in Northwest Haiti

Seattle University
Department of Civil and Environmental Engineering
Structural Design of Dam Sluice Gate Walkway Slabs: Retrofit and Replacement Options

University of Texas at El Paso
Department of Civil Engineering
Development of a Sustainable Infrastructure Management System for a City

2010

GRAND PRIZE

University of Delaware

Department of Civil and Environmental Engineering
Pomeroy Trail East Annex

ADDITIONAL AWARDS

California Polytechnic State University, San Luis Obispo

Civil and Environmental Engineering Department
Bridging the Gap between Theory and Practice through Capstone Design

California State University, Los Angeles

Department of Civil Engineering
Connecting Practice with Education through Civil Engineering Capstone Experience: Puddingstone Reservoir Operations Level Study

Clemson University

Holcombe Department of Electrical and Computer Engineering
Engineering Haptic Virtual Manipulatives to Enhance K–12 Math and Science Education

University of Maryland

Department of Civil and Environmental Engineering
Engineers Without Borders: Solar Recharge Project in Burkina Faso, Africa

University of New Mexico

Department of Civil Engineering
Integration of Civil Engineering and Construction Management Education: A Multidisciplinary, Mentor-led Capstone Experience System for a City

2009

GRAND PRIZE

Florida A&M University–Florida State University

Department of Civil and Environmental Engineering
Senior Design Capstone Course: Collection of Projects with Featured Everglades Restoration Project

ADDITIONAL AWARDS

Seattle University

Department of Civil and Environmental Engineering
Structural Design Package for the Replacement of a County Bridge

University of Arizona

Department of Civil Engineering and Engineering Mechanics
Practitioner-Led Engineering Experiences

University of Missouri–Kansas City

Department of Civil and Mechanical Engineering
Redcone Civil Design Group: A Practitioner-Centric Capstone Experience

University of Tennessee at Chattanooga

Department of Civil Engineering
Intermodal Transit Center

Virginia Polytechnic Institute and State University

Charles E. Via Jr. Department of Civil and Environmental Engineering
Land Development Design Initiative

HONORABLE MENTION

University of Iowa

Department of Civil and Environmental Engineering
Pilot Program for Expanding Connections between Professional Practice and Education

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