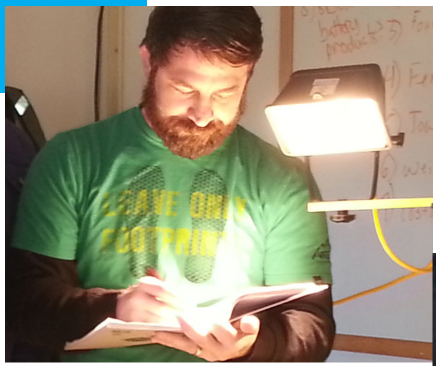

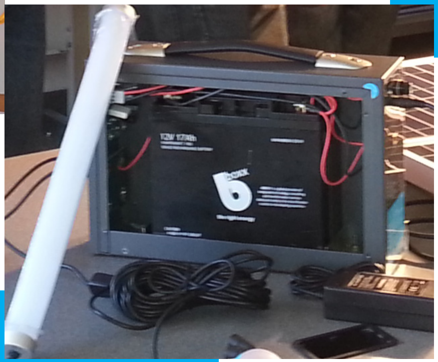

Engage. Enrich. Inspire.

2014

NCEES
advancing licensure for engineers and surveyors

NCEES Engineering Award

Connecting Professional Practice and Education

Cover art: Details of display board submitted by Seattle University Department of Electrical and Computer Engineering

2014 NCEES ENGINEERING AWARD

ENGAGE. ENRICH. INSPIRE.

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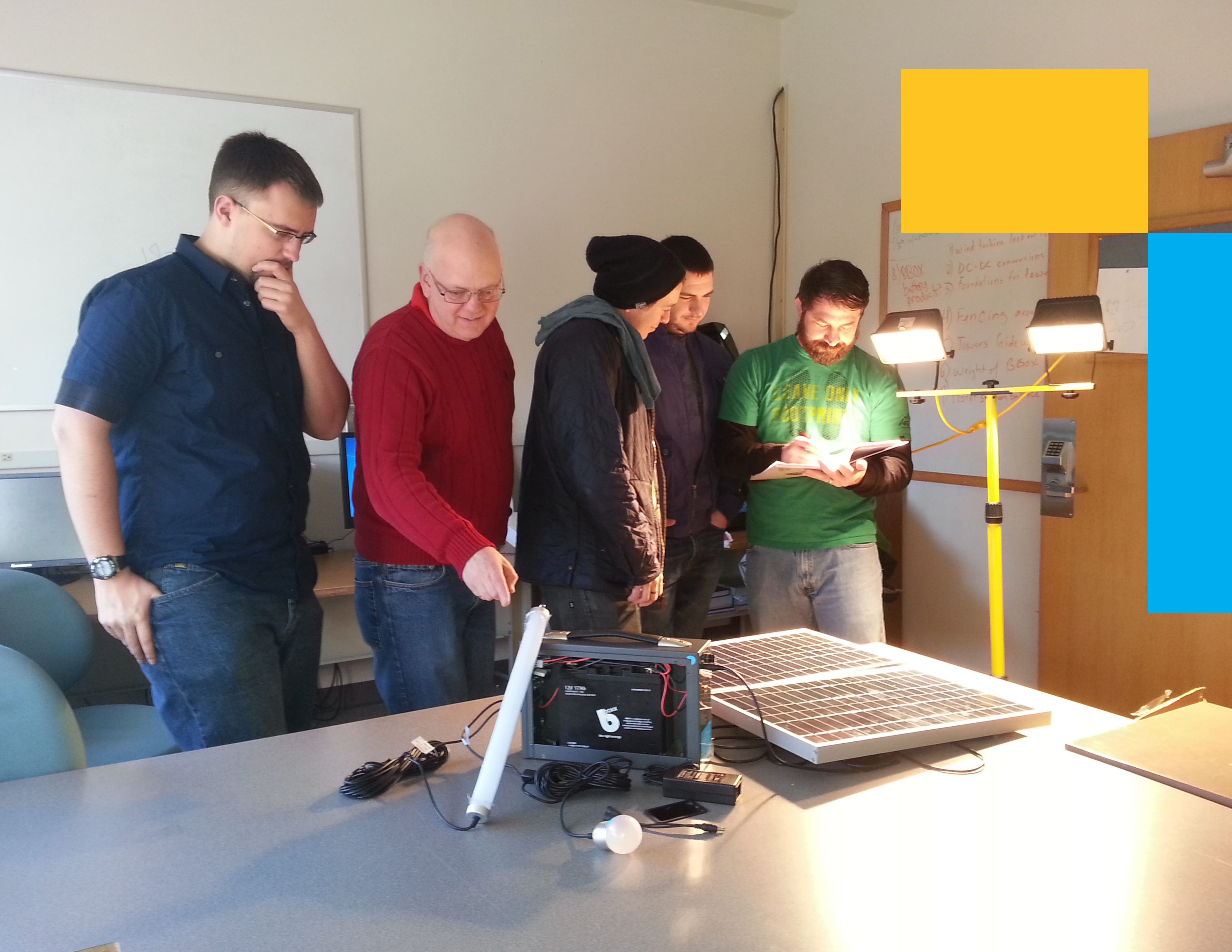


PRESIDENT'S MESSAGE

In 2009, the NCEES Engineering Award was launched 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 ensures success for all involved. The projects afford students the opportunity to apply classroom lessons to real-world issues, along with increasing their knowledge of engineering principles.

Engineering reaches all parts of our lives. These projects allow students to work with professional engineers and learn how licensure protects the public's health, safety, and welfare. Students not only work with professional engineers, but they also collaborate with their peers, other engineering disciplines, and other professions.

We at NCEES thank the students, faculty, and practitioners who participated in this year's projects. We commend your efforts to connect professional practice and education. We especially thank the jury members for giving your time and expertise to support this initiative.

NCEES has published this book to recognize the 2014 winners, and we hope these projects will encourage other engineering programs to develop collaborations with the professional engineering community and continue to engage, enrich, and inspire.

David H. Widmer, P.L.S.
2014–15 NCEES President

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 15, 2014. 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 NCEES Engineering Award jury met in Clemson, South Carolina, on June 3, 2014, to conduct a blind judging of the 37 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
- Benefit to public health, safety, and welfare
- Multidiscipline and/or allied profession participation
- Knowledge or skills gained

The jury selected the Seattle University Department of Electrical and Computer Engineering to receive the $25,000 grand prize. The jury chose five additional winners to each receive $7,500 awards.

2014
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.

Roger Helgoth, P.E., Jury Chair
Nebraska Board of Engineers and Architects

William (Bill) Pierson, Ph.D., P.E.
West Virginia State Board of Registration for Professional Engineers

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

David Whitman, Ph.D., P.E.
Wyoming Board of Registration for Professional Engineers and Professional Land Surveyors

Dennis Irwin, Ph.D., P.E.
Dean, Ohio University Russ College of Engineering and Technology

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

Rochelle Williams, Ph.D.
Senior Manager for Professional Development and Research Services, ABET

Randolph (Randy) Collins Jr., Ph.D., P.E.
Member, American Society for Engineering Education

Michael Smith, D.Eng.
Chair, DiscoverE Diversity Council

Teresa Helmlinger-Ratcliff, Ph.D., P.E.
Past President, National Society of Professional Engineers


REVIEW
3
+ 4

2014 NCEES ENGINEERING AWARD

$25,000 GRAND PRIZE WINNER

SEATTLE UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Microgrid System for a Wind and Solar Farm Located in Rural Kenya

$25,000 GRAND PRIZE

SEATTLE UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Microgrid System for a Wind and Solar Farm Located in Rural Kenya

PARTICIPANTS

Students

Patrick Berg
Michael Koppi
Andrew Mewborn
Daniel Nausner
All electrical engineering students

Faculty

Stephen Szablya, P.E.

Professional Engineers

United States
Stephen Szablya, P.E.
Matthew Salmon, P.E.

Kenya
Clemencia Ongaki, P.E.

Additional Participants

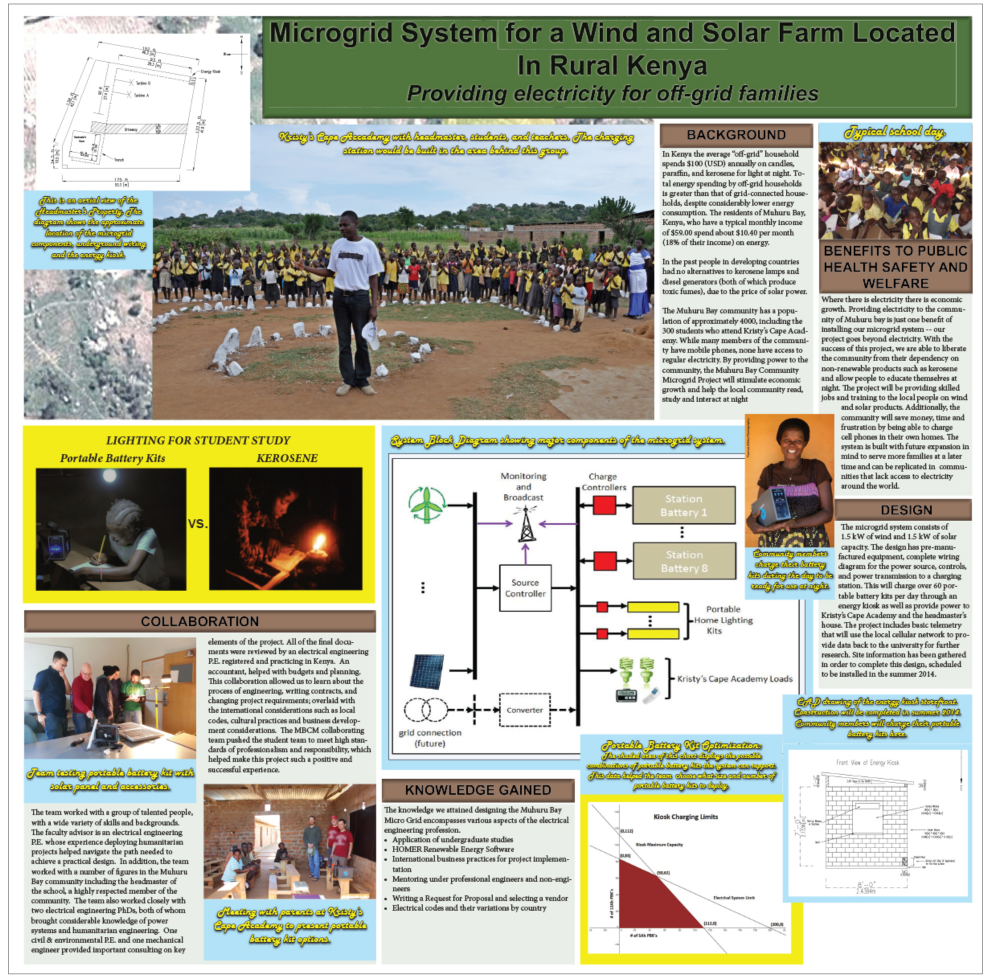
Henry Louie, Ph.D., electrical engineer
Vincent Van Acker, Ph.D., electrical engineer
Eli Patten, Ph.D., mechanical engineer
Tommy Wong, software engineer
Ayesha Pirbhai, E.I.T., electrical engineer
Kimberly Kroh, mechanical engineer
Karim Farraj, E.I.T., electrical engineer
Jay Heitman, licensed electrician
Byron Lynch, licensed electrician
Dan McKnight, carpenter
Jenna Isakson, treasurer
Michael Danhauer, machinist
Symon Warioba, headmaster of Kristy's Cape Academy

Jury Comments

"A first-world solution to a third-world problem—but it has applicability domestically, as well as abroad. This project was not just a concept but went all the way to practical implementation. This was truly interdisciplinary."

"This project has strong interaction with professional engineers both in the United States and Kenya, which was a key to their successful design."

"Fantastic new technology application to a real-world problem."



ABSTRACT

This project is the design of a 3-kilowatt hybrid wind and solar power microgrid system to be used to provide electricity to a school and surrounding community in Muhuru Bay, Kenya. Kristy's Cape Academy (KCA) is a primary school with approximately 300 students, many of whom are orphaned due to HIV/AIDS. The school and surrounding area have no grid connection, which hampers the instructors and prevents the students from studying in the evening. Moreover, access to electricity strongly correlates with measures of community development. The project benefits public safety, welfare, and the developmental outlook for the students and the community.

In addition to supplying electricity to KCA and the headmaster's house, the system is to support a "community charging station" model of electricity distribution in which families of the students at KCA can rent portable battery kits that are brought home at night to power lights and recharge small devices such as cellular phones. The project also includes integrating basic telemetry that will use the local cellular network to provide data to the university for future research.

The team consisted of four electrical engineering undergraduate students, a university faculty member, engineers from various disciplines, licensed professional engineers (P.E.) in both the United States and Kenya, allied professionals (licensed electrician, machinist, and carpenters), and accountants. The complex nature of development projects necessitates such a multidisciplinary and collaborative team.

The students' role was to design the system and document its technical specifications. This included determining the capacities of the solar panels, wind turbines, and station batteries; developing component specifications for controllers and converters; and designing the complete wiring diagram for the power source, controls, and power transmission to the portable battery kit charging station. The students' design accounted for all of the technical issues to provide a safe utility-grade installation using the international and local building codes.

The knowledge gained from this project was broad, including designing to meet international and local codes, collaborating with many technical experts, and learning the importance of having key opinion leaders in the village understand and support the project. The team also learned about the importance of site information after the assessment team returned, helping to refine the high-level design so the technical specifications of the final design could be completed. The project will be implemented in August of 2014, with some of the student team members participating in the construction and management.

SEATTLE UNIVERSITY

PERSPECTIVES ON

The benefit to public health, safety, and welfare

An estimated 1.5 billion people in the world lack access to electricity today—800 million of those are in Africa and 3,000 of them are in Muhuru Bay, Kenya. The Muhuru Bay community uses kerosene lamps as lighting. Kerosene is not only expensive but also exposes people to hazardous fumes. Some of the lamp designs are very dangerous, and children have been burned badly from kerosene fires. This project allows the community to live a healthier lifestyle when reading, studying, or interacting during the night.

The knowledge or skills gained

Throughout the project, the students learned the value of active listening. The students could not simply show up to KCA and provide a technical solution to the community without first understanding KCA needs and aspirations, both for themselves and their children. Multiple assessment trips to Kenya were required to gain that understanding. They told us that access to electricity would bring value to their daily lives. They also collaborated with us on developing the mechanism to do that. Only after that could the team provide a technical solution to meet the needs.

The students also learned a significant amount about the difficulties of working internationally, especially in a country where communication can be scarce. Gathering data to be input into HOMER, the renewable energy modeling software that was used to model the microgrid system and to determine which parts were necessary for the wind turbines, was difficult because Kenyan meteorological data was limited and there was very limited site data that could be gathered. More difficulties arose when working with the Kenyan manufacturers. There were times when it was difficult to contact them because there was insufficient information on their websites or they were slow to respond to communications.

Multidiscipline or allied profession participation

The student team encountered many professions throughout the project but were solely responsible for producing the technical design. There were many teams within the entire Muhuru

Bay Microgrid Community (MBCM) group, including the microgrid, battery kit, public relations, and business model and training teams. Many of those involved in this project have mechanical and electrical engineering backgrounds and are employed at Fortune 500 companies.

Even though most of the MBCM team members were engineering professionals, there were others involved in accounting, computer science, and public policy and business management. The beauty and uniqueness of the project was that some of the collaborating engineers took responsibility of positions that were nontechnical, and those that had nontechnical backgrounds joined technical teams. This diversity added a productive and fresh perspective to all elements of the project.

POINTS OF VIEW

Stephen Szablya, P.E.
Faculty advisor

What value does a real-world project bring to the students?
Real-world problems allow students to understand constraints and requirements of all stakeholders in a project. Those stakeholders include owners, funders, local jurisdictions, and physical constraints, among others. Theoretical design is important to develop optimized solutions; however, working within the constraints, the students learn to navigate from inception to successful and sustainable project conclusion.

How do you decide which projects to work on?
This project evolved over several years from previous senior design projects that provided appropriate technology solutions for off-grid power to developing countries. Several proof-of-concept solutions were delivered in sub-Saharan Africa, and during that time, the conditions for a hybrid microgrid solution were refined. The project site became known to the team about one year prior to kicking off the project through a member of the Seattle University faculty working on a school project at the same site.

How did this project prepare students for professional practice?
The students worked hand-in-hand with professional engineers, academics, and people who have mastered their technical field. They were mentored in how to read the International Electric Code, technical drawings, and specification sheets for equipment and how to consider local codes and ordinances.

One of the most important preparations was taking the design concept from the lab to a robust design that can be left in the field to work with minimal maintenance required. It also taught them how to consider maintenance issues, both preventive and corrective.

What was the biggest challenge on this project?
Getting the students to understand that the design will be implemented in one of the most remote areas in the world. There is no Home Depot within a nine-hour drive of the installation.

What advice do you have for other programs wanting to add similar collaborative projects to their curriculum?
I highly recommend that programs use collaboration from the professionals in their community. In this case, we not only called upon the professional engineers but other professions as well, including academics, electricians, and a longshoreman. This depth gave us the perspective of taking theory, putting it together in a lab, making it code compliant, checking it with the community stakeholders, and making sure all of the nuts and bolts fit together when building it. Having the practical trades involved provided invaluable experience for contingency planning.

How does Seattle University plan to use its $25,000 prize?
In 2013, Seattle University's electrical and computer engineering department created a fund for humanitarian engineering. The prize will go to the fund for development of future projects like this one.

SEATTLE UNIVERSITY

POINTS OF VIEW

Patrick Berg
Student

What did you like best about participating in this project?

My favorite part about working on the Muhuru Bay community microgrid project is that the final result will eventually impact the lives of so many people in such a large way.

What did you learn?

The biggest takeaway from the project was the process of taking a design concept and converting that idea into a request for proposal, which was the document that provided the vendors with details of what we envisioned for the microgrid.

How did the participation of professional engineers improve the experience?

The experience of the professional engineers in their respective fields proved invaluable. Their prior knowledge allowed them to make sure we covered all of the necessary details in our project.

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

I believe the engineers discovered that our student team was able to provide a lot of new and different ideas for the microgrid project. Some of those ideas were implemented in the final design of the system.

Michael Koppi
Student

What did you like best about participating in this project?

The fact that it was a humanitarian power project and all of the hard work we put in.

What did you learn?

I learned a lot about solar/wind power systems and how to work as a valuable team member. I also learned a lot about international coordination and the willingness of others to donate their time to projects like this.

How did the participation of professional engineers improve the experience?

They were very valuable to our learning of the power system and mentoring. I really learned a lot just by watching how they think about certain situations. Their expertise helped us polish this project into what it is today.

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

I would hope they learned that there are many different perspectives to consider when managing a project like this one.

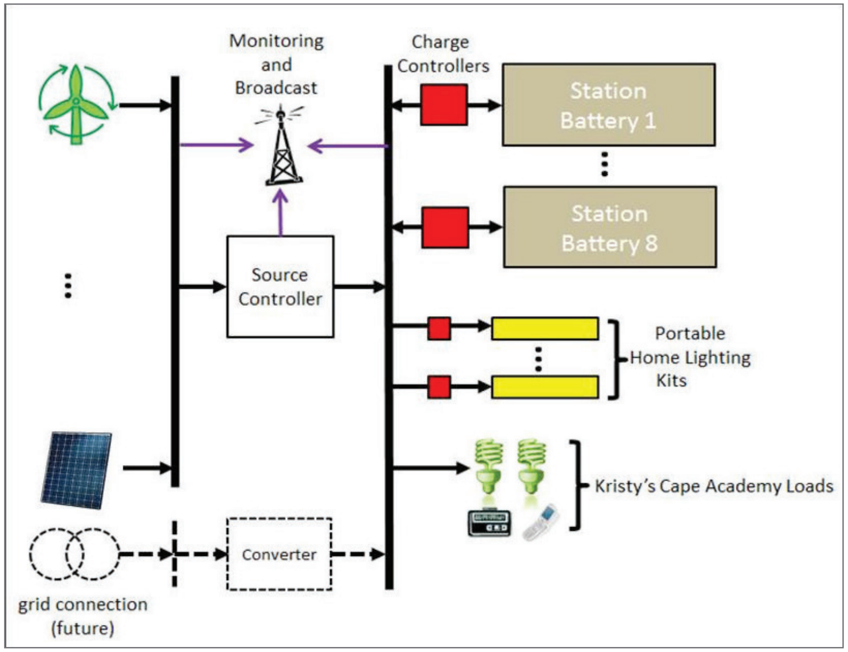
Andrew Mewborn
Student

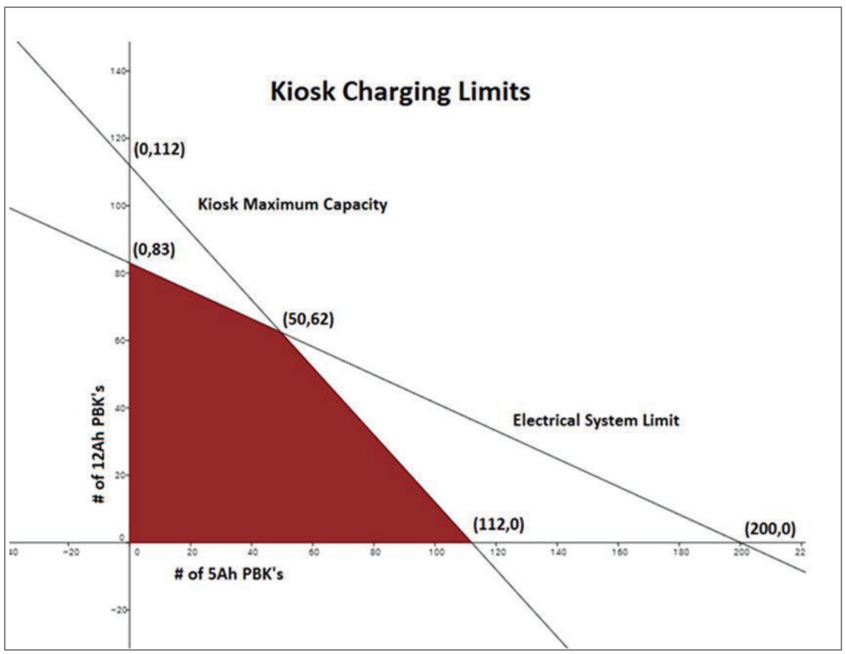
What did you like best about participating in this project?

I loved everything about the project, from the people I had the pleasure of working with to actually being able to go on the implementation trip to Africa. I not only put my engineering skills to work, but I also had the chance to analyze the needs of those living in Muhuru Bay. I utilized my problem-solving skills in various areas: business, engineering, and personal relations. Being able to participate in hands-on tasks also made me more confident in my engineering abilities.

What did you learn?

I learned that you cannot think simply about the engineering side of things. One should focus on trying to analyze all areas of a project before diving in and designing. Also, when working on projects, one can learn about other opportunities in innovation that do not yet exist. After working on this project, I have a fire inside of me that wants to continue working on humanitarian engineering and innovating in that space.





How did the participation of professional engineers improve the experience?

Mentorship of the engineers is key. I do not know what I would have done without the help and guidance of people like Henry Louie and Steve Szablya. Working with them has definitely made me realize that I have a ton more to learn.

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

As students, we tend to keep track of the newest and greatest technologies available. We were able to provide a different perspective on how to solve issues that arose. I think they also got the idea that they need to encourage more hands-on training within their companies or classrooms.

Henry Louie, Ph.D.
Practitioner—electrical engineer

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

I liked the nature of this project and that it had a high social impact on people who were in need. It also was in a topic that is directly in my line of work.

How did you assist the students in the Wind and Solar Microgrid System project?

I worked as an industry advisor, although I always felt like a full member of the team. In that role, I evaluated all aspects of their work in a weekly meeting with them. In most cases, I was a consultant, giving them direction as needed. My key focus was to ensure a safe and sustainable outcome.

What did you learn from working with the students?

Students are incredibly bright and have at their disposal the most advanced analysis tools. It was refreshing having the students drive the computer modeling, while I was able to provide them with the sources to find the real-world data. This was rewarding because I found that there are many tools available that I was not aware of. I also learned the limitations of the students. Although they have tools to solve technical problems, they need mentoring to get to the right solution by considering all aspects of the project.

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

The most important thing for me was to prepare them for a successful career by taking a real-world project and using their education to make it a working product. In this case, it was a product that will change the lives of many people in a profound way.

SEATTLE UNIVERSITY

POINTS OF VIEW

Vincent Van Acker, Ph.D.
Practitioner—electrical engineer

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

I have been working on similar projects with Seattle University over the last five years. This project was much bigger in installed capacity and budget. As a result, the impact of this project on the lives of the local affected community will be much bigger, as well. The size of the project brought along interesting challenges and opportunities with it, and that is why I wanted to be involved. Also, my employer is funding about 80 percent of this project.

How did you assist the students in the Wind and Solar Microgrid System project?

My interaction with the students was mostly regarding the business part of the project and reminding them of the project constraints we were working with when they were designing the microgrid. I helped them find a compromise between the technical limitations and the needs and limitations on the ground.

What did you learn from working with the students?

I was particularly impressed with the way they were able to adapt technical solutions when facing roadblocks. I learned a lot from them about data logging technology and how to transmit the logs over a GSM network to be captured by an online database. I am not an expert in that field, and now I find myself knowing a lot more about this technology and getting more excited about all the research areas that will benefit from this captured data.

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

I would like them to remember that solutions in a lab are only valid when they have been tested on the ground. As an engineer, you need to take into account more than the technical aspect of your proposed solution. You need to look at the business side, the environmental side, the sociological side, and also the human aspects of any proposed solution.

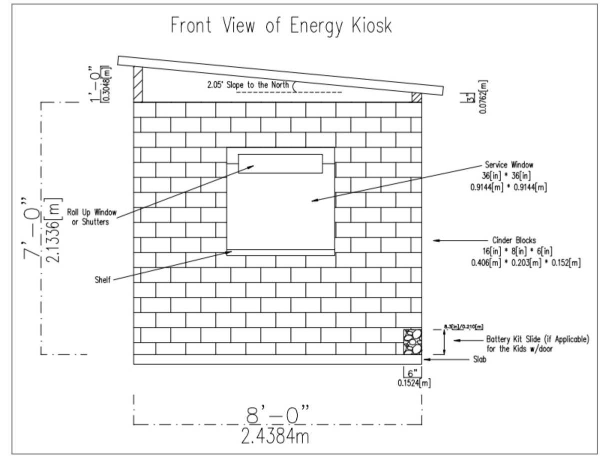
Jenna Isakson
Practitioner—treasurer

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

I initially became involved in this project as the grant manager within the college of science and engineering. But when Steve approached me about volunteering outside of work as the treasurer, I was very excited by the opportunity and quickly said yes because I had been looking for a new place to volunteer and because this project was much bigger, more impactful, and more concrete than any other volunteering opportunity that I had been involved in previously. The thought of being able to be part of bringing electricity to a community that currently does not have it was very exciting, and I am grateful to have been asked to participate.

How did you assist the students in the Wind and Solar Microgrid System project?

My involvement with the students' portion of the project was minimal, as I was mainly involved in the financial and business aspect of the microgrid project. However, the students' project development and knowledge was essential to informing the business model that the energy kiosk was based on. We met biweekly as a full team to go over all aspects of the project, where the students always gave an in-depth update on their progress.



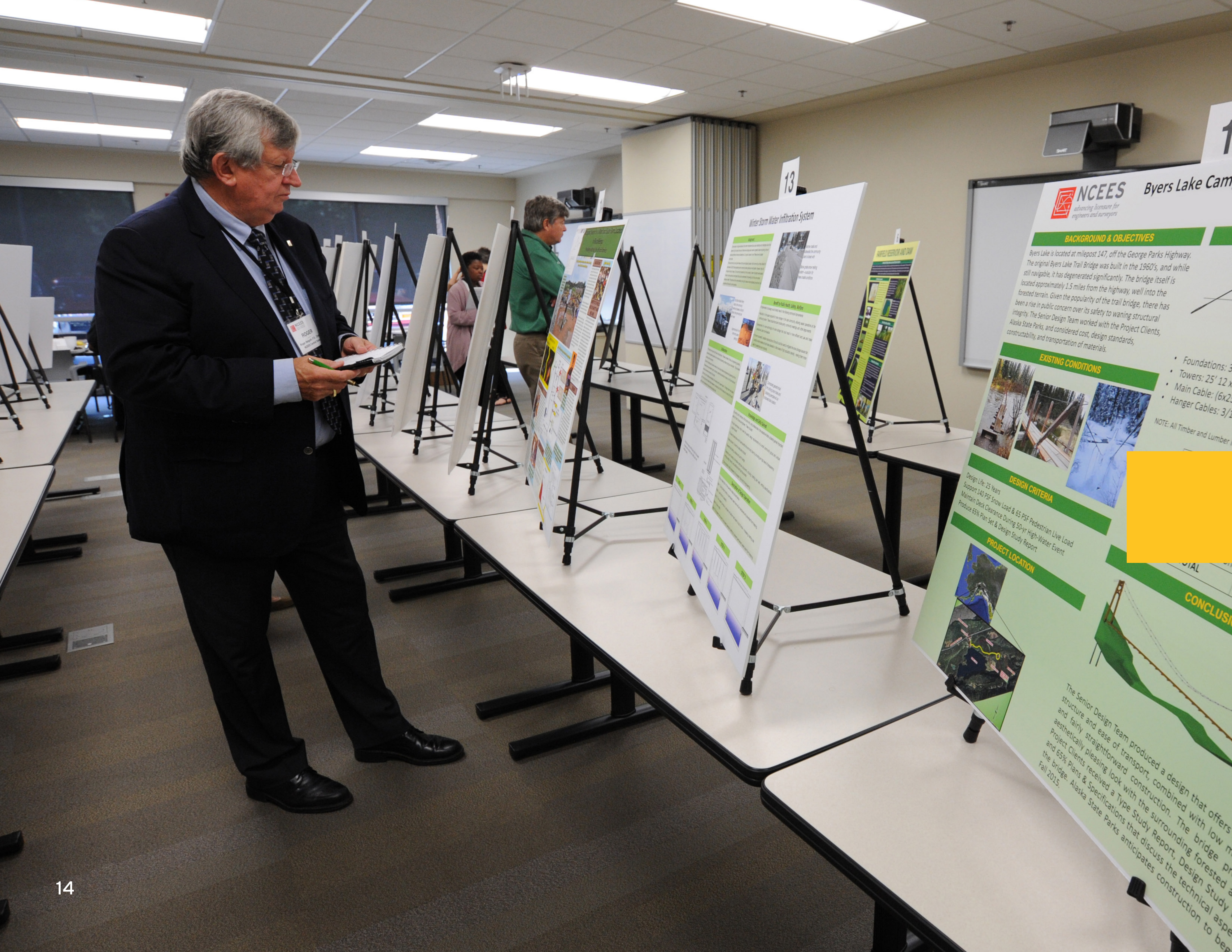
What did you learn from working with the students?

Since I do not have an electrical engineering background, I learned about the basics of the technical components of the solar and wind power, the control room set-up, and the data logging aspects. Although I still don't know in-depth electrical concepts, I have a general understanding of how these different components work together to electrify the buildings and charge the portable battery kits. The students had become very good at concisely discussing the project and how best to accommodate the needs of charging 70 battery kits, while also powering the house

and energy kiosk. I feel I've learned a great deal more than I ever thought I would, as a non-engineer, about the configurations of solar and wind power. As someone who does care greatly about sustainability and the environment, it was an awesome experience to contribute to a project of this magnitude.

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

By working with professional practitioners, I hoped the students would learn real-world teamwork and problem solving skills on a professional level. While the students have worked as a team of four with two professionals throughout the year, this team was comprised of around 20 individuals, most of whom are working professionals of various engineering backgrounds and ages. The students worked seamlessly with this group; it was almost hard to tell who were the students at times due to their leadership and professionalism.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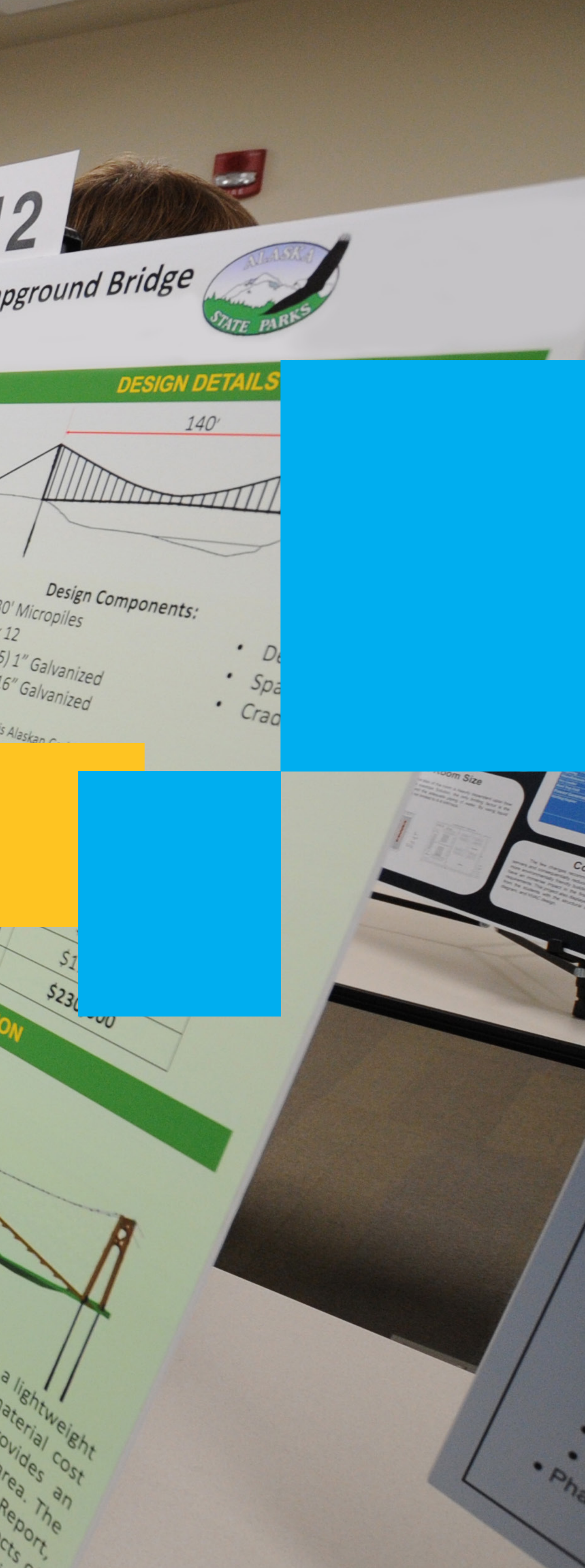
Winter Storm Water Infiltration System
NCEES
advancing licensure for engineers and surveyors
BACKGROUND & OBJECTIVES
Byers Lake is located at milepost 147, off the George Parks Highway. The original Byers Lake Trail Bridge was built in the 1960's, and while still navigable, it has degenerated significantly. The bridge itself is located approximately 1.5 miles from the highway, well into the forested terrain. Given the popularity of the trail bridge, there has been a rise in public concern over its safety to waning structural integrity. The Senior Design Team worked with the Project Clients, Alaska State Parks, and considered cost, design standards, constructability, and transportation of materials.
EXISTING CONDITIONS
DESIGN CRITERIA
Design Life: 25 Years
Support 140 PSF Snow Load & 65 PSF Pedestrian Live Load
Maintain Deck Clearance During 50-yr High-Water Event
Produce 65% Plan Set & Design Study Report
PROJECT LOCATION



2014 NCEES ENGINEERING AWARD

$7,500 WINNERS

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

$7,500 AWARD

THE CITADEL

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Wave Dissipation System

PARTICIPANTS

Students

Victor Ajide
Matt Arend
Elias Ashby
James Clardy
Jake Dopson
Garrett Dorn
Reginald Dozier
John Duane
Josh Funderburk
Grayson Gasque
Cameron Gilbert
Brent Grenda
Matthew Halter
Taylor Hart
Adam Huskins
James Johnson
Luke Johnson
Colt Kirkpatrick
Matt LaFlamme
Shane Lee
William Livingston
Erik Maslankowski
Warren May
John McMillian
Landon Messal
Chris Miller
William Parker
Brian Paxton
Karl Pearson
Moraud Roudsari
Kyle Smiley
Tim Smith
Chris Somheil
Kyle Stroud
Joshua Tassone
Reid Thrower
William Waldrop
Ashley Watkins
Joe Windham

Faculty

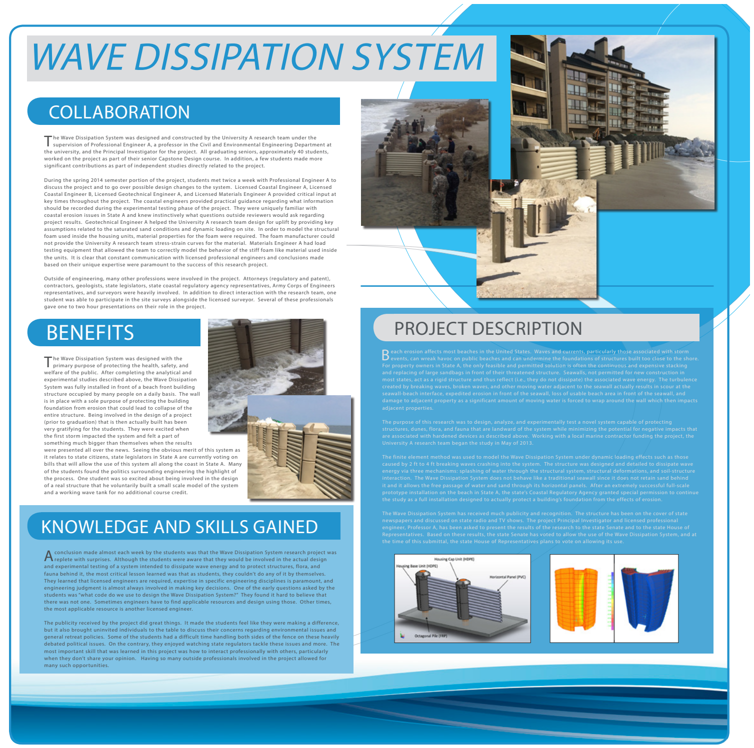
Timothy Mays, Ph.D., P.E.
Kevin Bower, Ph.D., P.E.

Professional Engineers and Engineer Interns

Tim Mason, P.E.
Justin Davis, P.E.
Michael Ulmer, P.E.
Angela Musselwhite, P.E.
Matt Halter, P.E., P.L.S.
Eric Tobias, P.E.
Antonia Gonzalez-Pereira, E.I.

Additional Participants

Deron Nettles, marine contractor
Harry Stumpf, coastal geologist
Matt Hamrick, attorney
Blair Williams, SCDHEC/OCRM
Bill Eiser, SCDHEC/OCRM
Nat Ball, Army Corps of Engineers
Matt Halter, P.E., P.L.S.
Members of the South Carolina Legislature



Jury Comments

"A most interesting outcome with student awareness of public policy and political obstacles in the development of solid engineering application"

"The students were exposed to the challenges of designing structures in an area where the codes are not fully developed."

"A really neat project that addresses a critical issue facing coastal areas nationally and worldwide. The project incorporated politicians and others outside of engineering."

ABSTRACT

All seniors in the undergraduate program at University A, approximately 40 students, participated in the analysis, design, and experimental testing of the Wave Dissipation System that is currently installed and protecting a large building along the coast in State A. The system is an extremely lightweight structure composed of plastic materials, including PVC, HDPE, and FRP. It was designed to serve as an alternative to sandbags, which are currently the only structural element that is state-approved for erosion control. The Wave Dissipation System was detailed to dissipate energy associated with breaking waves and fast-moving broken waves via three mechanisms: splashing of water through the structural system, structural deformations, and soil-structure interaction. The structure does not behave like a traditional seawall since it does not retain sand behind it, and it allows the free passage of water and sand through its horizontal panels.

The Wave Dissipation System was first modeled analytically using the finite element method. These results were used to optimize the structural shapes, cross-sectional properties, and pile embedment requirements. Next, a prototype full-scale system was installed at a specific site along the coast in State A. Students were involved in economic, environmental, social, political, and manufacturability decisions and discussions. Interaction with licensed coastal engineers, structural engineers, a geotechnical engineer, a materials engineer, coastal geologists, regulatory officials, state legislators, and attorneys led directly to the students' better understanding of how engineering and other disciplines must work together to design a solution.

$7,500 AWARD

THE CITADEL

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Wave Dissipation System

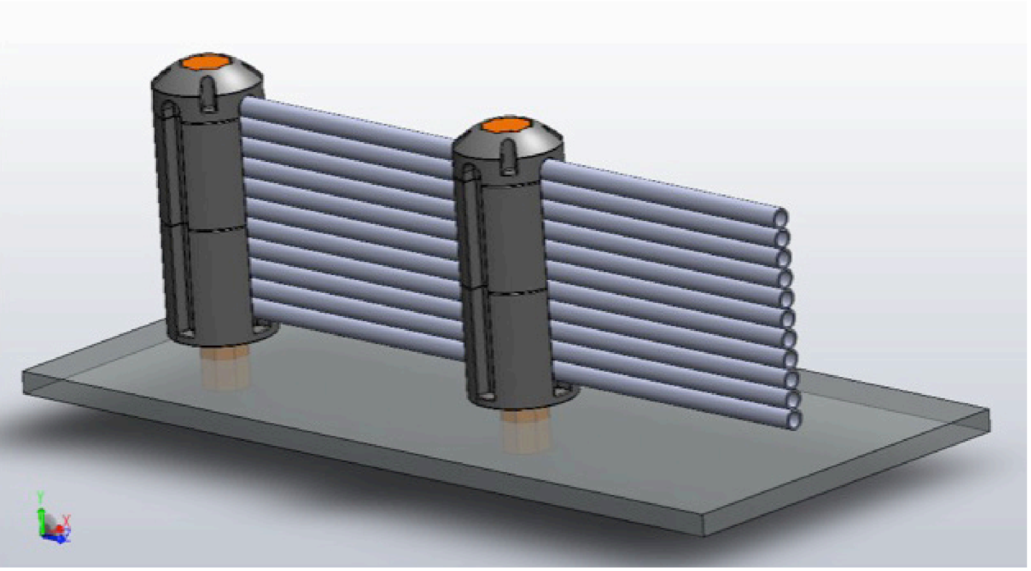
PERSPECTIVES ON

The benefit to public health, safety, and welfare

The Wave Dissipation System was designed with the primary purpose of protecting the health, safety, and welfare of the public. After completing the analytical and experimental studies, the Wave Dissipation System was fully installed in front of a beachfront building structure occupied by many people on a daily basis. The wall is in place with a sole purpose of protecting the building foundation from erosion, which could lead to the collapse of the entire structure. Being involved in the design of a project, prior to graduation, that is then actually built has been very gratifying for the students. They were excited when the first storm impacted the system and felt a part of something much bigger than themselves when the results were presented all over the news. Seeing the obvious merit of this system as it relates to state citizens, state legislators in State A are currently voting on bills that will allow the use of this system all along the coast in State A. Many of the students found the politics surrounding engineering the highlight of the process.

Multidiscipline or allied profession participation

The design of the Wave Dissipation System involved several engineering disciplines. In addition to civil engineering, both coastal engineering and ocean engineering (e.g., wave mechanics) were heavily involved. Two licensed coastal engineers provided key input needed during the experimental phase of the project. Outside of engineering, many other professions were involved in the project. Attorneys (regulatory and patent), contractors, geologists, state legislators, state coastal regulatory agency representatives, Army Corps of Engineers representatives, and surveyors were heavily involved in the project. In addition to direct interaction with the research team, one student was able to participate in the site surveys, alongside the licensed surveyor. Several of the professionals gave one- to two-hour presentations on their role in the project. In the area of civil engineering, geotechnical engineering was used to determine pile uplift and lateral capacities, and materials engineering



was used to determine properties needed for finite element modeling of the system components. Structural engineering was used to design the Wave Dissipation System, and environmental engineering played a huge unexpected role in the project, as the only outside resistance to this research has come from those actively pursuing sea turtle conservation and focusing primarily on retreat policies. The team was required, as part of the course, to fully consider opposing positions on beachfront construction, and many of the students indicated this was actually the most critical part of the overall process. Several students designed improvements to the system in an attempt to make it even more sea turtle friendly.

$7,500 AWARD

NORTH CAROLINA STATE UNIVERSITY

UNC/NCSU JOINT DEPARTMENT OF BIOMEDICAL ENGINEERING

Creating a Better Way to Locate Vasculature for Intravenous Therapy

PARTICIPANTS

Students

Michael Baporis
Jordan Hjelmquist
Daniel Long
Colleen McGuire
Shannon Robinson

Faculty

Andrew DiMeo, Ph.D.
Ronald Baynes, Ph.D.
Susan Bernacki, Ph.D.
Steven Callender
Jim Brooks

Professional Engineers

Daniel Fuccella, P.E.

Additional Participants

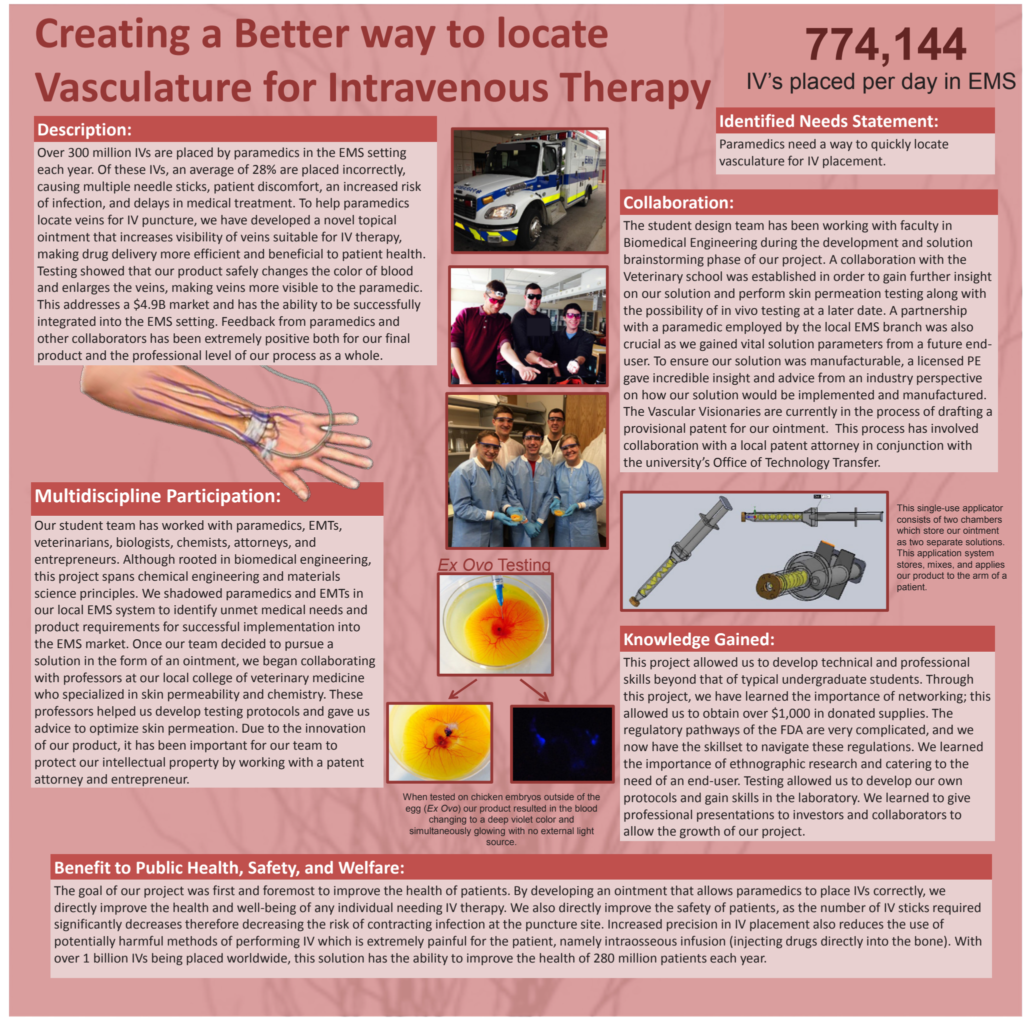
Bently Olive, Ph.D.
Joseph Luna
Armando Contreras
Mike Zippay
Bhavesh Patel
Bob Armington

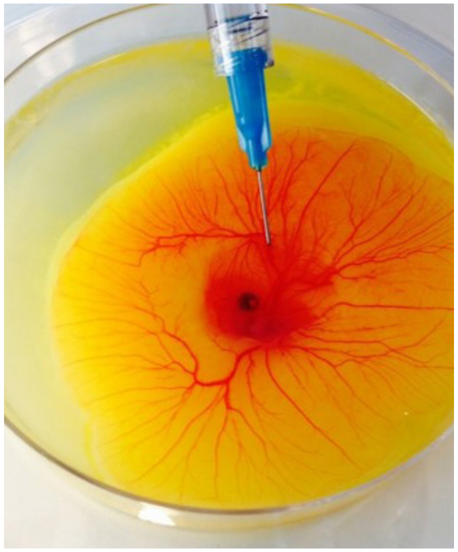
Jury Comments

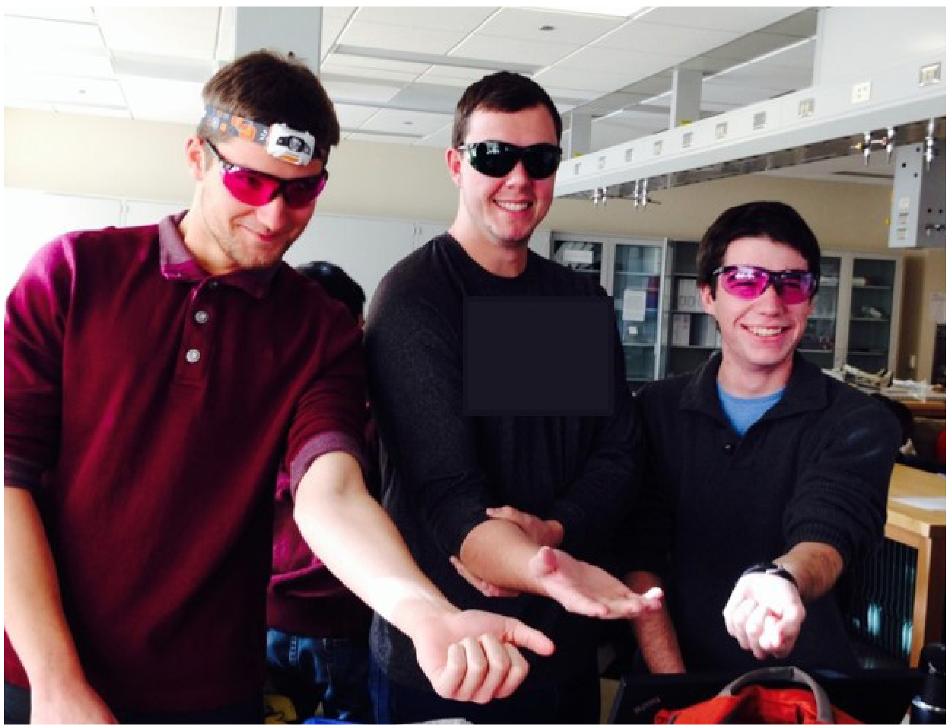
“This project met a real need. It also demonstrates the way P.E.s in industry can be a needed, integral part of a project that would not traditionally involve licensed engineers.”

“Strong global impact”

“The project has the potential to have a huge, positive impact on treatment of patients. Good collaboration with allied professionals.”







ABSTRACT

The Vascular Visionaries' project has been a yearlong design process completed by a team of five undergraduate biomedical engineering students. We were tasked with identifying an unmet medical need and developing an innovative solution for it. We identified hundreds of needs, and through a feasibility process, decided on a need to help paramedics initiate IV (intravenous) therapy by assisting them in locating the patient's vasculature. Our goal was to make IV therapy more efficient, cost effective, and beneficial for the roughly 774,000 patients affected each day. Throughout this year, our team has learned the process of gaining FDA approval for medical devices and has worked in multidisciplinary collaboration with professionals across different industries to create an effective solution for this problem.

Our solution is a topical ointment that both increases blood vessel size and augments color contrast such that first responders can easily visualize vasculature and gain needle access. The augmented color contrast is accomplished by temporarily changing the color of the blood, while simultaneously causing it to luminesce (glow) in a locally targeted area. A strong relationship with local emergency medicine personnel was established to develop product requirements and ensure the clinical effectiveness of our final solution. This relationship was developed over many ambulance ride-alongs, iterations of needs, current solution landscape, and brainstorming. Initial testing, business models, and different risk analyses were completed with help from professors in biomedical engineering and biomanufacturing with focuses in entrepreneurial ideation. An attorney from a local law firm and the office of technology transfer at the team's university were consulted to help with drafting a provisional patent to protect the team's innovative ointment. Animal testing and further development of the ointment was done through a partnership with faculty at the local college of veterinary medicine. A professional engineer with decades of experience in the design and manufacturing of plastics was collaborated with to create an effective device that properly stored, mixed, and dispensed the components of our ointment to the patient. The final product, which consists of both the device and ointment, is estimated to have a cost of goods sold of $4 per dose. At this cost, a price point can be established that will enable emergency medical services divisions to effectively employ the team's solution.

$7,500 AWARD

NORTH CAROLINA STATE UNIVERSITY

UNC/NCSU JOINT DEPARTMENT OF BIOMEDICAL ENGINEERING

Creating a Better Way to Locate Vasculature for Intravenous Therapy

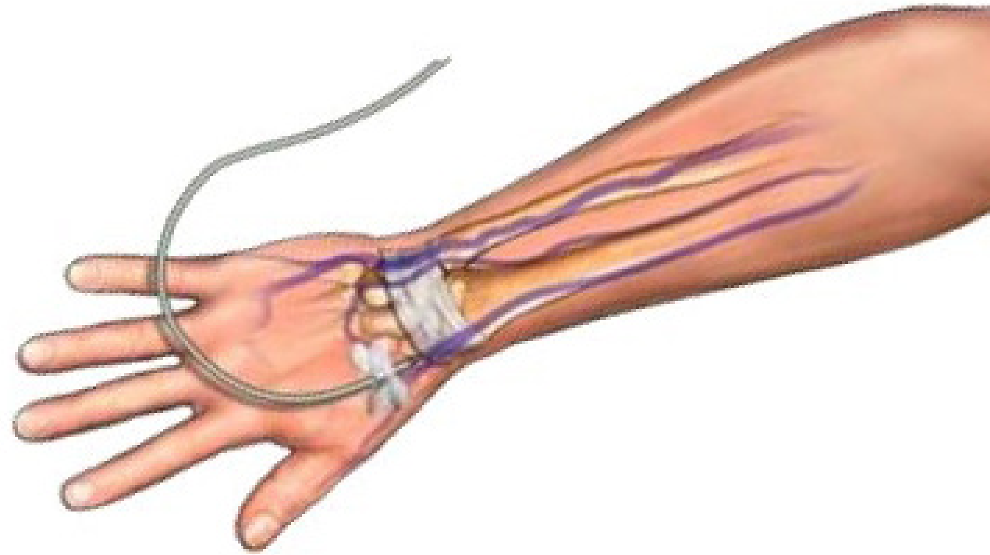
PERSPECTIVES ON

The collaboration of faculty, students, and licensed professional engineers

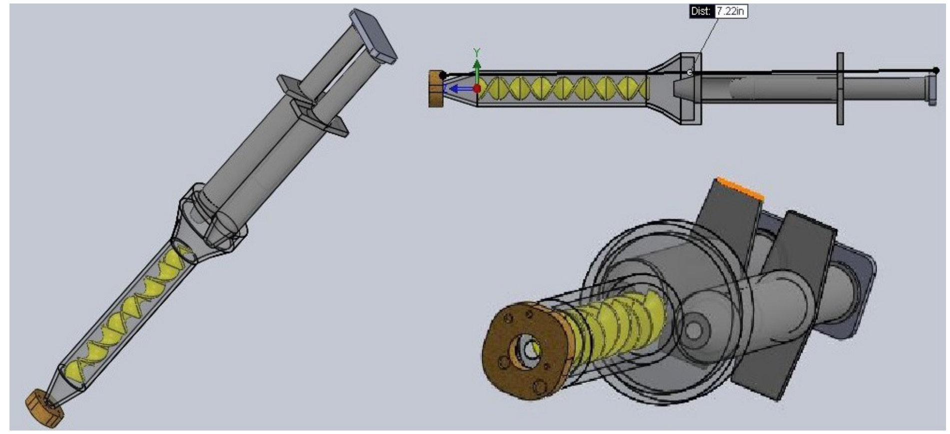
The success of our novel ointment is due largely to the collaborative nature of our project and team. A licensed P.E. monitored our progress since the start of this project and became a crucial member. As an expert in manufacturing, his input was essential in determining the feasibility of our product's production in an industrial setting. Aspects such as packaging, application, and logistics were developed with his insight. While the P.E. dealt largely with the manufacturing process, students also collaborated intensely with faculty from the college of veterinary medicine. This collaboration was used primarily to develop and use a testing protocol to assess the effectiveness of our ointment. The students were also able to interact with several paramedics in order to keep the voice of the customer the main concern during the development and testing of our product. The intense collaborative environment of this project provided opportunities students never would have had otherwise. Students were able to establish contact with professionals such as professors, paramedics, attorneys, doctors, and P.E.s and use this network of contacts to develop a very marketable and effective product. Working with professionals in many fields has prepared us for our future careers and has been an integral part of the design process.

The knowledge and skills gained

The five-phase design process used to develop this product fostered the creation of new knowledge for the student team. The process spanned the entire realm of device development, from observation and ideation to creation and testing of a device to meet an identified need. Acting under the process, the team documented all items necessary for an FDA submission. The regulatory pathways required us to gain knowledge in the process for FDA approval, medical device classification, and document control. These skills were also honed when learning about patent law. Since we were working with a local attorney to draft a provisional patent with the intent of filing a full patent, extensive research was also done to ensure our intellectual property would be protected within the United States and internationally.



When identifying unmet medical needs, several skills were gained, such as the importance of ethnographic research. When conducting interviews, surgeons and doctors were unable to state many problems they currently experienced in the medical field. However, observing them during their shifts allowed us to assemble a list of 70 needs that had not been effectively met in the medical field. Ethnographic research allows us as outsiders to see medical professionals working in their natural environment, which is more revealing and effective than literary research or even interviews. Networking is another skill gained throughout this process. Our team started with one clinical mentor, and through networking, we gained an extensive list of professionals to help us throughout the process.



At first, our networking was limited to medical professionals as we tried to find unmet medical needs. As the project progressed, our networking efforts increased to include company representatives, a law firm, a P.E. mentor, veterinarians, a chemist, and countless other professionals who have helped us along the way. Through this network, over $1,000 of equipment has been donated to our project, over twice that of our original budget. A veterinarian contact recently told us, "Our project and professionalism has given me hope for the next generation of researchers." This proves that we have not only learned networking, but also professional practices that will serve us well in the future.

$7,500 AWARD

SEATTLE UNIVERSITY

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Historic Landmark Incline Lift Structural Evaluation and Retrofit

PARTICIPANTS

Students

Ryan Blair
Nicholas Bleich
Timothy Thorpe
Maxx Toyama

Faculty

Carla Keel, P.E., S.E.
Katherine Kuder, Ph.D., P.E.
Nirmala Gnanapragasam, Ph.D., P.E.

Professional Engineers

Daniel O'Sullivan, P.E.

Additional Participants

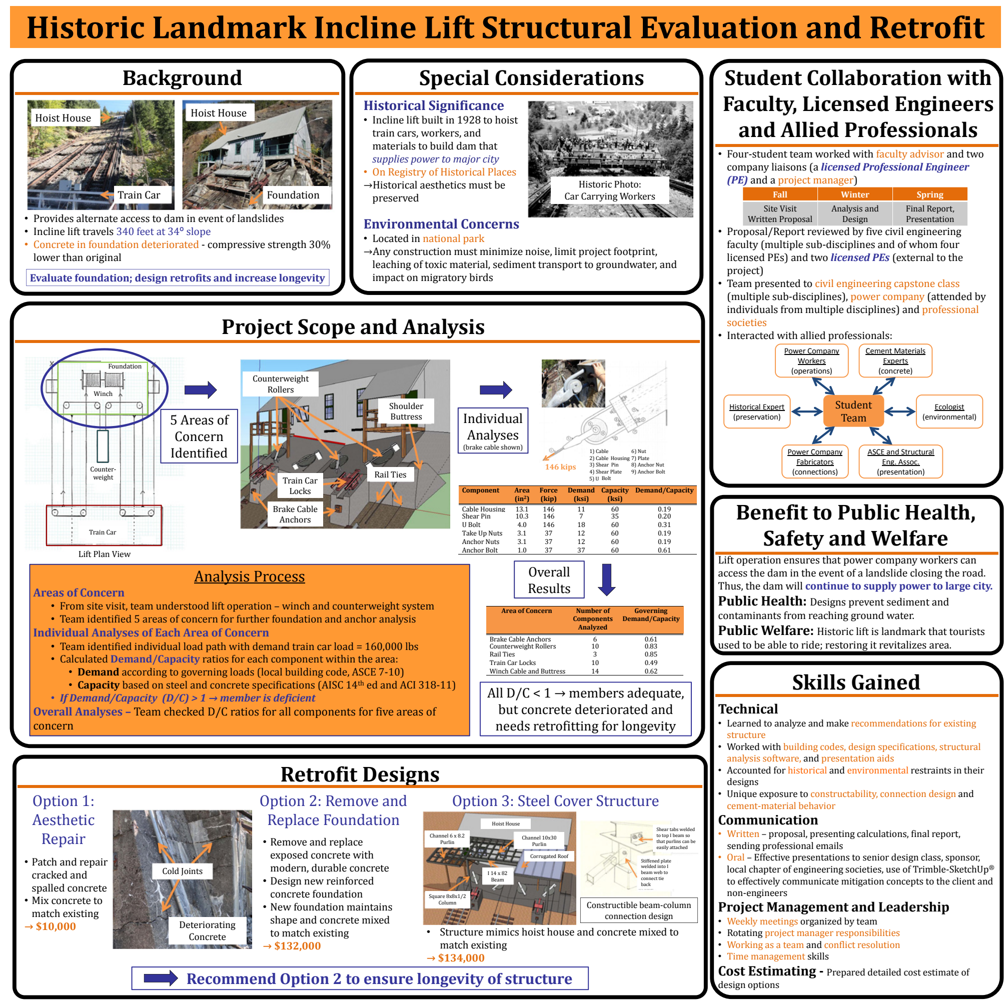
David Anderson, Project Manager, Seattle City Light

Jury Comments

"I appreciate the historical preservation aspect of the project and the challenges of working within the limitations of an existing design."

"Excellent project both preserving a historic structure and recommissioning for use"

"Restoring historical structures is a must in our society. Rather than putting into a landfill, we need to rebuild, renovate, and repurpose."



ABSTRACT

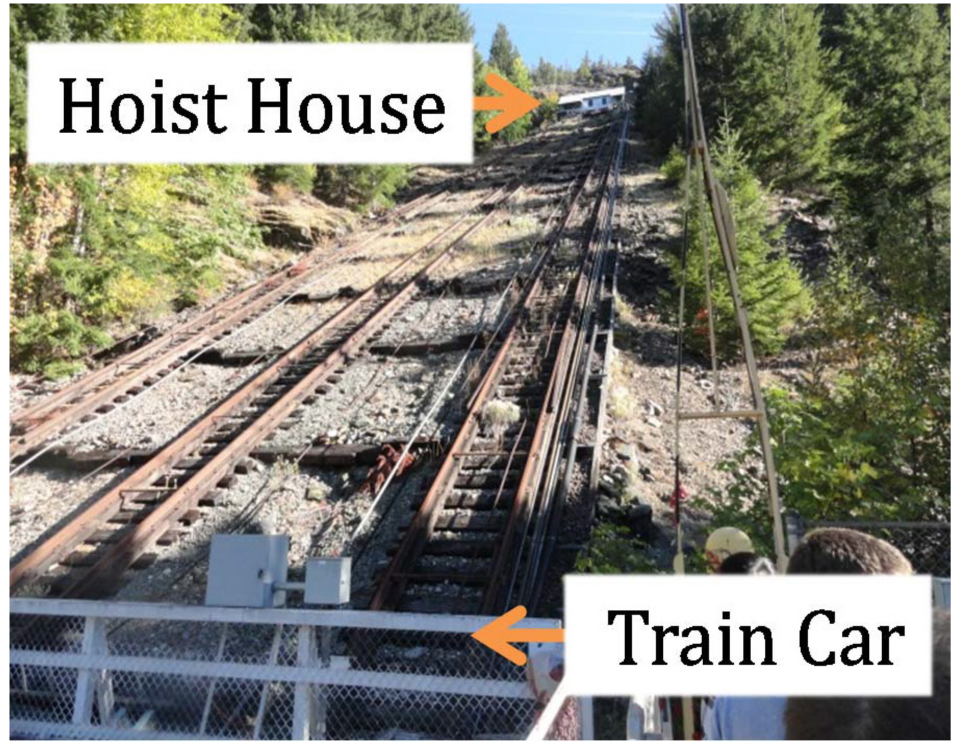
A local power company requested our university's capstone program to perform a structural evaluation and retrofit of their historic incline lift. A design team was tasked with assessing the structural integrity of the lift's concrete foundation and anchorages to propose retrofit designs to mitigate deficiencies and increase the longevity of the structure.

The incline lift was built in 1928 to access the mountainous construction site at a dam critical to the power supply of a large city. The lift was designed to hoist train cars, materials, and workers up the slope. After completion of the dam, the lift remained an integral part of power company operations until it was decommissioned in 2001 due to security concerns. The power company wanted to bring the lift back into service to provide redundant access to the dam for when the highway is closed due to landslides. The lift is on the National Registry of Historic Places and is located in a national park; thus both historic and environmental factors had to be considered.

The team visited the project site to learn how the incline lift is intended to function. They also observed the deteriorated state of the exposed concrete foundation. A materials laboratory report done on the lift confirmed that concrete in exposed areas was deteriorating and the compressive strength severely compromised. From the site visit, the team identified five areas of concern within the lift system. Each of these areas of concern was analyzed by tracing the individual load path through the components to the concrete foundation. The governing demand to capacity ratios of the five systems showed that all components were adequate.

Although the foundation and anchors had sufficient capacity, the aesthetics of the existing foundation were a concern, as was the longevity of the foundation as it was exposed to continued weathering. Therefore, the design team presented three retrofit options to the power company: (1) aesthetic patching of the concrete, (2) removal of the existing weathered concrete and replacement with new modern, durable concrete, and (3) construction of a steel roof cover structure to protect the exposed foundation. The total estimated costs of the three options were $10,000, $132,000, and $134,300, respectively. The team recommended that design option 2 be implemented.

Students met weekly with their faculty advisor and the sponsoring company liaisons, two of which are licensed professional engineers (P.E.s). The team's design calculations



were reviewed by the faculty advisor, company liaisons, and two other P.E.s. Project highlights include site visits; professional presentations to their class, the project sponsor, and outside professional chapters; working with a historical specialist and ecologist; and a visit to the sponsor's fabrication shop to discuss connection design. The team also learned to use Google SketchUp® to effectively communicate their mitigation concepts to the client and nonengineers. The project culminated in a final report to the utility company and a poster presentation to the local university and 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

Historic Landmark Incline Lift Structural Evaluation and Retrofit

PERSPECTIVES ON

The collaboration of faculty, students, and licensed professional engineers

At our institution, senior civil engineering students are required to complete a year-long, real-world, capstone design project. Four students were assigned to this project and worked under the guidance of a faculty advisor, a licensed professional and structural engineer (P.E. and S.E.), and two company sponsor liaisons, one of whom is a licensed professional engineer (P.E.) and the other a project manager.

As part of the capstone course, students completed (1) a project 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. To accomplish these tasks, the student team held weekly meetings with their faculty advisor and company liaisons. They gave two presentations for the sponsor—one in the fall detailing the proposal and one in the spring explaining the final design. Other licensed professional engineers (P.E.s) and project managers attended presentations from the company sponsor. The team also interacted with licensed professional engineers (P.E.s) outside of the sponsor company by giving a presentation at the local chapter of the Structural Engineers Association (SEA) in fall.

The benefit to public health, safety, and welfare

The design team considered public health, safety, and welfare in the project. The operation of the lift ensures that power company workers can access the dam in the event of a landslide closing the road. Thus, the dam will continue to supply power to a large city. Additionally, the project addressed issues related to

Public health—All designs included measures to prevent sediment and toxic materials from reaching the ground and surface water during construction.

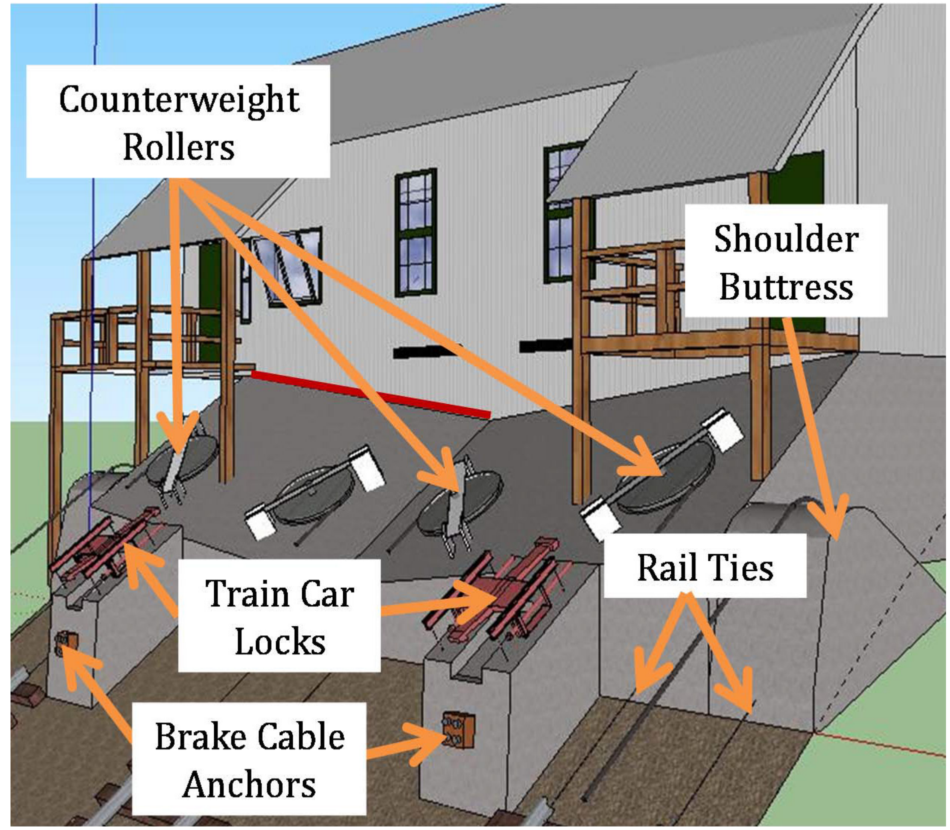
Public welfare—The historic lift is a landmark that tourists used to be able to ride as part of a tour of the dam and surrounding areas. Restoring the lift will revitalize the area.

Multidiscipline and allied profession participation

The project included a number of opportunities for the students to interact with other disciplines and licensed P.Es.

Power Company Interactions—During the site visit, the design team interacted with power company workers and P.E.s to learn about the site. They also presented their proposal and final recommendations at the power company to an audience that included staff working regularly at the dam, project managers, and engineers (all P.E.s).

Materials Lab Report—The team was provided a comprehensive materials laboratory report about the condition of the concrete foundation. They discussed this report with a materials lab engineer and also a faculty member specializing in cement-based materials,



both of whom are P.E.s. Understanding the report required knowledge of American Society for Testing and Materials (ASTM) and American Concrete Institute (ACI) testing methods as well as cement-based material behavior.

Historical Preservation—As mentioned earlier, because this site is a historical landmark, the aesthetic appearance had to be taken into account when designing the retrofit options. In winter quarter, the students met with the power company's historical specialist to discuss the design challenges presented by the historic nature of the lift. They learned about the company's Historic Management Plan and that the historical aesthetics are to be preserved and any additional structure must be identifiable from the original construction.

Environmental Considerations—The team met with an environmental ecologist from the power company. The incline lift is within a national park and requires authorization for the implementation of the design options. Environmental considerations in the designs included noise impact, project footprint, potential leaching of toxic material, and sediment transport caused by construction processes. Additionally, toxic materials or sediment could not be allowed to reach water sources because of its adverse impact to the aquatic life. Construction also could not impact migratory birds that inhabit the area.

Connection Design—The students visited the sponsor's fabrication shop to discuss connection detailing. The sponsor prepared a mock-up of their beam-column connection for the team's final presentation. The students also received feedback from the fabricators about how to improve their design and drawings.

$7,500 AWARD

UNIVERSITY OF EVANSVILLE

COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Fairfield Reservoir and Dam

PARTICIPANTS

Students

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James Gabe
Jamie Johnson
Chris Kuester
Alex Loehrlein
Hieronymus Mitchell
Zach Neukam
Heather Passey
Alex Schwinghamer
Killian Sweet

Faculty

Brian Swenty, Ph.D., P.E.

Professional Engineers

Ron Spively, P.E.,
Patriot Engineering

Brian McKenna, P.E.,
Christopher B. Burke Engineering, LLC

David Haas, P.E.,
Christopher B. Burke Engineering, LLC

Lindsey Lenker, P.E.,
HMG Engineering, Inc.

Additional Participants

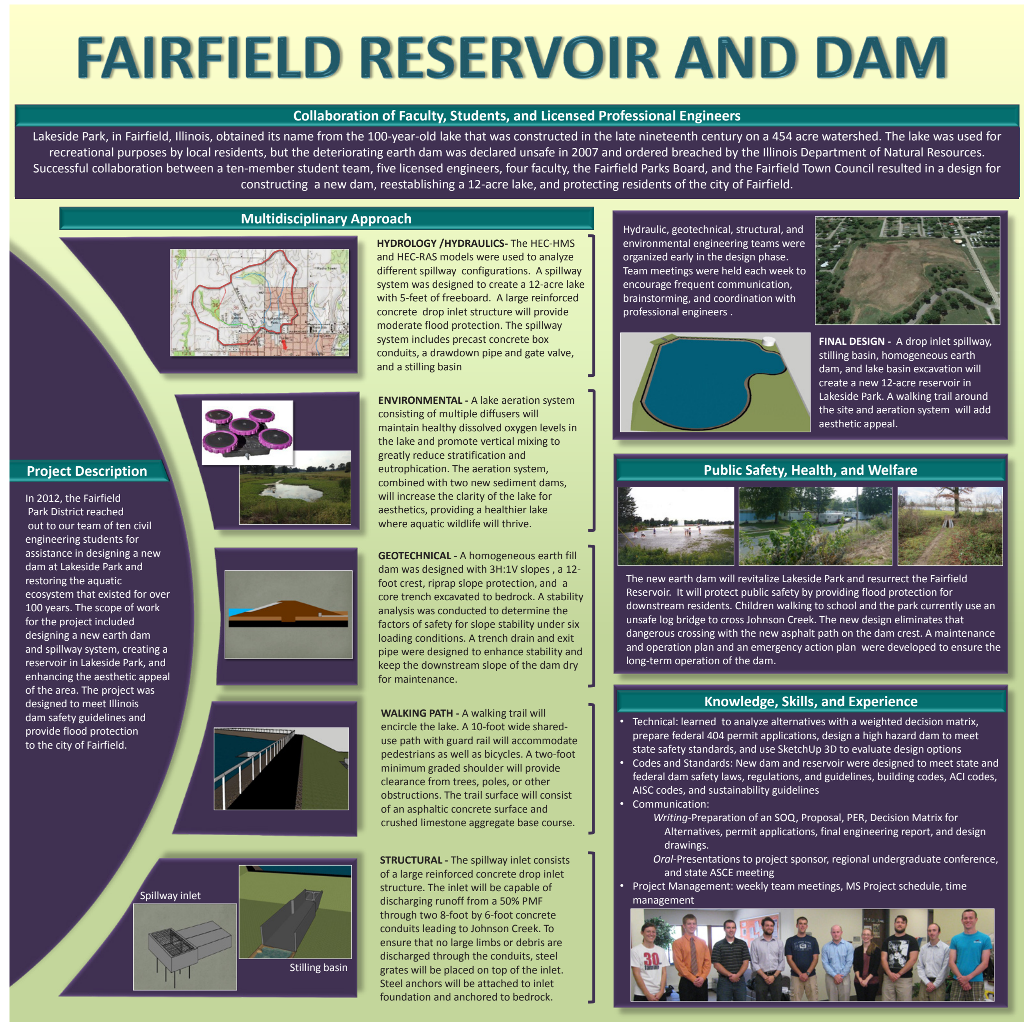
John Marks,
Patriot Engineering

Jury Comments

"An important design project for the community"

"Clearly addressed a community issue with a complete solution"

"The most effective engineering project poster I've ever seen"



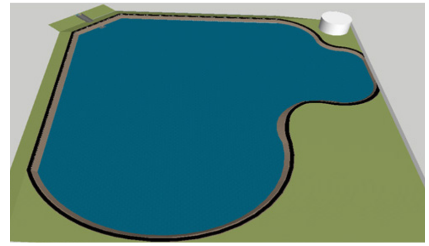
ABSTRACT

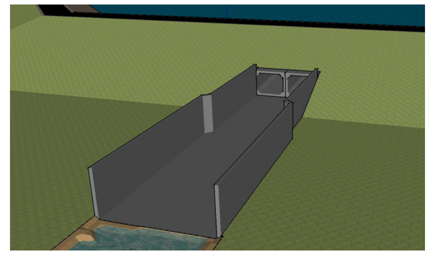
All civil engineering students complete a two-semester long, real-world, team capstone design project with an external project sponsor. For this project, the student team prepared a statement of qualifications (SOQ), visited the project site, met with the project sponsor, developed a scope of work, and prepared a project proposal. The proposal included the scope of work, a project schedule, and a list of tasks and deliverables. After the project sponsor accepted the proposal, students spent the fall semester performing site investigations, engineering surveys, code and standards familiarization, and permit research. The team evaluated four alternatives and prepared a decision matrix. A preliminary engineering report (PER) and conceptual drawings were developed and presented to the project sponsor. After the project sponsor selected a preferred alternative, the student team spent the spring semester performing final design. The team had two project managers and was advised by a faculty member who is a registered professional engineer. Throughout the two-semester project, the student project managers provided written updates to a four-person professional engineering advisory group, maintained an electronic project file, and conducted numerous meetings.

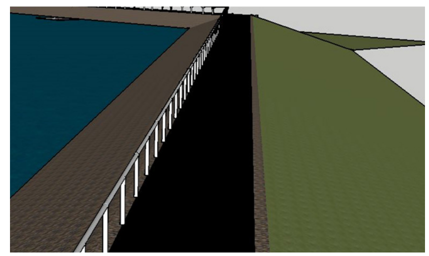
Lakeside Park, in northwest Fairfield, Illinois, obtained its name in honor of the over-100-year-old lake that was constructed in the late nineteenth century. For most of its existence, local residents used the lake for recreational purposes, but the deteriorating earth dam was declared unsafe in 2007 and ordered breached by the Illinois Department of Natural Resources. Since 2007, the absence of the reservoir caused increased flooding downstream of Lakeside Park in the community of Fairfield. The park's aquatic ecosystem transitioned to a low-quality wetland, forcing any future construction to require U.S. Army Corps of Engineers approval.

In 2012, the Fairfield Park District contacted the university and requested assistance from a team of 10 civil engineering students in designing a new dam at Lakeside Park and restoring the aquatic ecosystem that existed for over 100 years. The scope of work for the project included designing a new earth dam and spillway system, creating a 12-acre reservoir in Lakeside Park, and enhancing the aesthetic appeal of the area. The spillway was designed to meet Illinois dam safety guidelines for high hazard dams and provide flood protection to the city of Fairfield.

The Fairfield Park District was presented with four design alternatives by the team in December 2013, and a final design was selected. The new earth dam was designed with







3H:1V slopes, a 12-foot-wide crest, a riprapped upstream slope, and a 21 foot-8 inch by 11 foot-8 inch reinforced concrete spillway inlet. The inlet will be connected to two 8-foot by 6-foot precast concrete conduits capable of safely discharging runoff from the 50 percent probable maximum flood (PMF) to a concrete stilling basin. Keeping with the park board's desire to create an aesthetically appealing park the community would embrace, the design includes a walking trail around the lake, a lake aeration system, two sediment dams upstream of the lake, and a deeper reservoir to increase recreational opportunities. Permit applications were prepared to allow the park board to obtain state and federal approval for the project and resolve any wetlands issues prior to construction. The design was complicated due to the structure's location in a residential area, its classification as a high-hazard dam, and the large 37:1 watershed-to-reservoir ratio, which required the design of an innovative high capacity spillway system.

$7,500 AWARD

UNIVERSITY OF EVANSVILLE

COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Fairfield Reservoir and Dam

PERSPECTIVES ON

The collaboration of faculty, students, and licensed professional engineers

The 10-member student team engaged in frequent and detailed communication with groups including university faculty, practicing professional engineers, the Fairfield Park District, the Fairfield mayor's office, the U.S. Army Corps of Engineers, and several other organizations. The civil engineering faculty of the university contributed advice and knowledge during the design process in their areas of expertise, and the chair of the civil engineering department served as faculty advisor throughout the project. Our team worked closely with a professional advisory board that consisted of several practicing engineers from reputable engineering firms, including firms that currently work for the Fairfield Park District and the city of Fairfield (two completely separate political entities). The professional advisory board received written project updates every three weeks during the spring 2014 semester, and they actively contributed advice and recommendations based on their years of engineering experience. The project sponsor was the Fairfield Park Board. The team followed stringent dam safety design procedures that met codes, standards, and regulations.

Team members met with members of the Fairfield Park Board in early September 2013 at Lakeside Park and discussed design options for the site. Describing the current park as an eyesore, the park board's primary desire was to construct a new lake and enhance Lakeside Park to allow it to serve as a gathering place as it did for over 100 years.

On September 25, 2013, our faculty advisor attended a meeting in Fairfield led by the mayor. In attendance were the chair of the Fairfield Park Board, members of the city council, two members of the U.S. Army Corps of Engineers regulatory branch, the city's consulting engineers, and staff representing the local state representative, the district congressman, and a U.S. senator. The situation at Lakeside Park, primarily the increased flooding in Fairfield downstream of the park, was discussed. The Corps of Engineers members visited Lakeside Park prior to the meeting and explained that wetland mitigation may not be necessary to the extent originally thought, as it appeared to them that only two to three acres of low-quality wetlands existed in the old lakebed.

In December, the student team presented four design options to the Fairfield Park Board in a preliminary engineering report. A planned presentation was canceled due to heavy snowfall, and the options were discussed over a conference call. The team's preferred alternative was selected by the park board. This option included designing

- A new dam slightly upstream of the old dam, a spillway, and stilling basin
- A walking path around the lake and on the dam crest
- Sediment dams at the two lake inlets
- A lake aeration system
- A new 400-foot-long culvert in a ditch to route Johnson Creek around the eastern edge of the lake

Additionally, the lake would be deepened, increasing its overall storage capacity.

Professional engineers from Engineering Firm A answered geotechnical team questions about Fairfield's historical and geological data, which was not readily available. The Fairfield Park Board provided a 2003 soil boring report to the team. The soils report included four boring logs, SPT test data, Atterberg Limits test data, and consolidated undrained triaxial test data for undisturbed samples from the old dam and foundation. Two professional engineers from Engineering Firm B reviewed team calculations and reports in addition to suggesting additional design steps. Engineering Firm C contributed experience in filing Corps of Engineers permits and critiquing reports. Team members then met with the Corps of Engineers in February to discuss the wetland permits.

Having the opportunity to work with practicing professionals and organizations allowed the team to gain valuable communication and collaborative skills. Throughout most of the design phase, the team provided progress reports to professional engineers working with the Fairfield Park Board and the city of Fairfield. These engineering firms will ultimately be responsible for ensuring the dam design project comes to fruition after the members of the team graduate. In addition, two professional engineers specializing in dam design were consulted for advice in development of the site. Through the interaction

with professional engineers, students learned how to accept criticism and advice. Design is much more than simply complying with codes and standards. Meeting the needs of the project sponsor, understanding the needs of the community, protecting public safety, and developing a sustainable design are very important. Team members learned intermediate design steps, which assisted them in delivering a complete and thorough design. The professional engineers were aware of current practices in the real world as compared to information in handbooks and textbooks that can be dated. Using this modern knowledge and wealth of experience, the team was able to efficiently complete a design.

The benefit to public health, safety, and welfare

The final design will revitalize Lakeside Park and resurrect the Fairfield Reservoir but will also establish a safe living area downstream of the dam by providing flood attenuation. The most important governing factor was protecting public safety, and that was accomplished by designing a stable earth dam and a spillway that could safely pass runoff from the 0.5 PMF event. The design incorporated the concerns of the Fairfield mayor's office by providing some inflow hydrograph attenuation to lessen downstream flooding. The final design is expected to attenuate 13 percent of the peak inflow for the 100-year storm and 17 percent of the peak inflow for the 0.5 PMF event. The high watershed to reservoir ratio (37:1) and a lake site surrounded by residential development forced the team to develop an innovative spillway design that met state dam safety criteria. The new spillway inlet structure and stilling basin system were integrated with the new earth dam design to create a 12-acre reservoir. The walking trail and aeration system will add aesthetic appeal to the site. The dam will contain an internal drain to control seepage, improve embankment stability, and keep the downstream slope of the dam dry. A drawdown pipe was designed with the spillway inlet to allow the lake to be drained to comply with Illinois DNR regulations. During the design of these project features, students gained an awareness of how each design aspect would influence the outcomes of future features and the final design.

A maintenance and operation plan was prepared for the park board to specify procedures for operating and caring for the new dam, spillway system, and outlet works. Items addressed include preventing overgrowth of trees and vegetation on the dam, erosion control measures, inspection of the dam and spillway system, seepage measurements, lake drawdown limits, and a schedule for routine testing of the facilities to be performed in compliance with state regulations.

The team prepared an emergency action plan that outlines steps to be taken in the event of three levels of emergencies at the dam. Examples include anticipation of heavy rainfall that could cause high reservoir levels and large spillway discharges that pose a flooding risk downstream of Lakeside Park, discovery of high levels of uncontrolled seepage, and the presence of slides in the dam. This document requires the owner to notify local law enforcement, fire department, emergency management officials, and the state dam safety office in determining the appropriate course of action for any severe event that could threaten the safety of the dam and areas downstream. These types of plans are very site-specific, but the general idea can be applied to any community project.

Although the city of Fairfield was neither the property owner nor project sponsor, its flood protection concerns were reflected in the design of the new hydraulic structures. Learning code requirements compelled students to develop a sense of responsibility for the citizens of Fairfield. The learning process was a group effort, but with the small team size, students were forced to focus on becoming "experts" in particular areas, such as dam safety, wetland mitigation, park utilization, and aquatic wildlife. This emphasized

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UNIVERSITY OF EVANSVILLE

COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Fairfield Reservoir and Dam

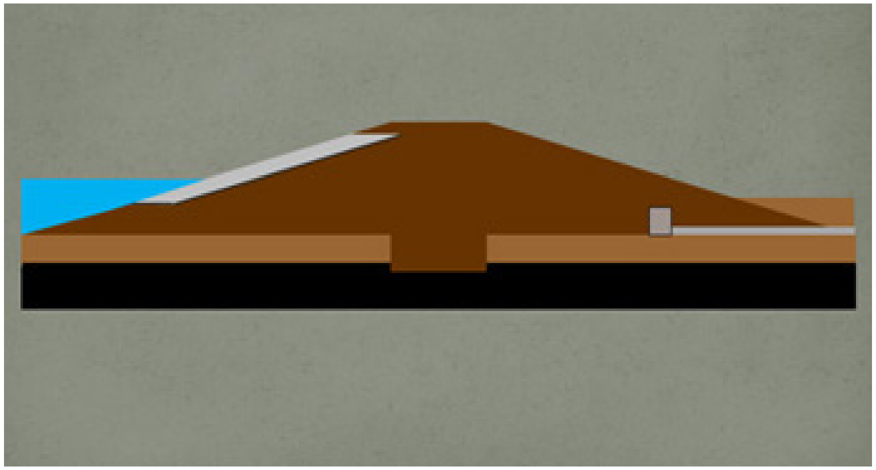
the importance of self-reliance and confidence. Students may not routinely use their knowledge of these specific codes, but having the experience of researching and utilizing available resources allowed the team to make educated decisions to solve future problems.

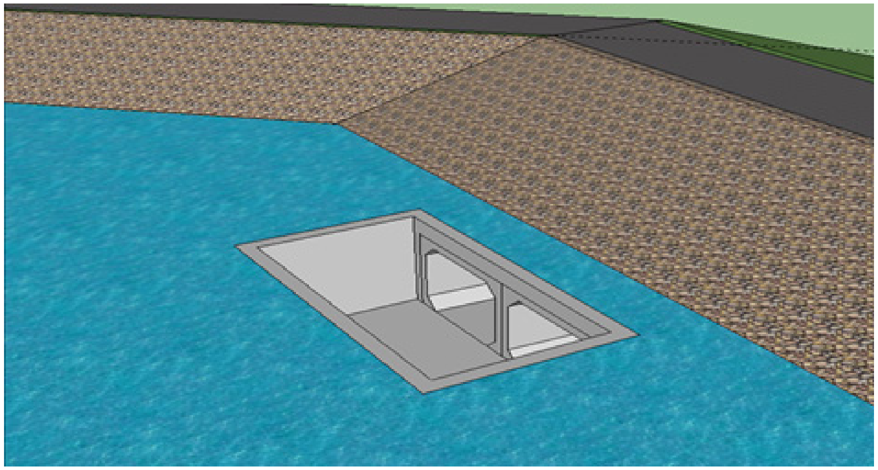
Multidiscipline or allied profession participation

After the park board approved the recommended design at the end of the fall semester, specialty teams were formed to complete various aspects of the design. Several branches of the civil engineering discipline were involved in the design of the dam and reservoir. Hydraulic, geotechnical, structural, and environmental engineering teams were developed, and team meetings were held each week to encourage frequent communication and brainstorming. The hydraulic team used the Corps of Engineers HEC-HMS model to analyze different spillway designs, with a goal of keeping the normal pool elevation five feet below the crest of the dam and preventing the reservoir from overtopping the dam and a busy street upstream. Providing flood attenuation downstream was also desired. The team surveyed Johnson Creek downstream of the dam and used the HEC-RAS model to develop water surface profiles for design spillway flow rates to determine the impact of spillway flows on downstream residents.

Separate principal and emergency spillways could not be constructed due to the proximity of the dam to residential areas immediately downstream of the dam. Public safety dictated that a combined spillway system be designed to safely pass both 100-year and 0.5 PMF design flows. Spillway conduits were analyzed for various flow conditions and designed to ensure that pressurized pipe flow did not occur during the 0.5 PMF. A 10-inch diameter ductile iron pipe will be connected to the spillway inlet and controlled with a gate valve to allow the park district to comply with state regulations for draining the lake. A Type II SAF stilling basin was designed to dissipate energy from the water exiting the spillway conduits and reduce damage to Johnson Creek downstream.

The geotechnical team determined the approximate elevation of bedrock from a 2003 soil investigation report and the amount of fill that could be removed from the existing lakebed.





The homogeneous earthfill dam was designed with 3H:1V upstream and downstream slopes and a 12-foot crest. To limit seepage, a key (cutoff) trench excavated to competent bedrock was included in the dam design.

A stability analysis was performed using the STEDWin and PCSTABL6 computer models. PCSTABL6 uses the simplified Bishop Method to evaluate slope stability. The analysis was conducted to determine the factors of safety for slope stability under the six required loading conditions. The dam is located close to both the Wabash Valley Fault system and the New Madrid Fault system, forcing the dam design to accommodate a peak seismic acceleration of 0.4g. A trench drain was included in the design to increase the stability of the dam, provide the owner with a means of monitoring seepage, and keep the downstream slope of the dam dry for regular mowing. The trench drain will include a perforated pipe that will exit into a solid 4-inch diameter PVC pipe that runs along the edge of the spillway conduits and exits above the base of the stilling basin, allowing the park board to monitor and measure seepage.

The environmental team focused on designing two sediment dams upstream of the lake and a lake aeration system. Using the results of a lake aeration undergraduate research study performed by a recent civil engineering graduate, the team determined that the aeration system will maintain healthy dissolved oxygen levels in the lake and promote the vertical mixing of lake water to greatly reduce stratification and eutrophication. The aeration system will increase the clarity of the lake for aesthetics and vastly decrease the amount of chemical usage, providing a healthier lake where fish and other aquatic species will thrive. Using information from a meeting with regulatory personnel from the Corps of Engineers, the environmental team prepared permit applications for wetland mitigation.

The structural team designed a spillway that will consist of a 21 foot - 8 inch by 11 foot - 8 inch reinforced concrete inlet structure. The inlet is capable of discharging runoff from a 50 percent PMF through two 8-foot by 6-foot concrete conduits leading to a stilling basin and Johnson Creek. To ensure that no large limbs or debris are discharged through the conduits, steel grates will be placed on top of the inlet, supported by three beams attached to the top of the 9-foot high spillway inlet structure. The foundation of the spillway inlet structure will be anchored to shallow bedrock beneath the lake.

A walking trail will encircle the lake. A 10-foot-wide shared-use path with guardrail will accommodate pedestrians as well as bicycles. The trail surface will consist of an asphaltic concrete surface and aggregate base course on top of the compacted subgrade. The aggregate base course will be a crushed limestone. Children currently use an unsafe log bridge over Johnson Creek downstream of the old breach. The new shared-use path on the dam crest will provide them with a safe means of walking to and from school and park facilities.

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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING AND EARTH SCIENCES

Innovative Housing Solutions for Post-Quake Haiti

PARTICIPANTS

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Erik Jensen

Panel Foreman
Ethan Zartman

CIP Foreman
Dan Rish

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Adam Logeman
Kaleigh McLaughlin
Spencer Ness
Quinn O'Heeney
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Brian Maloy, E.I.,
ARCO/Murray

Dave Williams, P.E.,
Western Forms International

Mason Xie, P.E.,
ASEII Corp Engineer of Record

Joe Pomerenke, E.I.,
ARCO/Murray

Additional Participants

Mike Cote, A/M Superintendent
Bernie Trout, WFI Framework Trainer
Paul Hundt, Concrete Supervisor
Brent Bach, Construction Technician
Karl Kuhlmann, WFI Estimator
Adam Bradley, JJ White
Myron Martin, Hoosier Concrete
Tim Miller, Kuert Concrete
Jim Dill, CMA Supply
Paul Pierre-Louis, Magepa S.A. Principal

Jury Comments

"This project demonstrates a practical solution to a real need. Prototypes were built at the university before being built in Haiti. It has applicability domestically, too."

"Terrific interaction and collaboration with end users in Haiti"

"A heartwarming experience for the participants, the beneficiaries, and the reader"

ABSTRACT

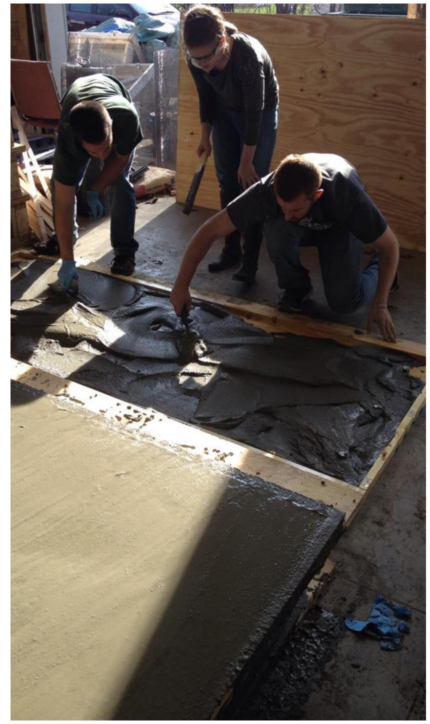
Haitian families still have no viable roadmap to enable reconstruction of resilient homes in the wake of the 2010 earthquake, as their traditional masonry construction has proven too expensive to safely reimplement, leaving them indefinitely confined to transitory shelters. As such, a team of faculty and students have been working for the last four years to formulate an integrated process that empowers Haitian entrepreneurs to deliver affordable, dignified, engineered housing within the local informal economy through innovative housing systems that navigate engineering and non-engineering constraints. To realize such a design, multidisciplinary participation between students and advisors from wide-ranging fields was necessary. These included four subdisciplines of civil engineering, mechanical engineering, electrical engineering, architecture, political science, international development studies, liberal studies, business (marketing), and social entrepreneurship; however, in order to bring their conceptual design into reality to meet the needs of displaced families in Haiti anxiously waiting its arrival, an ambitious semester-long project, the Expo, was executed in the spring of 2014, with the following objective:

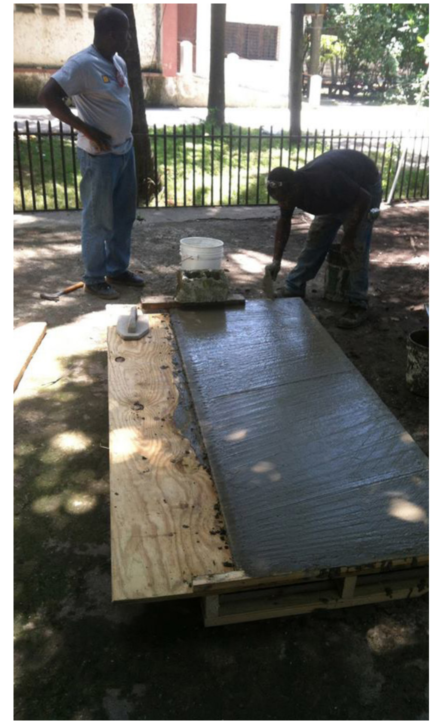
Through partnerships between faculty, undergraduate students, licensed engineers, allied construction professionals, and their Haitian counterparts, vet the constructability, feasibility, and scalability of two reinforced concrete housing typologies for post-quake Haiti using full-scale prototypes.

The Expo allowed students to directly experience the entire project life-cycle, including critical phases of conceptual design, concept refinement, material testing, code-compliant design, structural drawings, fabrication, construction sequencing, site-planning permitting, budgeting/quantity estimation, procurement, project management, and ultimately construction. The collaboration that backed this expo included four faculty, over 20 students, and three licensed engineers, as well as a number of local vendors and contractors who donated time, materials, and services. Practicing engineers hailed from a prominent design-build firm and one of the world's foremost concrete formwork providers. Moreover, to ensure a process that would yield a design that could be realizable in Haiti, the Expo created an Innovation Exchange between its U.S. university-based research and development of structural aspects, including full-scale prototyping, and operations in Haiti that would verify feasibility/constructability and identify non-structural finishes that best met their cultural expectations for a home. A U.S.-trained Haitian engineer, collaborating with in-country staff from the students' university, led this Haitian team of five builders.

The outcome of this expo, while most tangibly evidenced by the construction of two full-scale, two-room (288 square feet) reinforced concrete prototype homes, included many other deliverables, such as various student-led concept refinements. However, perhaps the most important direct outcome is the complete set of structural drawings, budget analyses, and comprehensive assessments of these housing typologies to yield a standardized design that is already being replicated in Haiti by a local crew on the first of what will hopefully be many homes.

The knowledge and skills gained by the students in this process have given them a greater appreciation for the role of engineering judgment, various aspects of professional practice, and the importance of licensure—and they are better, globally minded engineers for it. But ultimately, the true lessons the students learned through the Expo cannot be quantified in words but by the changed men and women they have become.





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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING AND EARTH SCIENCES

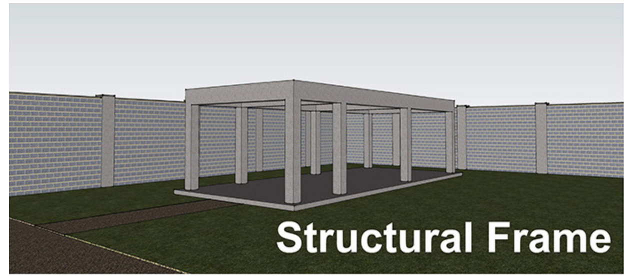
Innovative Housing Solutions for Post-Quake Haiti

PERSPECTIVES ON

The collaboration of faculty, students, and licensed professional engineers

Although the end product of this effort ultimately serves Haiti, the students were able to dramatically transcend the typical classroom experience by executing two full-scale prototypes in the United States and by enacting an actual microcosm of the life cycle of a typical project on campus. This included project phases, ultimately culminating in the construction and documentation of as-built details. At each step of this life cycle, the students directly benefited from the insight, experience, and mentorship of professional engineers and allied professionals in the construction industry, who held them to a high professional standard that tangibly demonstrated the expectations placed upon practicing engineers every day. By then having the feedback from formally trained engineers in Haiti[1], the students were able to gain a cross-cultural perspective of true solutions, which can ultimately be executed in their final application. Students also benefitted from an exchange of ideas, e.g., Haitian construction crews sending YouTube videos to teach feasible and efficient techniques to bend stirrups.

This interaction was facilitated through a number of formal academic and informal mentoring environments. The most formal was the department's senior capstone design course, where direct weekly mentorship and instruction was provided by three P.E.s (one of them faculty) to guide the expectations for a formal design process. This was complemented by a less structured directed studies course overseen by two additional faculty; this integrated the efforts of over 20 undergraduate students from five majors to address the wider R&D aspects of this effort and integrate the private sector partners from both Haiti and the United States. This course uses a hierarchical organization so that senior leaders meet weekly with the faculty and then self-organize and direct the underclassmen in the course. The U.S. private sector partners included a prominent design-build firm and one of the world's foremost concrete formwork providers, both from major cities in the region. Both firms brought P.E.s and E.I.s to the process from within their organizations, as well as from collaborating subcontractors. Thus direct P.E. mentorship was provided for all structural designs/drawings, site planning, and construction scheduling. These firms additionally provided project managers, firm principals, and superintendents throughout the project from design through construction. The Expo team included members of a course on international development, which supported students in traveling to Haiti to formulate recommendations on how to best integrate this housing model within the evolving housing policies in-country.



Because of the geographic separation between the students and the U.S. private sector partners, outside of the week of construction when face-to-face

[1] Note: Haiti does not have a formal licensing program for engineers, but engineers who are formally trained in the United States are regarded as the highest level of professionals in their communities.

interaction was possible, student leaders conducted weekly conference calls with the firms and supervising faculty, using file sharing services to exchange drawings and maintain detailed agendas, meeting minutes, punch lists, and schedules, following up with personal emails and phone calls. Interactions with Haiti relied primarily on email, video conferencing, and mobile communications, outside of one week-long visit by two students. By the end of this experience, it was clearly evident to the faculty and students alike that such an ambitious semester-long project could not have been realized without the invaluable experience and insight brought by licensed engineers and allied construction professionals.

The benefit to public health, safety, and welfare

The existing construction practices and structural typologies in Haiti were proven vulnerable in the 2010 earthquake. Sadly, families cannot afford properly confined masonry homes as a means to address these vulnerabilities, and many are even reluctant to reconstruct with masonry altogether, leaving hundreds of thousands indefinitely confined to transitory shelters. These constitute harsh living conditions with a multitude of impacts on quality of life, prosperity, and health. The Expo, operating primarily on self-organized undergraduate student teams, demonstrates how innovation in typologies and construction technologies can find solutions to such daunting challenges. Thus, in developing these solutions, the students on the Expo Team directly contributed to the immediate safety of households in Haiti through their aseismic design, which ensured compliance with all locally imposed engineering constraints and international seismic provisions such as ASCE 7-10 and ACI 318-11. Moreover, through their concern for non-engineering constraints to lower the cost of safety for the masses, quality of life within these communities can be affected on a large scale. Because so many were previously priced out of the market for a safe home, this design has been enthusiastically received by the IDP population in Haiti, where hundreds of families have already enrolled in savings programs. For this reason, the project's emphasis not just on the design and construction of prototype homes on campus, but rather on the formulation of a housing system and process, shaped not only the current construction of the first home in Haiti but can empower reliable replication of this process many times over.

For this team of students, who held themselves to a high level of personal accountability considering the end goal of this project, simply reading about the failure mechanisms in the 2010 Haiti earthquake was not enough. Instead, they sought out their own funding to conduct personal reconnaissance in Haiti and other neighboring countries with similar construction practices and lack of code enforcement to reinforce for themselves the existing vulnerabilities in masonry construction and how even thoughtful designs can be compromised in construction due to a lack of quality control or resources. This underscored for them the responsibility of engineers to provide designs that can be executed in light of both the available skill sets and budget. Failure to do so, in this instance, has deadly consequences that can promote dangerous practices, e.g., feeble attempts to execute confined masonry even when having only a fraction of the budget necessary. Ultimately, the end result for all involved was a valuable lesson in how sound engineering judgment and a return to engineering fundamentals was necessary to provide the requisite safety and cost savings.

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Based on their personal reconnaissance in developing countries, the students realized that there is a chasm between the engineering available to these nations and the engineering that is needed to broadly protect their citizens' lives. This project provided tangible evidence of how engineering can close that chasm by being a catalyst for innovation and change, to not just design common typologies but to invent new systems for a unique context. Doing so required a great deal from the students, all of whom voluntarily joined this effort and self-organized to execute various design and prototyping activities. In the process, they learned a valuable lesson: they can be the catalyst that drives a new paradigm that is so desperately needed, not just in Haiti but throughout the world's slums, where a billion individuals vulnerably reside.

Multidiscipline and allied profession participation

The Expo involved over 20 students from nine different majors and minors, primarily hailing from civil engineering. The project receives advisement from the campus institutes for global development, who facilitated student travel to Haiti to meet with major actors in housing at the governmental and non-governmental level and formulate recommendations for formal integration of this housing model in their recovery plans. The program of liberal studies similarly facilitated student travel to Haiti and guided research on community attitudes and adoption barriers for this new housing model, all critical to identifying the many non-engineering constraints that defined the solution space. Finally, the university's master's program in engineering entrepreneurship incubated the business plan for the housing model, including all aspects of market research, finance, and commercialization, under the mentorship of a renowned social entrepreneur. These non-engineering perspectives are not only essential for buy-in and uptake in Haiti for the ultimate goal of building local businesses around building homes but also to build support for this approach to the Haiti housing crisis through marketing and public awareness campaigns.

While the design of the home has technical roots within structural engineering, the realization of this project across the entire

design-build life cycle incorporated other civil engineering subdisciplines, including geotechnical, materials, and most critically, construction/project management. Moreover, as the private sector partners themselves brought a wide array of backgrounds, including civil/structural engineering, architecture, project management, construction management, and accounting, the students benefited from a diversity of mentoring styles, experiences, and skill sets to realize that no problem can truly be solved in a disciplinary silo.

2014 PARTICIPANTS

California Polytechnic State University, San Luis Obispo
College of Engineering
Engineers Without Borders Thailand Micro-Hydroelectric Power Generation System

California Polytechnic State University, San Luis Obispo
Architectural Engineering Department
Linking Multidisciplinary Learning and Practice: The Samè Polytechnic College Master Plan and Schematic Design

California Polytechnic State University, San Luis Obispo
College of Engineering
Sanitation in Sainji

The Citadel
Department of Civil and Environmental Engineering
Wave Dissipation System

Clemson University
Department of Automotive Engineering and Department of Mechanical Engineering
Vehicle Structural Analysis for Automotive Systems: A University Course with Real-World Drive

Cleveland State University
Civil and Environmental Engineering Department
Veterans Memorial Park Slope Stabilization and Handicap Access Improvement

Lawrence Technological University
Department of Civil Engineering
Passing the Torch: The Girls of Vista Maria

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

Ohio University
Department of Mechanical Engineering
HBC Rotary Sifter

Portland State University
Fariborz Maseeh College of Engineering and Computer Science
First Floor Parking Garage Redesign Options

Portland State University
Fariborz Maseeh College of Engineering and Computer Science
Rainwater Harvesting System for Childcare Center

Princeton University
Department of Civil and Environmental Engineering
Learning from Practitioners: Developing Design Skills in an Introductory Mechanics of Solids Course

Rochester Institute of Technology
Kate Gleason College of Engineering
Actively Stabilized Hand-Held Laser Pointer

Rutgers, The State University of New Jersey
School of Engineering
Water Supply for NSCI, Guatemala

Saint Louis University
Parks College of Engineering, Aviation, and Technology
African Vaccine Initiative

Seattle University
Department of Civil and Environmental Engineering
Cooperative Preschool Playscape Design

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

Seattle University
Department of Civil and Environmental Engineering
Seismic Assessment and Retrofit of Two Substation Control Buildings

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

Smith College
Picker Engineering Program
Sustainable Stormwater Management for the Mill River

Texas A&M University–Kingsville
Department of Architectural Engineering
Engineering Campus Development

United States Air Force Academy
Department of Electrical and Computer Engineering
Advanced Concept Energy System

University of Alaska Anchorage
College of Engineering
Fairview Community Recreation Center Winter Stormwater Infiltration System

University of Alaska Anchorage
Department of Civil Engineering
Byers Lake Campground

University of Alaska Anchorage
Department of Civil Engineering
Glenn Highway Capacity Improvement

University of Alaska Anchorage
College of Engineering, Civil Engineering
Northern Access to U-MED District

University of Colorado Denver
Department of Civil Engineering
Fly Over the City

University of Dayton
Department of Civil and Environmental Engineering
Buckeye Motor Speedway

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

University of Kansas
Department of Civil, Environmental, and Architectural Engineering
Innovative Design/Build Pedestrian Bridge in Small Community

University of New Orleans
Department of Civil and Environmental Engineering
Real-World Engineering Project Design Through Professional Engineers and Engineering Student Collaboration

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

University of Texas at El Paso
Department of Civil Engineering
Green Globes Design of the Westside Recreational Community Center

Virginia Polytechnic Institute and State University
Department of Biological Systems Engineering
Downtown Blacksburg Bioretention

Virginia Polytechnic Institute and State University
Department of Biological Systems Engineering
Senior Capstone Design–Stormwater Retrofit to an Apartment Complex

Worcester Polytechnic Institute
Department of Civil and Environmental Engineering
Reducing the Carbon Footprint of Data Centers

PREVIOUS WINNERS

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

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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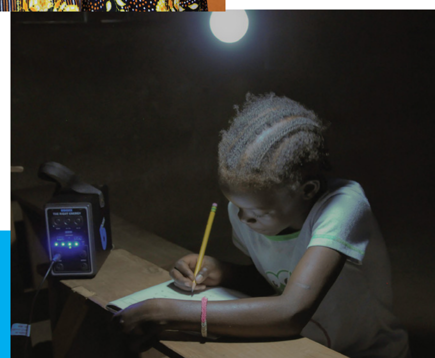

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