Engage. Enrich. Inspire.

NCEES

advancing licensure for engineers and surveyors

NCEES Engineering Award

Connecting Professional Practice and Education

2013

Cover art: Details of display board submitted by Cleveland State University

2013 NCEES ENGINEERING AWARD

Engage. Enrich. Inspire.

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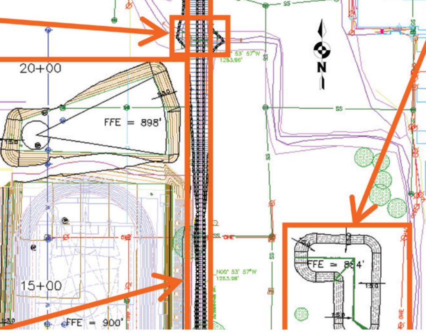
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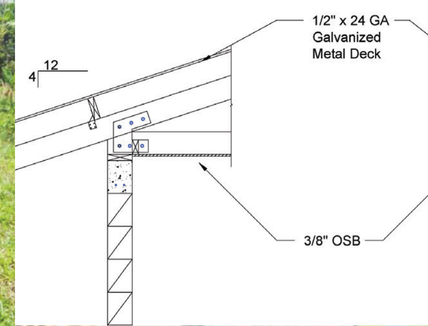
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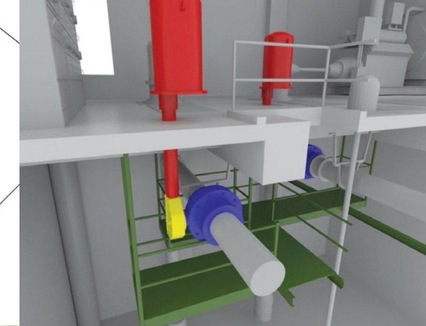

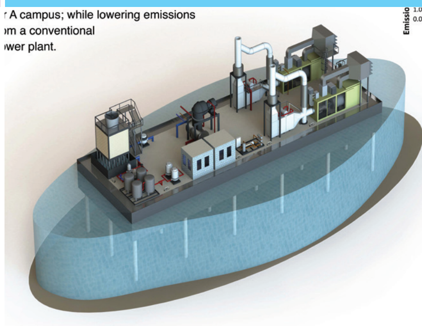
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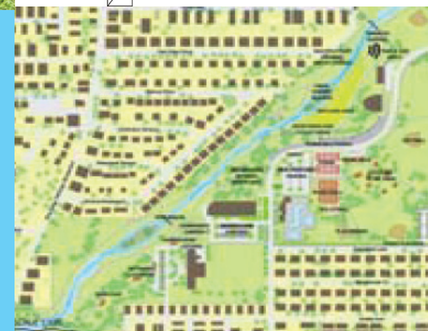

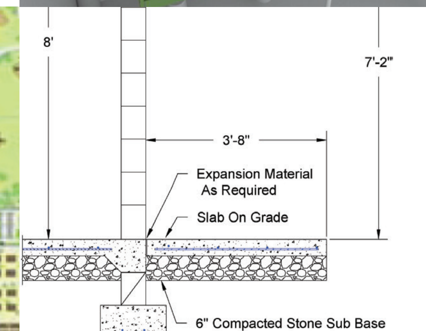
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3'-8"
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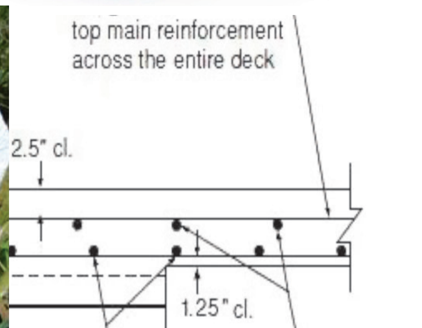
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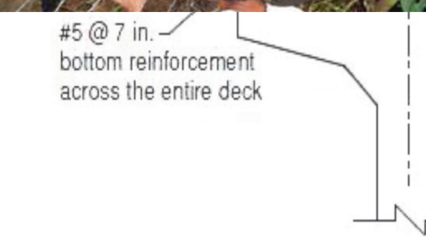
1.25" cl.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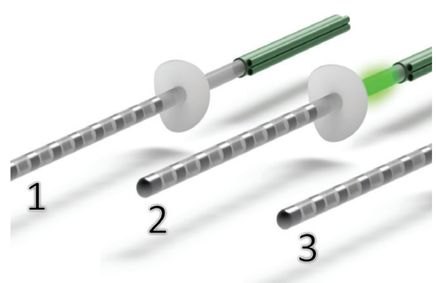
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3

PRESIDENT'S MESSAGE

Since 2009, the NCEES Engineering Award has celebrated engineering programs that bring students and professional engineers together in collaborative activities. These projects engage students by bringing classroom lessons to life and enrich their education with new technical and professional skills. Students increase their knowledge of engineering principles and how to apply them, and they also learn to collaborate with their peers and work with other engineering disciplines and other professions.

These projects are an exciting opportunity to inspire the next generation of professional engineers. Engineering touches virtually every facet of our lives. It shapes the future and makes our lives better and safer. Working with professional engineers teaches students about how licensure—with its emphasis on technical competency and ethical practice—can impact their careers and how it protects the American public.

NCEES thanks the students, faculty, and practitioners who took part in this year's projects, and we commend their efforts to connect professional practice and education. We also thank the jury members for giving their time and expertise to support this initiative.

NCEES has published this book to recognize the 2013 winners, and we hope these projects will inspire other engineering programs to develop collaborations with the professional engineering community.

Patty Mamola, P.E.
2013–14 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, 2013. 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 4, 2013, to conduct a blind judging of the 25 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
- Knowledge or skills gained
- Multidiscipline and/or allied profession participation
- Effectiveness of abstract, project description, and display board

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

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

Norma Jean Mattei, Ph.D., P.E.
Louisiana Professional Engineering and Land Surveying Board

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

Indira Chatterjee, Ph.D.
Associate Dean of the College of Engineering
University of Nevada, Reno

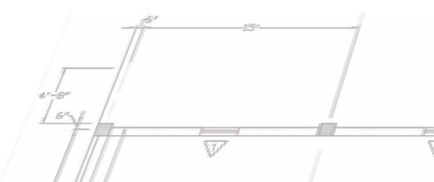
Dennis Irwin, Ph.D., P.E.
Dean of the Russ College of Engineering and Technology
Ohio University

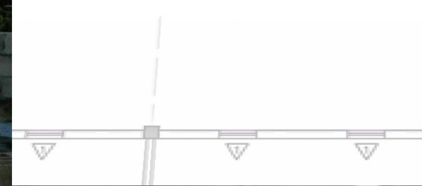
James Nelson, Ph.D., P.E.
Dean of the College of Engineering and Computer Science
University of Texas at Tyler

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

Joseph Sussman, Ph.D.
Managing Director—Accreditation, Chief Information Officer
ABET, Inc.

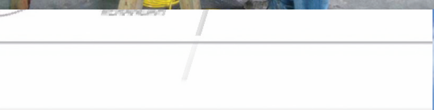
Ronald Welch, Ph.D., P.E., COL (Retired)
Member
American Society for Engineering Education

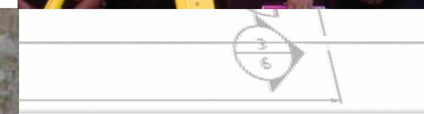





6" CMU WALL
CLASS ROOM


STALL
STALL
STALL
STALL
6" CMU WALLS
RESTROOM
OFFICE





2013 NCEES Engineering Award

$25,000 GRAND PRIZE WINNER

Cleveland State University

Civil and Environmental Engineering Department

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

$25,000 GRAND PRIZE

PARTICIPANTS

Students
Matthew Benovic
Joshua Cmar
Heather Duer
Lina Eadon
Candice Fellows
Anna Florian
Lori Folta
Dan Frehmeyer
Bozana Gazic
Jacob Giel
Joe Gotschall
Maria Hatzigeorgiou
Lauren Hedges
Marie Hornack
Tom Hyatt
Antonia Ivkovic
Tony Janisek
Marissa Jimenez
Amy Kalabon
Selena Kauffman
Zack Kudrna
Andrew Lesak
Kelly Marton
Veronica Newsome
Richard Obratil
Ryan Polder
P.J. Putich
Jenny Safranek
Jeff Schellhammer
Iddrisu Seidu
Ethan Siwik
Alice Sommerville
Benjamin Stafford
Matt Winters

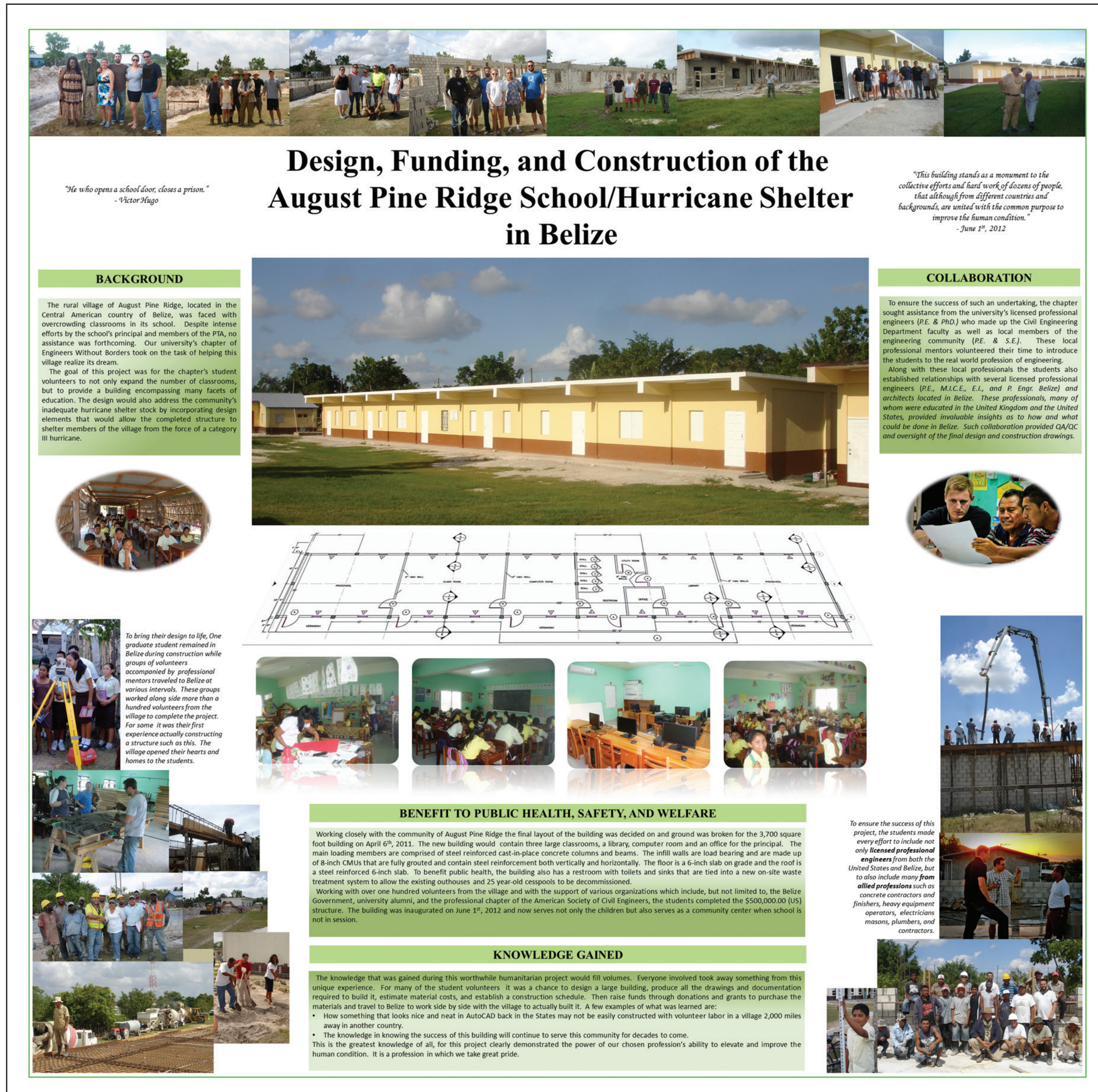
Faculty
Paul Bosela, Ph.D., P.E.
Norbert Delatte, Ph.D., P.E.
Stephen Duffy, Ph.D., P.E.
Lutful Khan, Ph.D., P.E.
John Tomko, Ph.D., P.E.
Mark Tumeo, Ph.D., P.E., J.D.

Professional Engineers and Engineer Interns

United States
Diane Burrowbridge, P.E.
Michael Russell, P.E., S.E.

Belize
Osvaldo Castillo, M.I.C.E., P.Engr
Euring Douglas Walker, C.Engr, M.I.C.E., P.Engr
Simeon Herrera, S.Engr, P.Engr
Robert Manzanero, E.I.
Scott Walker, C.Engr, P.Engr

Additional Participants
Over 100 community volunteers and dozens of allied professional participants, including Abel Flores, Lic. Arch. (Belize)



Cleveland State University

Civil and Environmental Engineering Department

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

ABSTRACT

This project, located in the rural village of August Pine Ridge, Belize, was the first undertaken by student members of the university's chapter of Engineers Without Borders. The goal was to address the insufficient classroom space for more than 400 children attending school. Our student volunteers also sought a solution to the community's lack of hurricane shelter capacity for its population of about 3,000.

Visiting Belize twice during the design phase allowed our volunteers to establish a relationship with the villagers and acquire a feel for what could and could not be accomplished in Belize. Collaborating with licensed professional engineers (P.E., S.E.) from the university's civil engineering department and local structural engineering community at home, the students began the process of designing a structure that would benefit public safety and welfare by providing shelter from winds of a Category 3 hurricane and provide new learning space for the children. After many alternatives were examined, the final design, which was agreed upon by all stakeholders, would total 3,700 square feet and provide three large classrooms, a computer room, a library, and an office for the principal. To benefit public health, the design would also include indoor toilets and sinks integrated into a new onsite waste treatment system that would allow the existing outhouses and 25-year-old cesspools to be decommissioned.

To ensure the project's success, the student volunteers established important relationships with licensed professional engineers (M.I.C.E., P.Engr Belize, E.I.) within Belize. These professionals, many educated and licensed in Great Britain and the United States, provided valuable knowledge as to local conditions. Two in particular, a Belize structural engineer and an allied professional (licensed architect) reviewed the final design documents and stamped the construction drawings. The use of their professional seal indicated their satisfaction that the students had utilized proper engineering methods and followed the requisite codes.

With great fanfare, ground was broken on April 6, 2011. One graduate student volunteered to remain in Belize during construction while several groups of students, accompanied by professional mentors, arrived from the United States to participate in the construction process. Working alongside the students were over 100 volunteers from the community. Also, contributing to the success of the project were allied professional participants that included concrete contractors, licensed electricians, heavy equipment operators, masons and plumbers. Those villagers who were unable to participate directly donated materials and provided meals to the students during their stay. After much hard work, the $500,000 (U.S.) project was completed and inaugurated on June 1, followed by completion of the septic system on August 22, 2012.

The knowledge gained from this experience can easily fill volumes. Students and professionals alike dealt with circumstances one does not find in the United States. Such opportunities would arise and allow everyone involved to gain a new perspective on the profession of engineering. Thus, students, faculty, and licensed professional engineers alike took away something from this experience, including pride in witnessing the awesome power of our chosen profession's ability to elevate and improve the human condition.

JURY COMMENTS

"This project demonstrates the value of collaboration and the challenge of finding improved, local solutions."

"This project really excelled at collaboration between faculty, students, and professional engineers—to include collaborating with engineers in Belize. They also nailed another important focus—the benefit to public health, safety, and welfare."

"There was thoughtful and careful collaboration between professional engineers, students, public, and facility users."





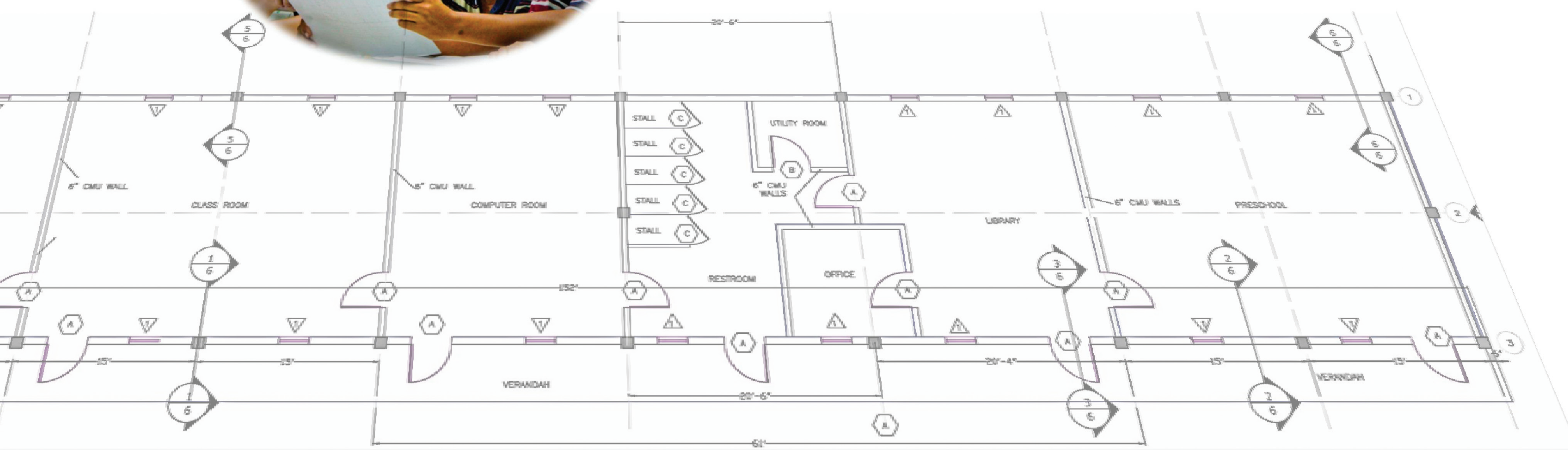

PERSPECTIVES ON

The benefit to public health, safety, and welfare

The safety and welfare of the community was always on the minds of the students, and the welfare of the school children was always first in the minds of the project manager and everyone involved in the project. From the volunteers to the contractors, care was taken to ensure that the building was properly built and would serve the community as a shelter during a Category 3 hurricane.

The knowledge and skills gained

From design through documentation to funding and construction, every student volunteer and faculty member alike learned something new. Those students who worked on the design and went on to construct the school learned the valuable lesson that what looks well and good in AutoCAD drawings doesn't always translate well in the field. This project was engineering on the frontier and back to basics. Even the everyday things one takes for granted in the United States, such as a ready supply of lumber and nails, were only procured after exerting great effort. Working with the community afforded the students and professionals alike a chance to teach new techniques and learn new ones themselves. For example, when the total station malfunctioned and no builder's level was available, the contractor on the job got a length of clear plastic hose,



filled it with water, and taught the students how to use a water level. When faced with similar circumstances, everyone involved was able to gain a new perspective on the profession of engineering.

For the project manager, the chance to see what was designed in the United States brought to life in Belize was a unique experience. During the course of this project, many challenges were dealt with on a daily basis. Only through close collaboration with everyone from the prime minister of Belize to the volunteers from August Pine Ridge was this task completed. Witnessing firsthand the awesome power of our chosen profession's ability to elevate and improve the human condition is something that will remain with many of the projects participants throughout our engineering careers.

Multidiscipline or allied profession participation
Licensed professional engineers and volunteers alone would not have been able to complete a project of this magnitude. Working alongside the students were over a hundred volunteers from the community who donated half their pay to the project, and those who were unable to participate directly still donated materials and kept the students fed. Also contributing to the success of the project were the dozens of allied professional participants that included concrete contractors, licensed electricians, heavy equipment operators, masons, and plumbers. The level of experience and expertise they brought to the project was indispensable in constructing what was designed in the United States into a reality in Belize.




POINTS OF VIEW

Norbert Delatte, Ph.D., P.E.
Mark Tumeo, Ph.D., P.E.
Faculty advisors

This was an Engineers Without Borders project. What do service projects like this add to students' educational experience?
Students often become civil engineers because they want to help the public, but they may not get opportunities during their undergraduate years. A service project gives the students purpose, as well as an opportunity to connect directly with their ultimate customers, the public. For this project, our students could actually meet the students of the August Pine Ridge RC School and hear from them directly how a new school building would improve their education. Engineering accreditation standards require students to develop and demonstrate "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context." There is no better way to learn the positive impact that engineers can have on society than to observe it directly in the eyes of children.

How do you decide which projects to work on?
This was a completely student-driven project. If it had been left to the faculty advisors, we would have selected something much less ambitious for our chapter's first project. However, the students responded to needs expressed by the children and parents of the village. We, as advisors, decided that we could do it—but just barely.

How did this project prepare students for professional practice?
In the classroom, the problems all have neat answers. Real engineering is messy and requires flexibility to overcome difficulties on the fly. In professional practice, the ability to improvise and overcome difficulties is an essential skill. It is also very important for engineering students to get their hands dirty and see how things are built so that they will have an understanding of the importance of constructability and respect for the workers that will execute their visions.

What was the biggest challenge?
It is tempting to say that there are too many to mention, but the biggest challenge was fundraising. It was difficult to raise money fast enough to be able to pay for building materials and other expenses at critical junctures, as well as for the various student groups to travel to Belize. Fortunately, Cleveland State University, the Fenn College of Engineering, and the department of civil and environmental engineering were generous in lending and granting funds to keep the project going.

What advice do you have for other programs wanting to organize collaborative projects?
Have a plan and have 75 percent of the money raised before you start. Organize your network of professionals in the host country—you need to partner with local engineers to get the appropriate reviews and approvals, and you need to partner with local contractors and laborers to provide the skilled labor that you need to supplement the volunteer labor.

How does Cleveland State plan to use its $25,000 prize?
Although the school is now complete, the village of August Pine Ridge continues to have issues with the cost and quality of the water supply. The water is too hard to use for drinking or for many other purposes. We are working on improvements to the water system, and the prize money will be applied to that project.

POINTS OF VIEW

Richard Obratil

CSU student and project manager

How were you involved in this project?
I was involved from the beginning. As an undergrad pursuing my bachelor's of civil engineering degree, I worked with other students to help start Cleveland State University's chapter of Engineers Without Borders. As a graduate student the next year, I worked with three other students to design the school/hurricane shelter. After the project passed its review by EWB, I became the project manager and headed to Belize to oversee the building's construction.

All totaled, I spent 10 months in Belize. The first five months were continuous, and the remainder going back and forth to complete the project. While overseeing construction in Belize, I also developed relationships with organizations both in Belize and northeastern Ohio to provide the funding required to complete the project. During the final year of construction, I became the president of the CSU EWB chapter and had the pleasure of cutting the ribbon upon the dedication of the school.

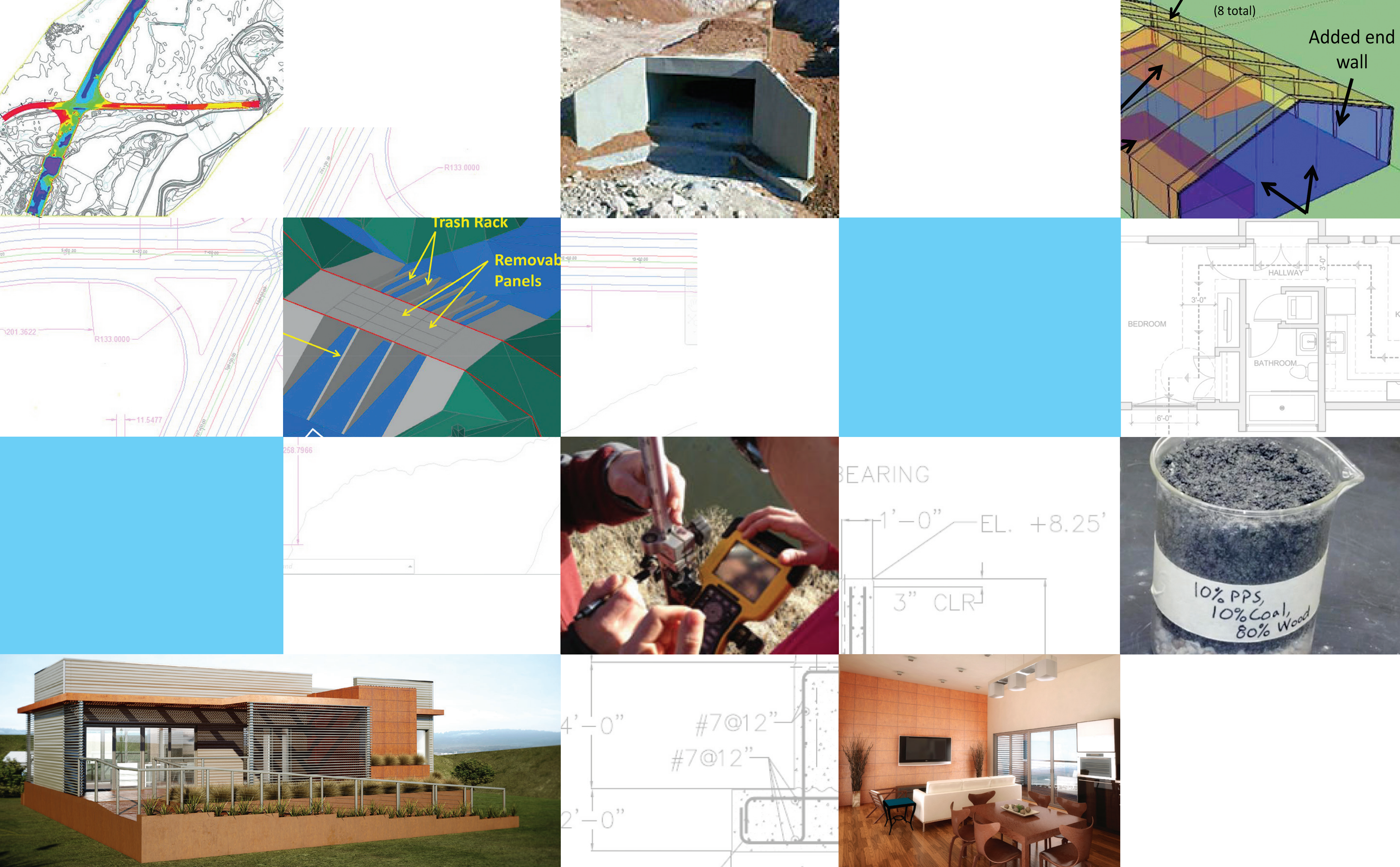
What did you like best about participating in the project?
What I enjoyed the most on this project were the people I had the opportunity to work beside. Not only did the CSU chapter count many exemplary students amongst its ranks, but this project tended to bring out the best in the numerous volunteers. It was really amazing to watch so many people from so many backgrounds come together to accomplish this worthwhile project.

What was the biggest challenge?
The biggest challenge was keeping everybody motivated and moving forward with this project while stretching every donated dollar.

How did working on this project prepare you to begin your engineering career?
Understanding that every problem has many solutions and that all you can do is pick one and move forward. When plan A doesn't work, then it's on to plan B, and so on down the line.

What do you think the engineers learned by working with students on the project?
For some, it was getting back to basic fundamentals, as many of the conveniences of working in the U.S.A. were left behind, and the chance to share their passion for the profession with the students and the community of August Pine Ridge.

Now a CSU graduate, Richard Obratil is project engineer for The Great Lakes Construction Company, which is based in Hinckley, Ohio.


(8 total)
Added end wall
R133.0000
Trash Rack
Removab
Panels
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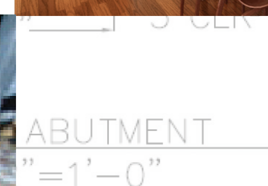
HALLWAY
BEDROOM
BATHROOM
EARING
1'—0"
EL. +8.25'
3" CLR
10% PPS,
10% Coal,
80% Wood
4'—0"
#7@12"
#7@12"
2'—0"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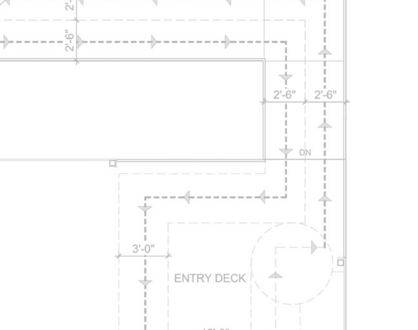
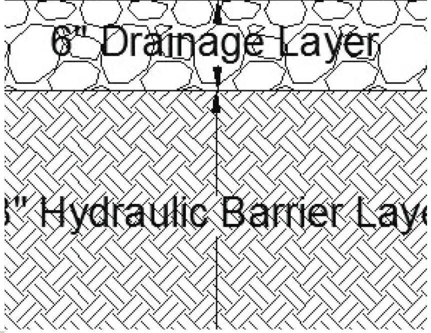




2013 NCEES Engineering Award $7,500 WINNERS

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

$7,500 AWARD

PARTICIPANTS

Students
Amy Anderson
Daniel Hamill
John Jowers
Nathaniel Lail
Gabriel Murray
Annalise O'Toole

Faculty
Terry Baxter, Ph.D., P.E.
Bridget Bero, Ph.D., P.E.
Mark Chopin, Ph.D.
Paul Gremillion, Ph.D., P.E.
Jani Ingram, Ph.D.
Tommy Nelson, MEng, E.I.T.
Wilbert Odem, Ph.D., P.E.
Alarick Reiboldt, MEng, E.I.T.
Charles Schlinger, Ph.D., P.E., PG

Professional Engineers
Matthew Morales, P.E.

Additional Participants
Kenneth Robinson, PG
Pat Pena (SCA Tissue)
Artisan Metal Works
Speedie and Associates

Paper Pulp Sludge Characteristics and Applications

Introduction

A paper mill in the United States Southwest currently produces approximately 40,000 tons of Paper Pulp Sludge (PPS) on a yearly basis. A nearby landfill is operating in a soil deficient environment and uses a fraction of the PPS waste as an alternative daily cover. The landfill accepts PPS at a reduced tipping fee and would suffer financially if forced to bury the excess with incoming municipal solid waste. New uses for PPS are desired by the landfill in order to reduce the amount of material requiring land filling.

Objectives

- Determine specific characteristics of PPS by designing test procedures
- Develop new use for PPS at the landfill

Multidisciplinary Approach

A team of five senior undergraduate environmental engineering students and a senior undergraduate chemistry student worked to complete the project from September 2012 through March 2013. The project managers at the landfill, a licensed environmental engineer and registered geologist, provided information on landfill operations, previously studied characteristics of PPS, and representative leachate composition data. University staff, including five licensed civil and environmental engineers, provided technical support to the students for materials testing, data analysis, and guidance on implementing final designs at the landfill. A PhD chemistry professor at the university provided technical assistance to the team when designing and running custom experiments, and a PhD business professor helped students analyze the financial reality of their final designs. An environmental specialist at the paper mill provided background information on PPS and mill processes. Two outside companies, a metal fabrication shop and a materials testing firm, were subcontracted by the students to aid in project completion.

Paper Pulp Sludge Investigations

The landfill operates in a soil deficient environment and is considering constructing landfill liners and caps made from alternative materials. The goal of investigations was to increase understanding of the material and determine the viability of using PPS in a landfill liner or final cap.

Leachate Interaction

The student team developed leachate interaction testing to determine if virgin PPS could perform as a reactive layer in a landfill liner system. The experiment was designed to quantify the interaction of a mock leachate and PPS. Figure 1 illustrates the batch reaction samples after 72 hours on a shaker table.

Figure 1: Leachate interaction samples

Results from analytical testing on leachate showed anion attenuation, pH buffering, and metal adsorption. In this experiment, conclusive anion attenuation and pH buffering trends were established. Metal adsorption had promising decreasing trends. However, further experimentation is required to determine if PPS can perform as a reactive layer in a landfill liner.

Gas Permeability

Virgin PPS gas permeability testing was conducted to determine the viability of using the material in a landfill cap to retard gas flow. The student team developed test procedures and equipment to model gas flow as laminar groundwater flow. Figure 2 depicts the student team's manufactured gas permeability testing apparatus.

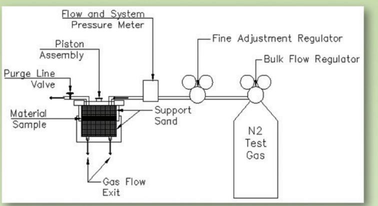


Figure 2: Gas Permeability Testing Apparatus

The results of gas permeability testing on compacted, saturated virgin PPS showed it has a gas permeability of approximately 10^{-5} m/s. A gas permeability of 10^{-9} m/s is typical of cap materials, therefore the student team recommends not relying on virgin PPS to retard gas flow through a landfill cap.

Final Landfill Cap Design

After concluding virgin PPS was not optimal for use as a layer in a final landfill cap/liner, regionally available waste streams were identified for the creation of PPS admixtures. The three materials considered as PPS amendments were coal fly ash, wood ash, and lime. The admixtures were qualitatively and quantitatively evaluated. Based upon results, decision matrices were created to determine the optimal PPS admixtures for use in a landfill cap. Figure 3 illustrates the granular and cohesive admixtures chosen for a final cap design.

Figure 3: PPS Admixtures

Figure 4 illustrates a profile of the final landfill cap design. The final cap created for the landfill consisted of an erosion layer, random fill layer, drainage layer, and hydraulic barrier layer. In combination, these layers meet all landfill and regulatory requirements. A cohesive PPS admixture (43.5%PPS, 43.5%Coal Fly Ash, 13%Wood Ash) functioned as a hydraulic barrier layer and a granular PPS admixture (80% Wood Ash, 10%PPS, 10% Coal Ash) functioned as a random fill layer.

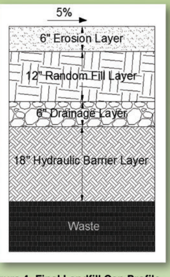


Figure 4: Final Landfill Cap Profile

Conclusion

A final cap design was developed using PPS as a major constituent. A hydraulic barrier layer (43.5% PPS, 43.5% coal ash, 13% wood ash) and random fill layer (80% wood ash, 10% PPS, 10% coal ash) were created for use in the final cap. The cap is expected to meet all landfill and regulatory requirements. In addition, cap materials will cost $8.3 million less per 100 acres than the existing landfill design. A total of 68,000 tons of PPS will be removed from the landfill for use in the cap, increasing the life of the landfill by approximately three quarters of a year.

Northern Arizona University

Department of Civil Engineering, Construction Management, and Environmental Engineering

Paper Pulp Sludge Characteristics and Applications

ABSTRACT

A landfill in the southwest United States requested an investigation into the characteristics of paper pulp sludge produced at a nearby recycling paper mill and the development of new uses for the sludge at the landfill site. A student team comprised of five senior undergraduate environmental engineering students and one senior undergraduate chemistry student accepted the project and completed their work in April 2013. The student team collaborated with project managers at the landfill, an environmental specialist at the paper mill, and various staff at their university to complete the project. Students subcontracted work when necessary to an outside materials testing firm and metal fabrication shop.

The student team conducted a literature review of the paper sludge to determine a portion of the requested material characteristics. Further laboratory testing was completed for leachate-pulp interaction mechanics, gas permeability, and structural characteristics. Students determined the paper sludge was able to adsorb anions, some cations to a lesser extent, and possessed some pH buffering capacity. Testing further showed the material had gas permeability approximately equal to 2.36 mm to 4.75 mm clean sand. Geotechnical testing indicated the paper sludge had low strength, high water content, and was extremely plastic, among other traits.

Based on this literature review, material testing, and discussions with the landfill's project managers, a landfill cap was chosen for development. Paper pulp sludge admixtures were created using Class F coal fly ash, wood ash, and lime to produce viable landfill cap materials. Admixtures of class F coal fly ash, wood ash, and paper sludge were combined to create a hydraulic barrier layer (43.5% paper pulp, 43.5% coal ash, 13% wood ash) and random fill layer (80% wood ash, 10% paper pulp, 10% coal ash).

A final cap design was developed based on federal regulations and the needs of the landfill's facility closure plan. Material cost analysis shows savings of $8.3 million if the paper pulp sludge-based hydraulic barrier and fill materials are used in place of a 60 mil HDPE liner and 2.5 feet of imported soil. Cost savings include freed airspace gained by using 68,000 tons of paper sludge in the cap rather than ultimately burying it with incoming municipal solid waste.

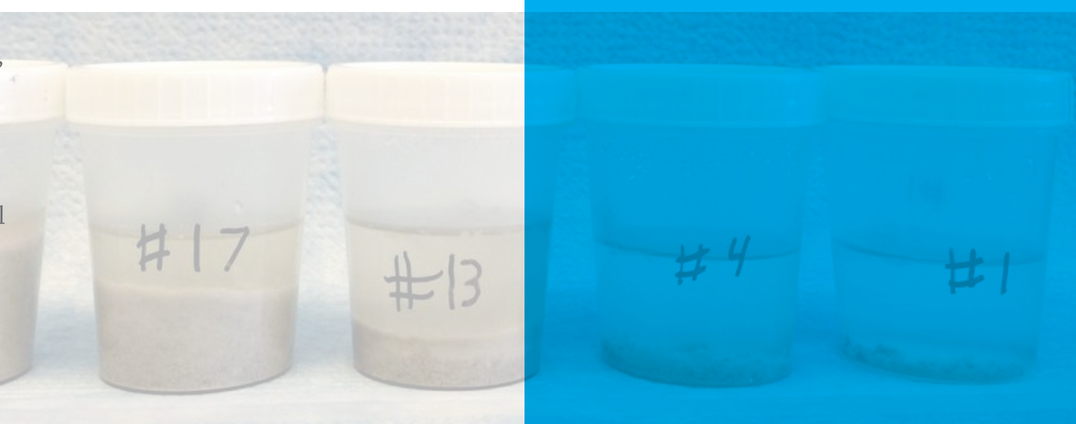
Currently, landfill managers are reviewing the findings and recommendations of the student team. Recommendations include an outlined plan for further testing and final implementation of the cap design. Laboratory testing is recommended to determine if contaminant leaching occurs from the created cap materials. Implementation of the cap can only be completed once local government and state regulatory approval is obtained. Test plots are therefore recommended to be constructed at the landfill and monitored to determine the performance of the design.

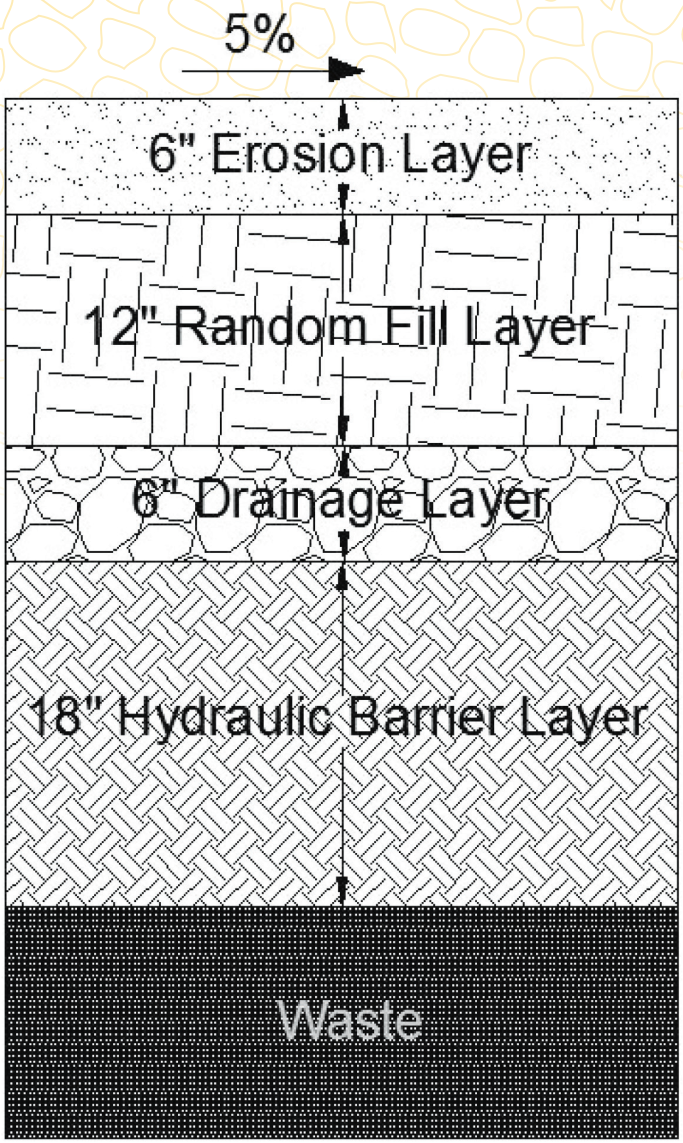
JURY COMMENTS

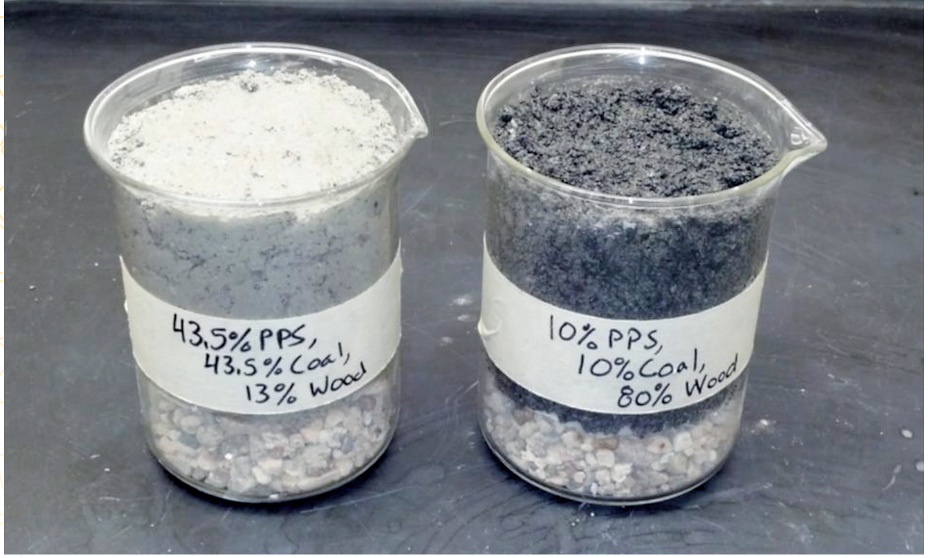
"This project excelled in presenting students with a challenging project that would rely on bench-scale testing and conversion of waste material into a useful engineering material. Such effort is a benefit to society and protects public health and safety."

"A very innovative project that, astoundingly, resulted in an ingenious invention through the collaboration of engineers and scientists"

"A good solid project with a well-written description"







PERSPECTIVES ON

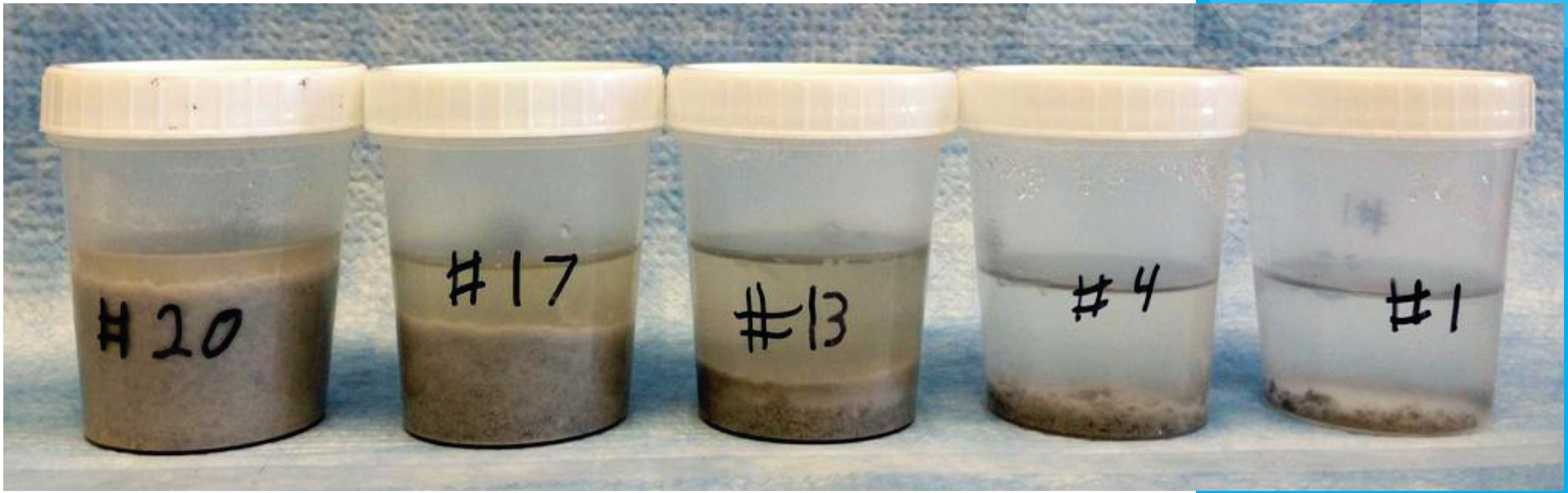
The benefit to public health, safety, and welfare

Landfill caps are designed to protect the general public from the spread of disease and unwanted odors while reducing the production and migration of leachate. Disease is a concern with municipal solid waste due to the large amount of birds and other wildlife that typically frequent a landfill. The cohesive layers developed by the student team provide an adequate barrier to wildlife and reduce the danger of diseases spreading. Further, the low gas permeability of the clay-like hydraulic barrier layer, on the order of 10^{-10} m/s, is expected to reduce the flow of odors from decomposing waste while settling with the landfill over time.

The hydraulic barrier layer also displayed a low hydraulic conductivity of approximately 10^{-7} cm/s at 50 cm of head. A low hydraulic conductivity is necessary to prevent water infiltrating the landfill and forming leachate, a hazardous substance with the ability to migrate out of the landfill and contaminate surrounding groundwater. As the landfill is a grandfathered installation with no liner to prevent the migration of leachate, a cap with a low hydraulic conductivity is necessary to protect the surrounding environment from excess leachate migration.

Multidiscipline or allied profession participation

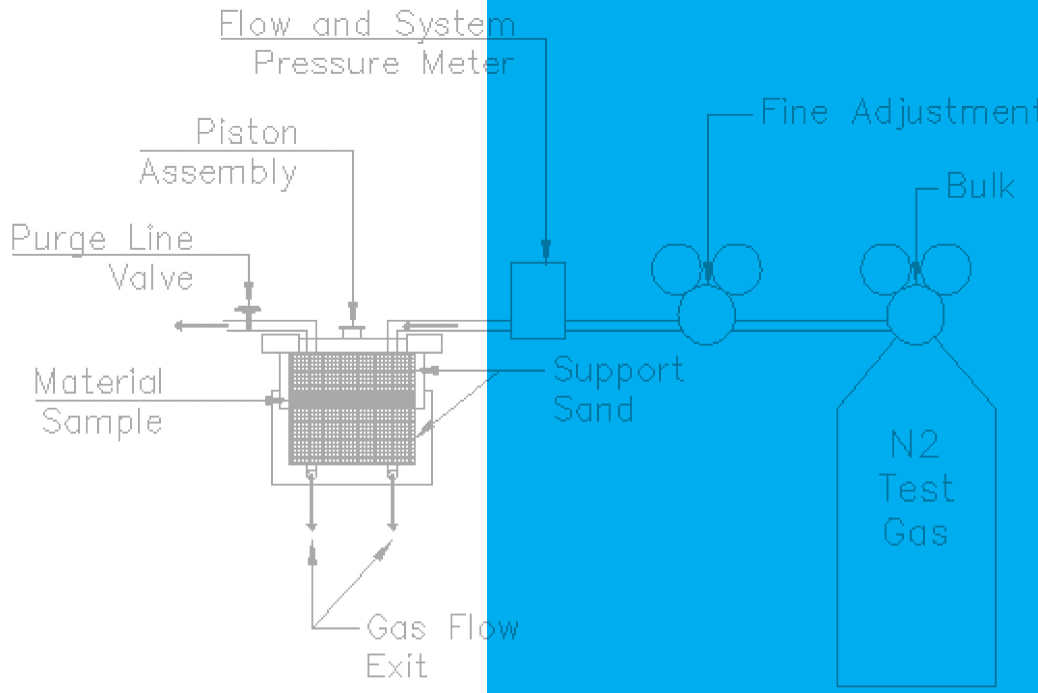
Project completion involved a multidisciplinary team consisting of college students, civil and environmental engineers, an environmental specialist, and experts in the fields of geology, chemistry, and business. The student team itself consisted of not only environmental engineering students but a senior-year chemistry student as well. The contributions of the civil and environmental engineering professionals included providing technical expertise in the fields of materials testing and design analysis, information on landfill processes, and guidance on implementing developed cap designs in the real world. The environmental specialist from the paper mill supplied information on plant



processes and known PPS characteristics. The geologist landfill project manager and Ph.D. chemistry professor supplied key information used in testing leachate and PPS interaction mechanics. Additional analysis by a Ph.D. business professor allowed the student team to develop a fiscally realistic plan to market and implement their final design.

A local metal fabrication company and a materials testing firm subcontracted by the student team were other key contributors to the project. To finalize gas permeability apparatus designs and construct the final test equipment, students approached an employee at the metal fabrication plant for guidance. This employee was instrumental in constructing the gas permeability testing apparatus that led to successful project completion. Due to the tight project timeframe, the students subcontracted geotechnical testing of virgin PPS to a local materials firm. Members of the firm worked with students to identify which tests were applicable to the project and could be completed within the available time.

Results of this multidisciplinary collaboration allowed the student team to successfully finish their project and deliver a viable final solution to the landfill. The student team chose to also submit their work to the New Mexico State University WERC competition, where they were awarded the Freeport-McMoRan Copper and Gold Award for Innovation in Sustainability.



$7,500 AWARD

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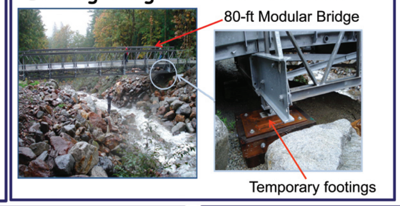
Design Options for a Creek Crossing for a Utility Company

Project Description

In order to access its critical communication towers located within a national park, a utility company currently uses a prefabricated, modular steel bridge that is supported on temporary timber supports. The utility company requested the senior design team to carry out structural designs for two alternative permanent creek crossings.

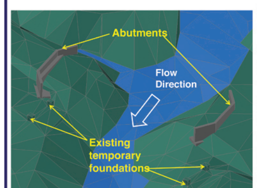
Existing Bridge and Site Condition



Scope of Work & Deliverables

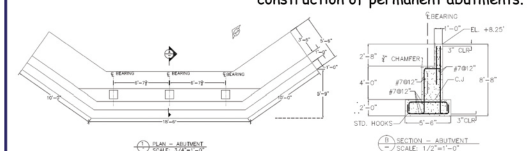
- Written Proposal (submitted in Dec '11)
  - Tasks, deliverables and milestones
  - Schedule and budget
- Final Design Report (submitted in June '12)
  - Design drawings & calculation package
  - Preliminary construction sequence
  - Design specifications for materials and procedures
  - Construction cost estimates
  - Recommended preferred alternative

Option 1: Design Permanent Abutments for Existing Bridge



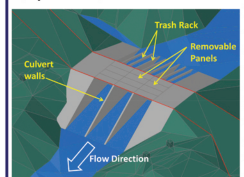
Design Features

- Existing modular steel bridge can be re-used on proposed reinforced concrete abutments.
- Proposed new crossing location (30 feet upstream) is narrower; therefore bridge span need not be increased.
- New location provides more free board thus reducing the potential of bridge damage during major runoff events.
- Existing bridge can provide access to communication towers during construction of permanent abutments.



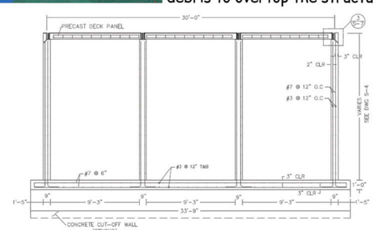
Plan View of Abutment   Sectional View of Abutment

Option 2: Vented Ford Design



Design Features

- 3-culvert structure replaces existing steel bridge.
- Components include reinforced concrete precast road panels, culvert walls, bottom slab and steel trash rack.
- Road panels are removable to provide access for debris cleanup.
- Steel trash rack upstream facilitates debris to overtop the structure.



Cross-Sectional View of Vented Ford

Multidisciplinary Features

- **Hydraulic Analysis**
  - carried out preliminary analysis to determine depth of flow and free board of crossing
- **Geotechnical Analysis**
  - carried out stability analysis of bank slopes & abutment walls, bearing capacity of soils
- **Site Development**
  - carried out cut and fill analysis and regrading
- **Environmental Issues**
  - considered breeding season of wildlife to define an optimum construction window
  - mimimum impact on natural environment
- **Permit Requirements**
  - researched Federal, State, county and city permits applicable to the project.

Cost Estimates and Cut-Fill Quantities

	Option1	Option 2
Cost	$120,000	$114,000
Cut	2200 cu. yd	1180 cu. yd
Fill	1470 cu. yd	290 cu. yd

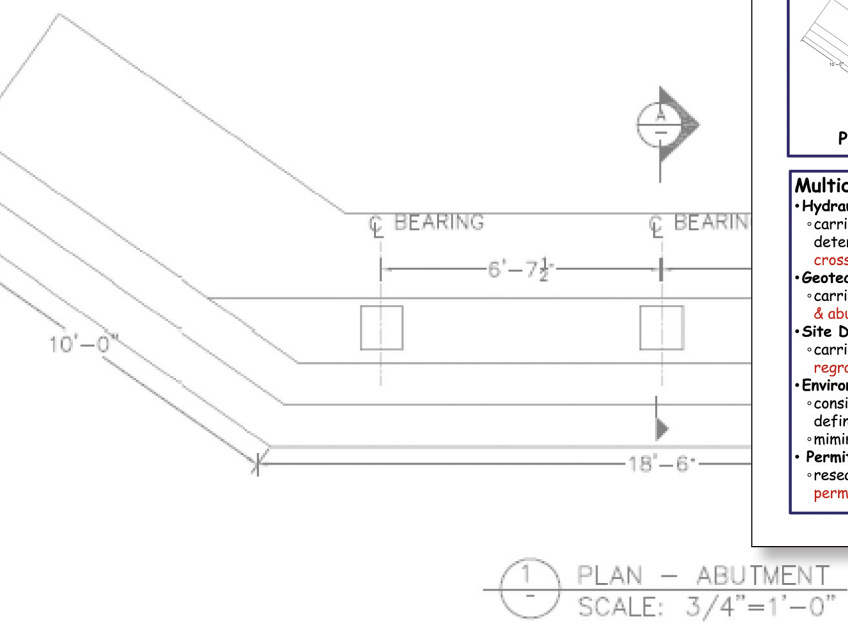
- **Cost Estimate** Excludes labor costs. Option 1 includes the cost of the prefabricated steel bridge

Recommended Option

- Vented Ford Crossing preferred due to lower cost, easy maintenance, better ability to withstand debris flow.

Knowledge and Skills Gained

- **Technical Skills**
  - Working knowledge of 2012 International Building Code, 2010 AASHTO LRFD Bridge Design Specification, Naval Facilities Foundation Design Manual, County Codes, Drafting Standards, AutoCAD 2010, and Construction Specifications
  - Cost Estimation using RSMeans and Sponsor's unit costs.
- **Communication Skills**
  - Oral presentations to class, to professional engineers from department advisory board, to sponsoring company and at local professional society meetings.
  - Developed technical writing skills through proposal, final report, technical memos and emails.
  - Worked closely with professional engineers, a project manager from the utility company, and a technical writer
- **Project Management and Leadership skills**
  - Prepared agenda and managed meetings, followed up on action items; managed schedules and budgets; worked as a team.



Seattle University

Department of Civil and Environmental Engineering

Design Options for a Creek Crossing for a Utility Company

ABSTRACT

All engineering students in our department are required to complete a team-based, nine-month long, real-life senior design project. A utility company approached our department requesting that one of our capstone teams design a crossing for a creek. The crossing allowed maintenance crew access to communication towers managed by the utility company. Currently, a modular steel bridge placed on concrete blocks serves as a temporary crossing. The company wanted the team to provide them with two crossing options: the first option had to reuse the modular bridge placed on permanent supports and the second option had to be an entirely new crossing design. Furthermore, the team was asked to recommend a preferred option.

A team of four students worked under the supervision of a licensed professional engineer and a project manager from the utility company and a faculty advisor who is also a licensed civil engineer to develop the design options. In fall quarter, the team prepared a written proposal to the utility company outlining the scope of work, list of tasks, deliverables, schedule, and budget. The team spent the winter and spring quarters carrying out the structural design of the crossings.

The first option for the crossing consisted of moving the existing modular bridge 30 feet upstream to higher ground where the creek width is narrower than its current location. Preliminary slope stability analysis showed that the relocation minimized bank instability issues. In addition, the existing modular bridge could provide access to towers during construction of the new crossing. The team designed the abutments and the wing walls for the modular bridge. The second option involved a vented ford crossing, which is a concrete culvert with three openings and a trash rack at the upstream end to clear the debris over the structure. The ford crossing was designed such that in the event of a storm event involving large debris, the structural members could be disassembled, the system cleaned up, and the crossing reassembled. The team prepared a final report describing the design options and the preferred alternative, including the AutoCAD drawings, construction cost estimates, and design calculations for both options.

In addition to the structural and geotechnical analyses, the team was exposed to other aspects of the project. The team performed a preliminary hydraulic analysis to ensure the new designs could handle the anticipated floods. The crossing was located in a national park, and the team had to consider the relevant federal, state, county, and city permits. The site was a breeding ground for marbled murrelet and spotted owl. Therefore, the team had to take the breeding period into account when recommending a construction window to the utility company.

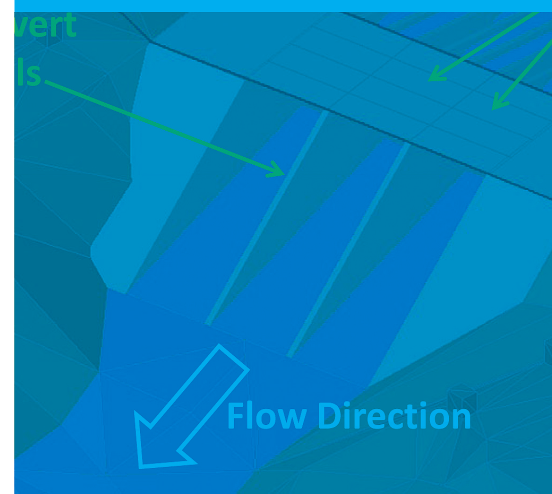
Throughout the academic year, the team had separate weekly meetings with the faculty advisor and the company liaison. Each team member served as the project manager during the year, running meetings, setting agendas, assigning tasks to members, and following up on action items. The team made multiple presentations to the class, the utility company, the departmental advisory board, and at professional society meetings. The project strengthened the team's ability to apply their technical knowledge to a practical problem, to work as a team, to communicate effectively, to develop and hone professional and leadership skills, and to meet the client's needs.

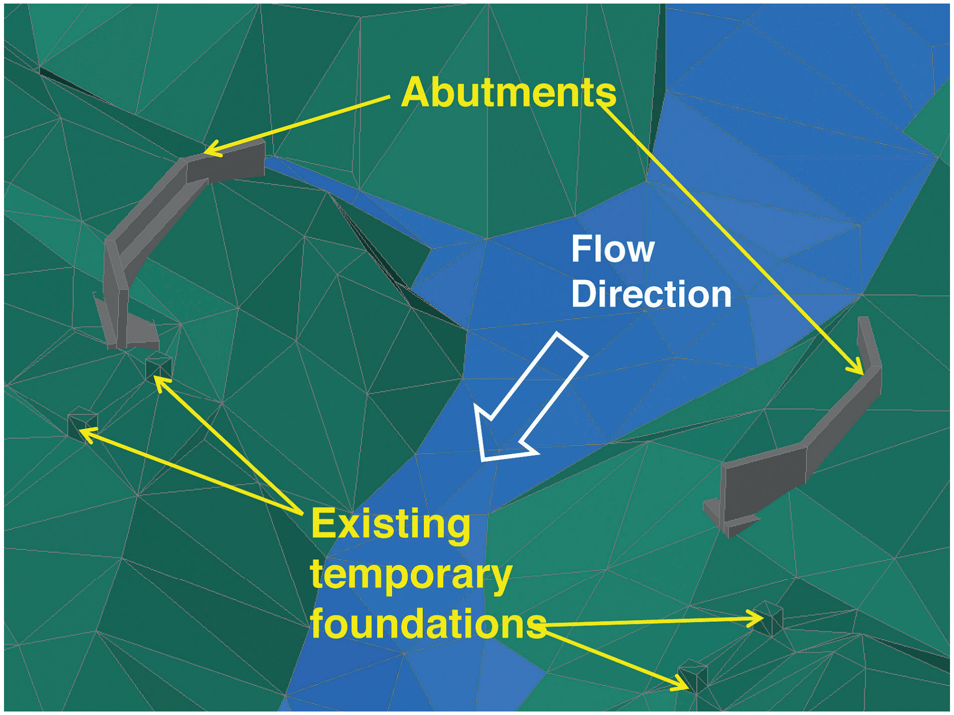
JURY COMMENTS

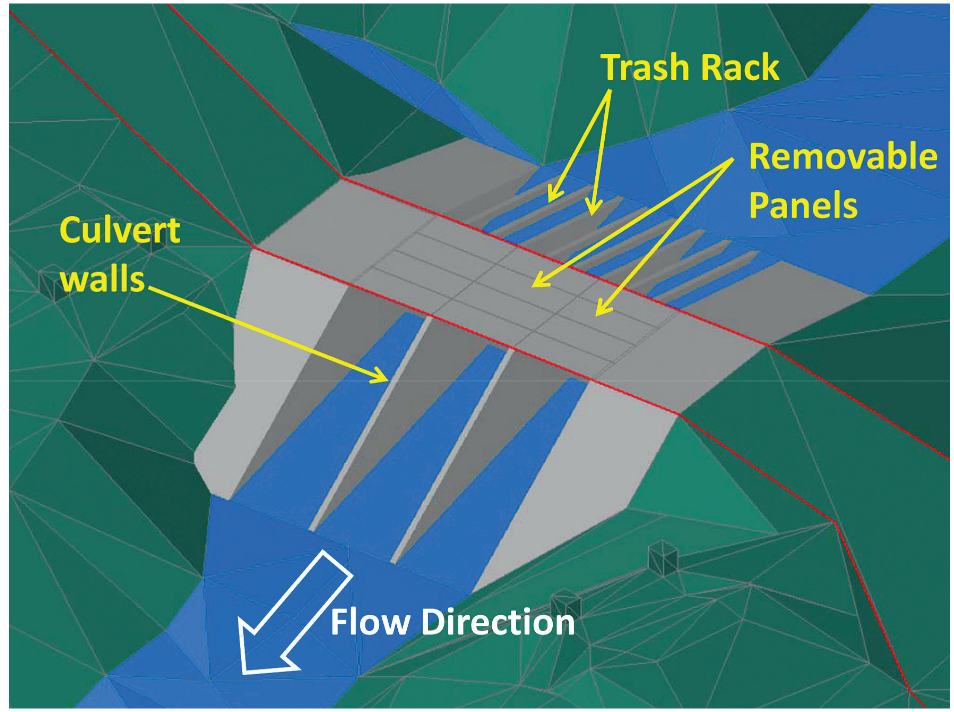
"A good real-world project that combined structural and geotechnical issues as well as environmental and permitting"

"Excellent project presentation with clear project alternatives"

"A well-defined and timely execution of a real problem confronting the U.S. manufacturing/distribution infrastructure"







PERSPECTIVES ON

The collaboration of faculty, students, and professional engineers
A diverse group of four students worked on this project under the supervision of a liaison engineer from the sponsoring agency and a structural engineering faculty member from the university, both licensed professional engineers. In addition, the senior design course is taught by a faculty member who is also a licensed professional engineer and served as a geotechnical engineering consultant to the team. The students met weekly with the faculty advisor and with their sponsor liaison. The faculty members and the liaison provided feedback on the proposal and report throughout the academic year.

Our department has an active advisory board consisting of about a dozen licensed, local civil engineering practitioners that meets quarterly to provide feedback on curriculum, future growth, and other industry-academic issues. The team made an oral presentation to the board in early winter quarter describing their project scope and plan of action. Two of the advisory board members provided critical feedback on the final drafts of the proposal and report. The students were required to address their comments when finalizing these documents.

In fall and spring quarters, the team presented their work to the company. Diverse groups of professionals attended these presentations. The students found these presentations to be quite challenging due to the extensive knowledge and experience of the audience and the questions asked. But they agreed that it was a great career growth experience.

Our department hired a professional technical writer during the fall quarter to help the team with the proposal preparation. The technical writer worked closely, meeting with the team frequently and providing critical feedback on several drafts of their proposal. This resulted in a high quality deliverable to the company.

The knowledge and skills gained
The project enabled the students to develop the following: technical skills, oral and written communication skills, project management and leadership skills, and the ability to work in a team setting and to interact with clients.

Technical skills: The students learned how to take a project from brainstorming stage to final design. During this project they acquired the skill to use the following tools:

> Design manuals: 2012 International Building Code, 2010 AASHTO LRFD Bridge Design Specifications, Naval Facilities Design Manual for Foundations and Earth Structures
> County design codes and drafting standards
> Software: SAP2000 for the determination of internal force demands

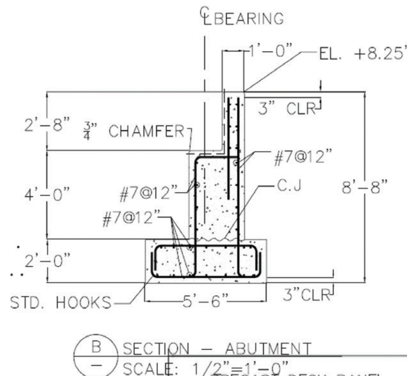
> Computer-aided drafting (AutoCAD 2010): The company conducted training sessions on their standard drafting practices so that the deliverables met company standards.
> Standard specification of materials and construction procedures

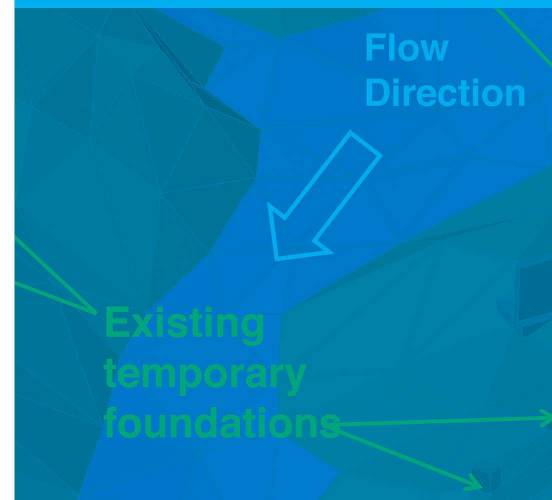
Students have had limited exposure to these design manuals, codes, and software in their classes. But they had the opportunity to work with them intensively on the project with the help of the faculty advisor and the liaison engineer.

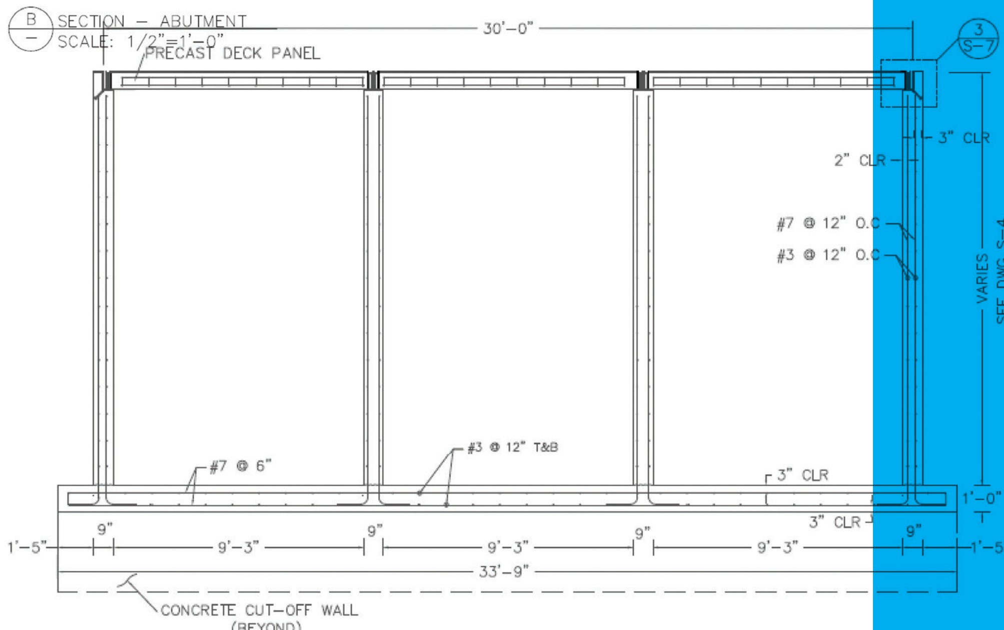
Communication skills: The students submitted a written proposal to the sponsor at the end of fall quarter, outlining their understanding of the project, scope of work, plan of implementation, and schedule. At the end of spring quarter, they submitted a final report describing the work done, engineering drawing, calculation, and other deliverables requested by the sponsor.

The students were required to make formal oral presentations to their peers twice a quarter. Every student was required to make at least one presentation each quarter. In addition, students presented their proposed work to the company sponsors at the end of fall quarter. They presented their final design to the company at the end of spring quarter. The academic year concluded with a major event on campus where the team presented its work to the entire university community, sponsors of all the various senior capstone projects, prospective sponsors, friends, family, and alumni through oral presentations and a poster session.

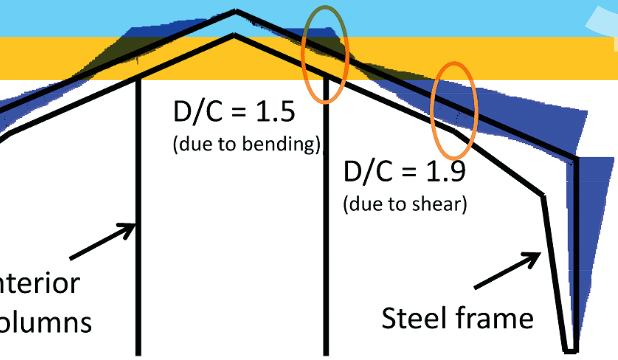
Project management and leadership skills: The student team met with the faculty advisor and the liaison each week. Each team member served as the project manager for part of the academic year. The project manager was responsible for setting up the team meetings, developing the meeting agenda, conducting the meetings, assigning tasks, and following up on action items. He or she was also responsible for contacting the liaison and the faculty advisor in between team meetings, when needed. The team provided formative feedback through the course instructor to the project manager.







$7,500 AWARD



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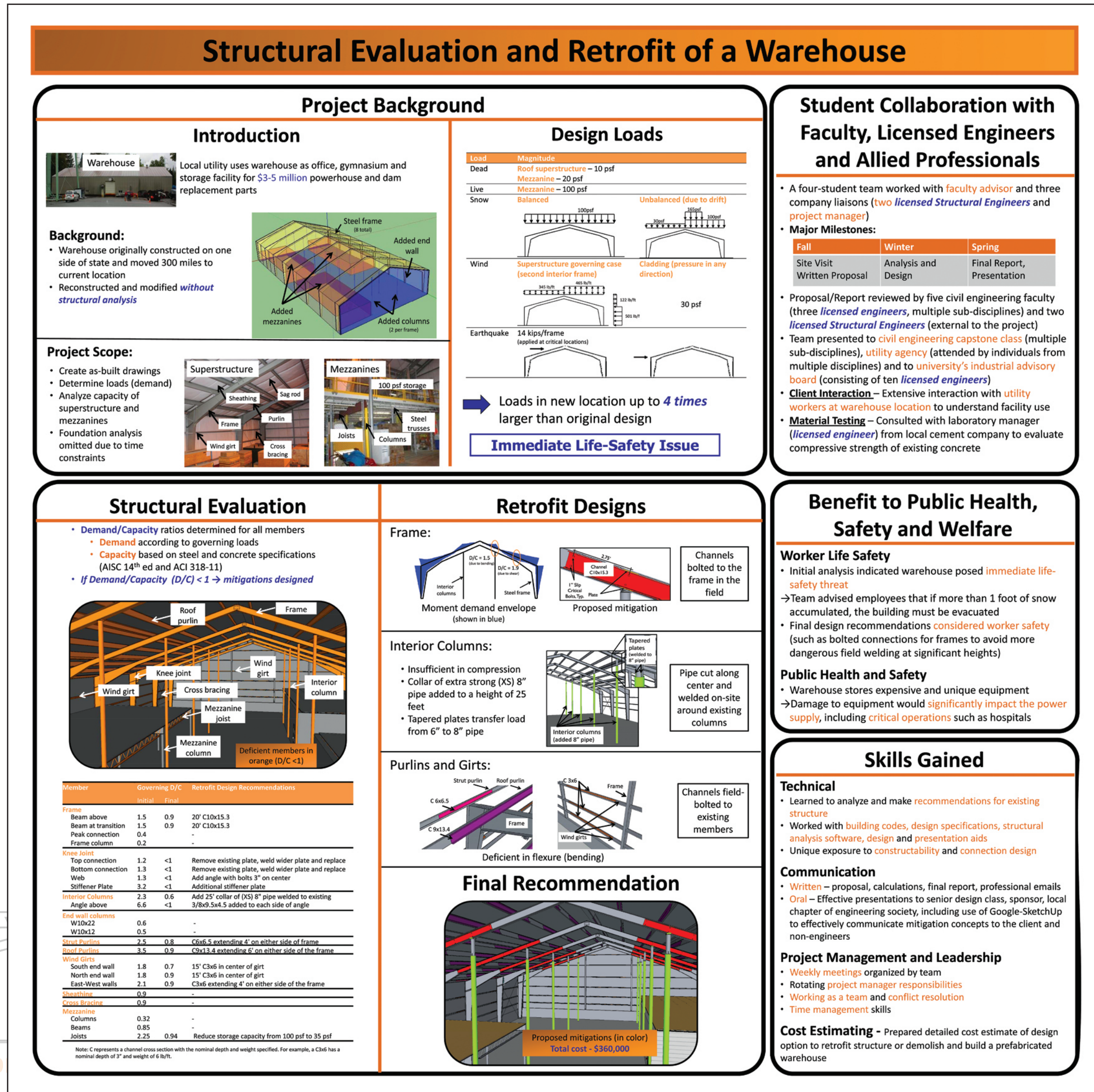
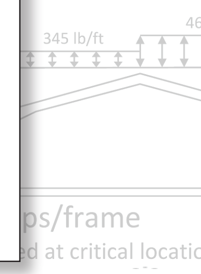




Seattle University

Department of Civil and Environmental Engineering

Structural Evaluation and Retrofit of a Warehouse

ABSTRACT

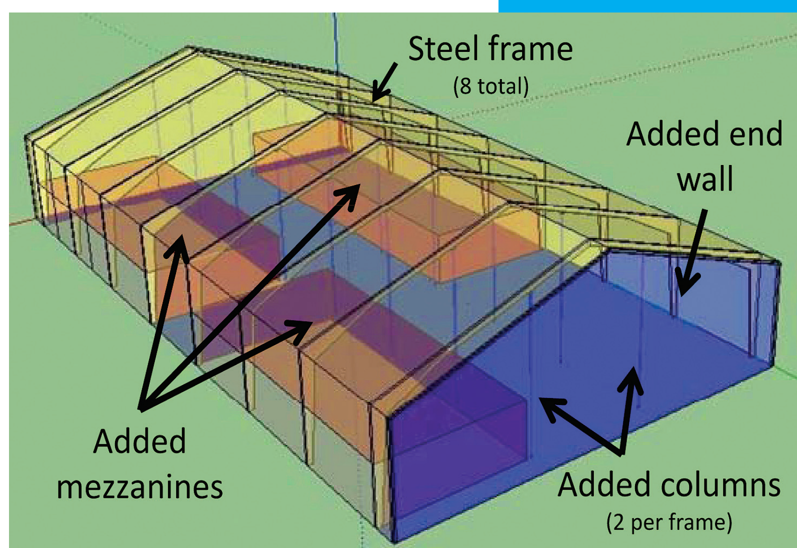
A local utility company requested our university's capstone program to perform the structural evaluation and retrofit designs of a warehouse that is not up to current codes and poses a life-safety threat to its employees. Working closely with two licensed structural engineers (S.E.s) from the company and a faculty advisor, a four-member student team analyzed the building based on current design codes and found multiple structural deficiencies. The final project deliverable was a report detailing these deficiencies, retrofit designs, and a comprehensive cost analysis.

The warehouse functions as an office, gymnasium, and storage facility of key replacement parts for the utility company's powerhouses and dams. It was originally constructed 300 miles from its current location and later moved and reconstructed at the project site. During reconstruction, multiple modifications were made without adequate structural analysis. As a result, at the beginning of the project there were no as-built drawings of the structure and much was unknown about the building's structural stability, strength, and stiffness. At its current location, the loads are considerably higher (up to four times greater) than those for which the building was designed.

The project began with a site visit and creation of as-built drawings. Next, the design loads were determined according to current building codes. Finally, a structural analysis was performed and retrofits were designed. Many deficiencies were identified, including the frames, interior columns, flexural beams (girt and purlins) and the mezzanines. Retrofit designs considered numerous constructability issues, such as the remote site location, severe winter weather, and the impact of construction on day-to-day operations at the warehouse.

The team performed a cost analysis that considered two design options: (1) to retrofit the existing warehouse based on the retrofit design concepts and (2) to demolish the building and purchase a new, prefabricated structure to replace it. The total estimated costs of the two options were $360,000 and $1.2 million, respectively. Based on these data, the team recommended that the utility retrofit the warehouse.

Students met weekly with their faculty advisor and the sponsoring company liaisons. The team's design calculations were reviewed by the faculty advisor, company liaisons, and two other licensed structural engineers. Project highlights included exposure to constructability issues and professional presentations to their peers, the utility company (including licensed engineers from various disciplines), and a local chapter of a professional society. The team also learned to use Google SketchUp to effectively communicate their mitigation concepts to the client and non-engineers. 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.

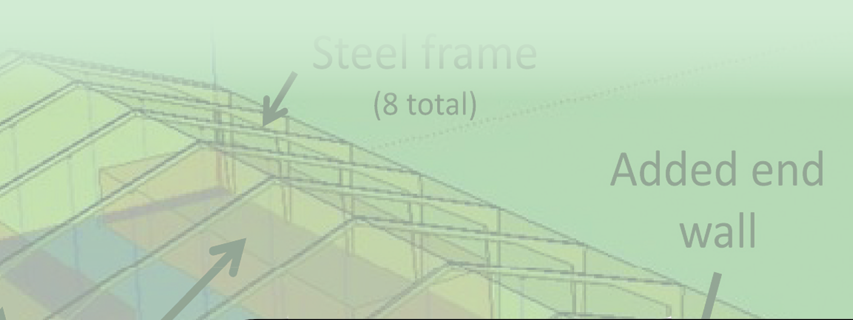


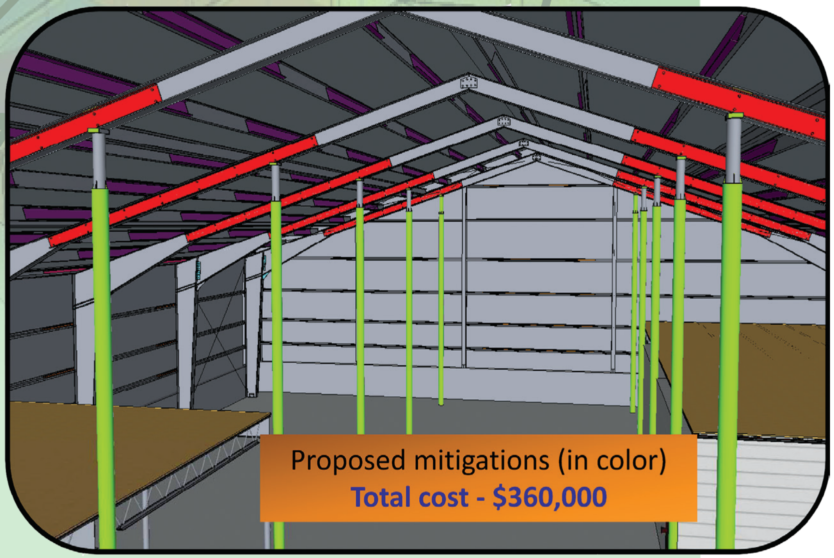
JURY COMMENTS

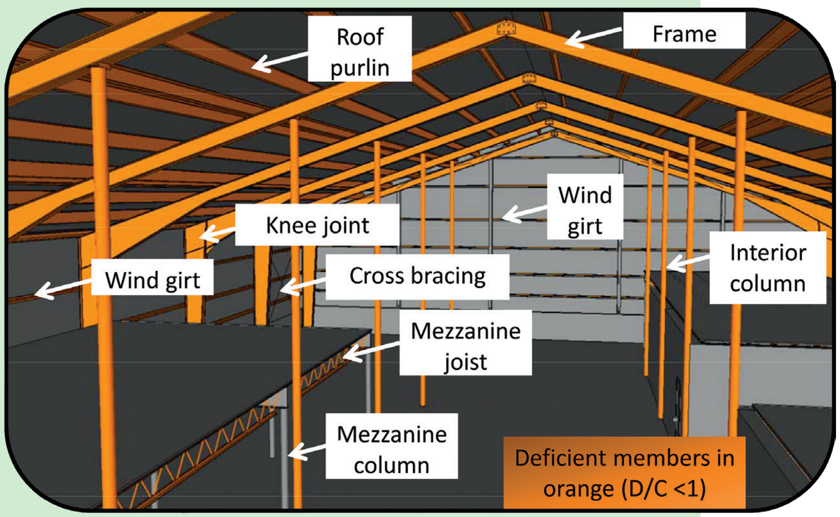
"Retrofitting is something that is becoming more prevalent in the United States, and steel building designs and projects are often the subject for disciplinary infractions. These students learned very valuable skills that will translate into practice."

"A well-defined, specified, and communicated project. It was an extremely solid project."

"A very realistic project that engineers face daily"







PERSPECTIVES ON

The collaboration of faculty, students, and professional engineers

At our institution, senior civil and environmental engineering students are required to complete a year-long, real-world, capstone design project. A diverse team of four students was assigned to this project, working under the guidance of a faculty advisor and three company sponsor liaisons, two of whom were licensed structural engineers 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. The student team held weekly meetings with their faculty advisor and company liaisons. They gave two presentations to the sponsor—one in the fall detailing the proposal and one in the spring explaining the final design. These presentations were attended by other licensed professional engineers (P.E.s) and project managers from the sponsoring company.

The team also interacted with licensed professional engineers outside of the sponsoring company. The team's proposal and final report were reviewed by two external licensed structural engineers. They also gave a presentation at the local ASCE chapter in the spring.

The benefit to public health, safety, and welfare

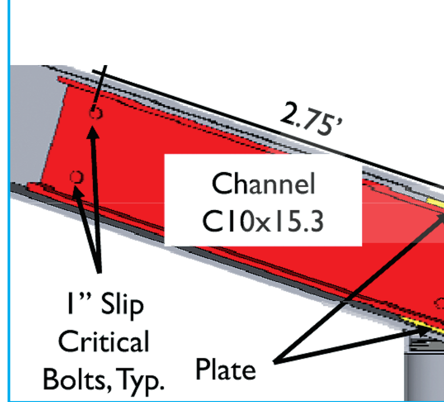
Worker life-safety: The warehouse poses life-safety concerns for utility workers. Preliminary analysis indicated that the structure would be in danger of collapse if subjected to excessive snow loads. The team immediately contacted the workers using the facility and advised that if snow in excess of 1 foot accumulated on the building, it must be evacuated. All designs considered worker safety. For example, bolted connections were designed for the frames since field welding at significant heights is difficult to accomplish on ladders.

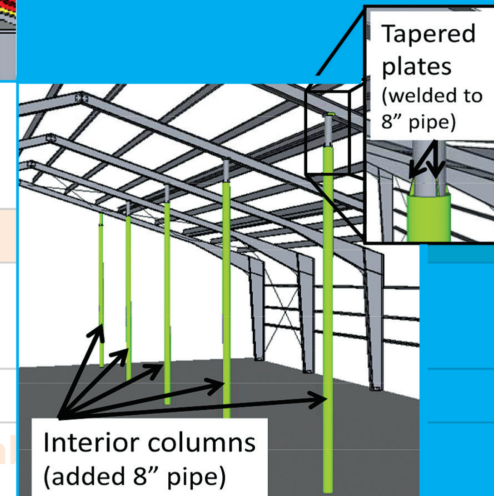
Public health and welfare: The warehouse is used to store $3 to $5 million worth of utility-owned equipment for the maintenance of dams critical to the power supply of a large city. Some of the equipment stored is unique and, if damaged, cannot be replaced for many months. Therefore, damage to the equipment would significantly impact the power supply to a large city, including critical operations such as hospitals.

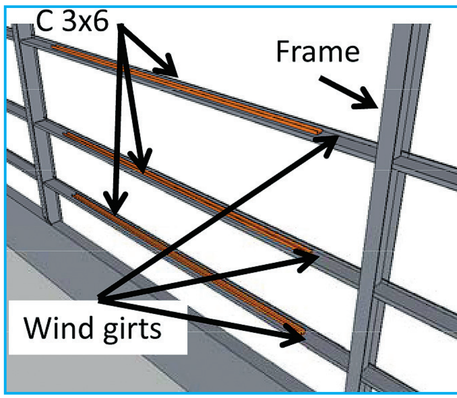
Multidiscipline and allied profession participation

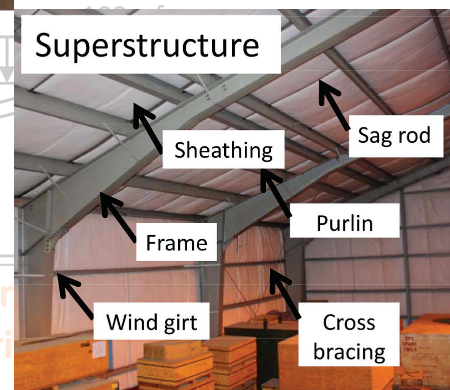
Client interaction: In addition to working with liaison engineers from the project sponsor, the team had extensive interaction with the utility workers at the warehouse location. During site visits, they learned about dam operations and the use of the building. In the spring, the team revisited the site to present their findings to the warehouse users. An important topic was the feasibility of the proposed mitigations based on how they would impact day-to-day operations.

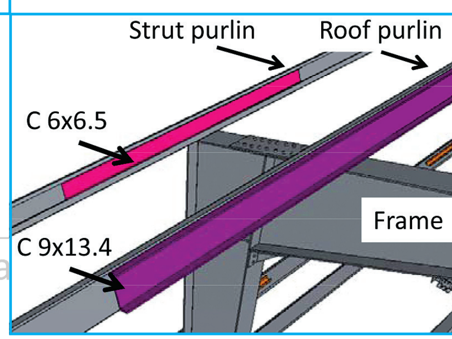
Material testing: Although the foundation analysis was not part of the scope, the team evaluated the condition and tested the existing concrete for its compressive strength to (1) analyze anchorage connections and (2) provide the sponsor with data for its future use. The team consulted with a laboratory manager (licensed professional engineer) from a local cement company about the relevant American Society for Testing and Materials (ASTM) standards and American Concrete Institute (ACI) provisions.











$7,500 AWARD

PARTICIPANTS

Students
William Barry
Christopher Bell
Andrew Boyd
Reed Cozens
Maxwell Dugan
Daniel Elizondo
Josiah Gerber
Alexander Hampel
Jason Hartman
Stephen Hughey
James Curtis
Kyle Jermstad
Chacha Kora
Cameron Lafferty
Daniel Lemmons
Nathan Loyd
Dimitra Maragakis
Scott Morton
Brian Nakashoji
Kimberly O'Kelley
Christopher Perez
Jacob Schill
Femmy Soelaiman
Mariela Solis
Megan Sulezich
Corey Tague
Samual Thompson
Sam Turman
Russell Whipple
Alex Wolfson
Derek Zimney

Faculty
Amy Childress, Ph.D.
Keith Dennett, Ph.D., P.E.
Elie Hajj, Ph.D.
David Sanders, Ph.D.
Raj Siddharthan, Ph.D., P.E.
Zong Tian, Ph.D., P.E.

Professional Engineers and Engineer Interns
Louis Bernasconi, E.I.
Michele Dennis, P.E.
William Glaser, P.E.
Brenda Lai-King Lee-Tan, P.E.
Randall Long, P.E.
Garth Oksol, P.E.
Jonathan Pease, P.E.
Richard Pettinari, P.E.
Jim Poston, P.E., PTOE
Cynthia Potter, P.E.
Randal Reynolds, P.E.

Additional Participants
Clark & Sullivan Construction
Donna Koepp, CPE, LEED AP

Granite Construction Company
Taylor Polan
Bobby Smart

Nev. Department of Transportation
Julie Maxey
Meg Ragonese

Nev. State Board of Professional Engineers and Land Surveyors
Noni Johnson
Lynell Higashi

Regional Transportation Commission of Washoe County (Project Owner)

UNR Advisory Board
Alexis Victors

U.S. Geomatics, Inc.
Glen Armstorng, P.L.S.

Vidler Water Company
Don Pattalock

University of Nevada, Reno

Department of Civil and Environmental Engineering

Capstone Design Project—SouthEast Connector

ABSTRACT

The department of civil and environmental engineering requires all undergraduates to complete two capstone courses in their senior year. One is a capstone design course that is structured to provide significant design experience to the students in their education by utilizing a real-world project that is local to the area.

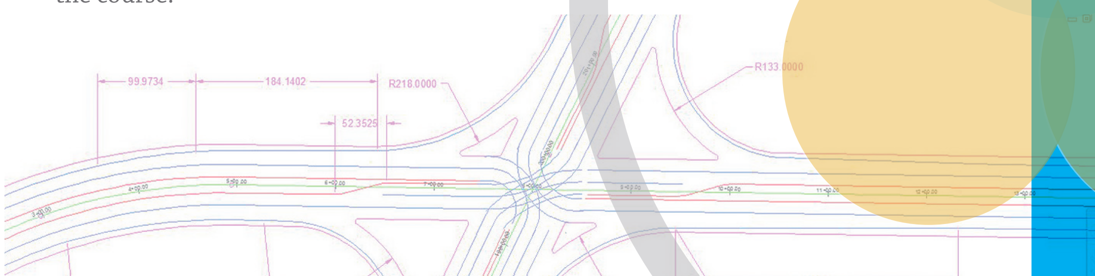
The Southeast Connector Project was chosen for the course in the Fall 2012 semester. The project involves designing five-and-a-half miles of new roadways that connect the southern part of City A to the eastern part of City B in the metropolitan area. To keep the scope within a one-semester period and still satisfy the multidiscipline aspect, the course project is concentrated on the pivotal intersection of Southeast Connector and P Drive and the restoration of S Creek.

The students work in teams of six, as consulting firms, participating in the roles of specialty design engineers and project managers. The roadway has to serve the 20-year traffic demand with a culvert that can safely pass the 117-year storm runoff. The teams also design the S Creek channel and floodplain to convey the discharge to the T River while protecting the nearby areas from flooding. The work each team performs includes traffic analysis, hydrology/hydraulic analysis, intersection layout, roadway profile, earthwork computation, geotechnical analysis, pavement design, and culvert structure design. The firms also survey the site to validate the topographic information provided to them and prepare a construction cost estimate for the improvements they designed. While environmental assessment is not part of the design services required, the firms have to review issues identified by others to gain an appreciation of any design impact to the environment and the society.

The core team of mentors includes six professors and four professionals. Each mentor first meets with the teams three times a week for one to two weeks to provide guidance related to his/her respective discipline. Upon the interim submittals, the mentor reviews the reports. Based on the feedback from the mentors, the teams then complete their final deliverables of a comprehensive written report and an oral project presentation. The scoring panel includes the core team of mentors and a representative from the industry who was not previously associated with the course.

Outside the area of the design services, guest speakers with different backgrounds also come to share their practical experiences. The topics are both technical and non-technical and include project management, intersection operations, design aesthetics, construction elements, public hearings, professional licensing, and ethics. The guest speaker sessions also provide ideal on-campus networking opportunities.

This course leads students to learn new tools such as SimTraffic, GPS, HEC-RAS, and AutoCad Civil 3D and to synthesize the material they have learned in the prerequisite courses. It provides an opportunity to apply the tools and skills they have learned in a real-world project. Through the strong collaboration among faculty, students, and practicing professionals, experience is gained not only on the technical aspects of engineering but also on many other aspects, including teamwork, communication, project management, funding constraints, ethics, and the engineer's role in regard to public welfare, health, and safety.

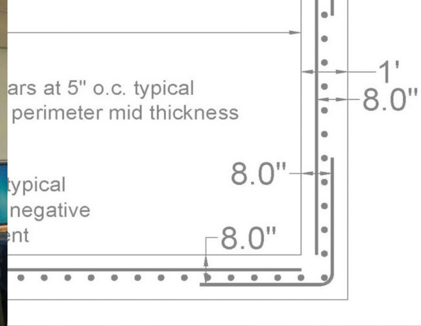


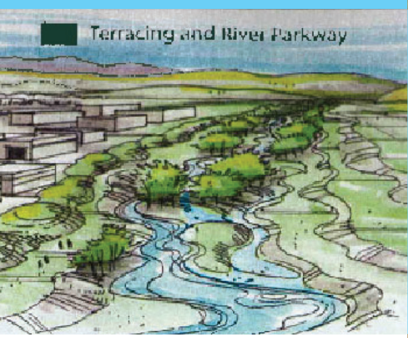
JURY COMMENTS

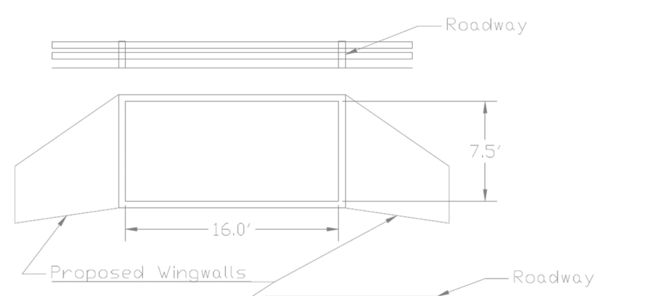
"A nicely executed, well-defined work up of a solution genuinely valuable to all collaborators and constituents"

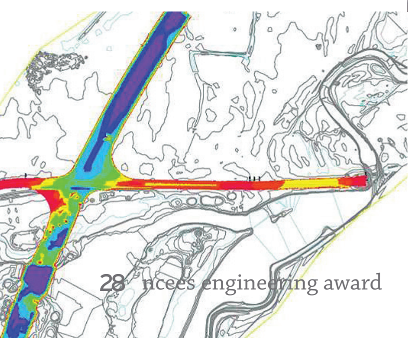
"There was good collaboration with professional engineers, involving a real-world problem."

"A superb project that tackled a critical problem in each city"









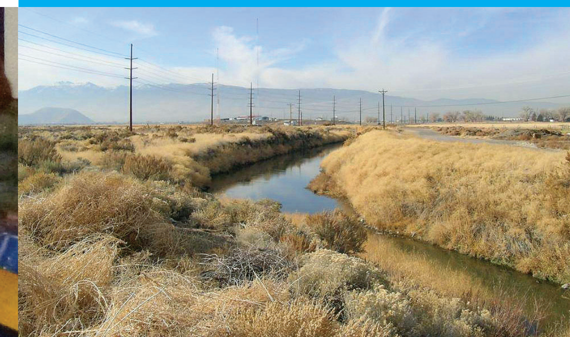
PERSPECTIVES ON

The collaboration of faculty, students, and professional engineers
With 31 students in the class, there were four teams of six and one team of seven. The teams worked as consulting firms, providing services in various disciplines as required by the project. Even though the project is the same, the work performed by each team is independent from other teams.

To mimic the business environment, the teams were divided into two sections. Each section consisted of a project manager (PM) and two project engineers. The Roadway and Floodplain Section (R Section) handled Traffic Analysis, Roadway Design, Earthwork Calculations, and Channel and Floodplain Analysis. The Culvert and Pavement Section (C Section) was responsible for Culvert Sizing, Geotechnical Investigations, Culvert Structural Design, and Pavement Design. The project engineers were the lead for the modules of the section's responsibilities, and the PMs played a supporting role. For the four general and encompassing modules of Surveying, Environmental Assessment, Estimating, and Reporting, the PMs led and the project engineers provided support. The PMs were also in charge of the overall project management and compilation of the final deliverables.

This structure was established so that the work of one section directly affects the work of the other section, as in real-world design. For example, a wider roadway designed by the R Section will require the C Section to lengthen the culvert; a thicker pavement section designed by the C Section will lead the R Section to reevaluate cut-and-fill quantities.

Each mentor first met with the teams three times a week for one to two weeks on their respective disciplines. Students in the R Section and the C Section met with the respective mentors of their



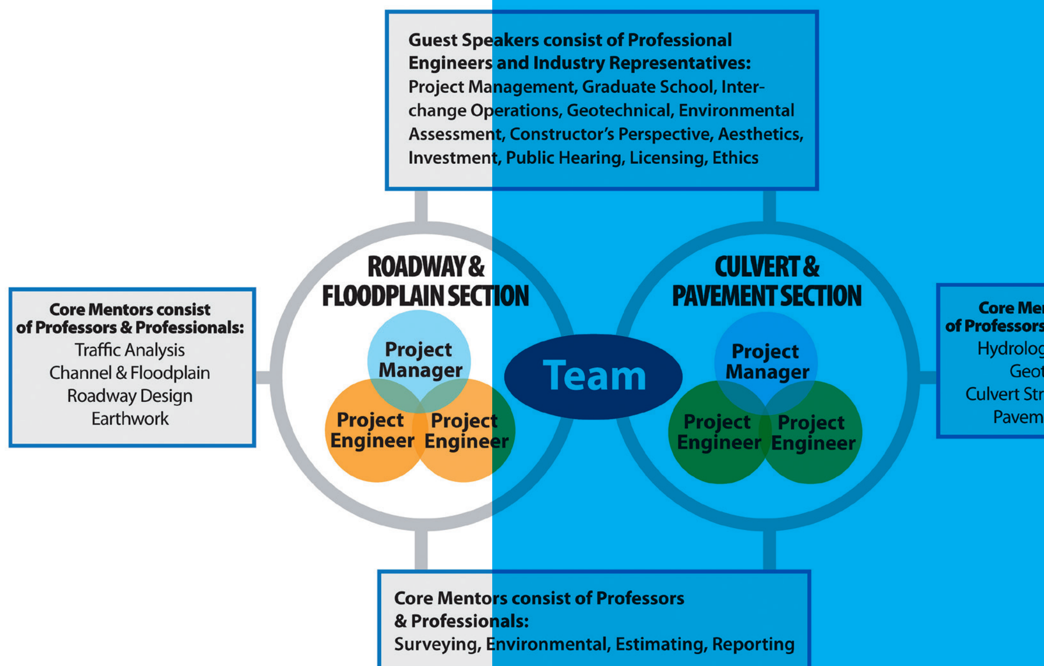
modules, while all team members met with the mentors for the remaining modules. The purpose of these meetings was to refresh the knowledge the students acquired in the prerequisite courses and to provide guidance on how to apply the knowledge to the capstone design project.

The project design was reported through an iterative process. After the initial design/analysis of each module, each team submitted an interim report to the module mentor. Based on the feedback from the mentors, the teams revised their design or evaluated other alternatives if needed. One of the final deliverables was a comprehensive report for the project inclusive of all design and analysis performed. The other final deliverable was an oral presentation. Each team had 30 minutes to present their project. The scoring panel included the core team of mentors and a representative from the industry who was not previously associated with the course.

The grading is set up such that all team members share one team grade for each module, with weight given to the members who led particular modules. In this manner, each team member had specific responsibilities and each team member contributed to others' work for the overall success of the team. Homework and examinations were given throughout the semester to assess individual student understanding of specific subjects.

Teams were formed using a qualification selection process. Each student presented his or her background, expertise, interest, and availability. Based on the information presented, the students chose their roles, sections, and their teams.

The core team of mentors included six professors, the majority of whom are licensed professional engineers (P.E.s), and four professionals, of whom two are P.E.s. One is a professional land surveyor, and one is a certified professional estimator.



$7,500 AWARD

PARTICIPANTS

Students

Project Coordinator
Jacob Nevarez

Team Leaders
Alberto Buhaya
Cecilia de León
Steven Garcia
Juan Carlos Gonzalez
Iraki Ibarra
Kristofer Johnson
Diego Kerstiens
Nicolas Mercado

Supporting Students
Jose Acosta-Rios
Eduardo Adame
Frankie Aidoo-Rodriguez
Melodie Armendariz
Ricardo Avila
Jorge Beltran
Yair Contreras
Karim Dajlala
Sergio Delgado
Wilberth Dorantes
Jesus Esparza
Diana Espinosa
Gary Galindo
Rafael Gandara
Oscar Garcia
Daniel Jimenez
Alonso Luevano
Alejandro Miramontes
Hector Moreno
James Newson
Rene Ontiveros
Adrian Ontiveros
Adalberto Ordoñez
Everardo Rodriquez
Miguel Rosas
Ivan Teran

Faculty

Lead Advisors
Carlos Chang Albitres, Ph.D., P.E.
Austin Marshall, J.D.

Technical Advisors
Cesar Carrasco, Ph.D.
Ken Gorski, B.Arch.
Vinod Kumar, Ph.D.
Jesus Lugo
Maria Prospero
Olga Valerio, Ph.D.

Other Faculty and Staff
Jessica Gutierrez
Edith Montes
Manny Pacillas
Raymundo Rapisand, Ph.D.

Professional Engineers

EMC Engineers
Andy Cook, P.E.
Melvin Glass, P.E.
Haley Rick, P.E.

HKN Engineers
Henry Ng, P.E.

Wright & Dalbin Architects
Geoffrey Wright, P.E.

Additional Participants

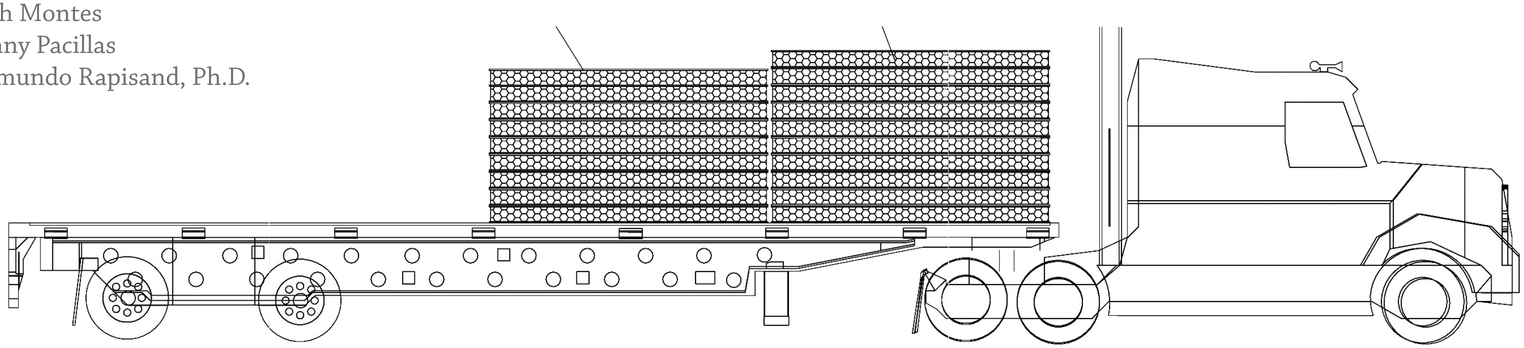
Veliz Construction
Omar Veliz

ABSTRACT

A multidisciplinary team of over 40 graduate and undergraduate students from civil, electrical, and mechanical engineering was challenged to design a sustainable house with three major objectives: sustainability based on energy efficiency, environmentally friendly, and affordability. In partnership with professional engineers from industry, professors from the university and a community college, the multidisciplinary team developed a sustainable house able to function with sunlight and water as unique energy sources. Engineering teams were complemented with a communications team with students from the college of liberal arts and the college of business responsible for increasing the public awareness of the project benefits and inviting sponsors for additional funding. Websites, videos, presentations, and education descriptions have been developed to promote the project.

The sustainable house design meets current building standard codes, LEED requirements, and city regulations and incorporates innovative technologies to address future energy threads. The sustainable house design is also "adaptable" to different climatic regions and transportable to other locations for reassembling.

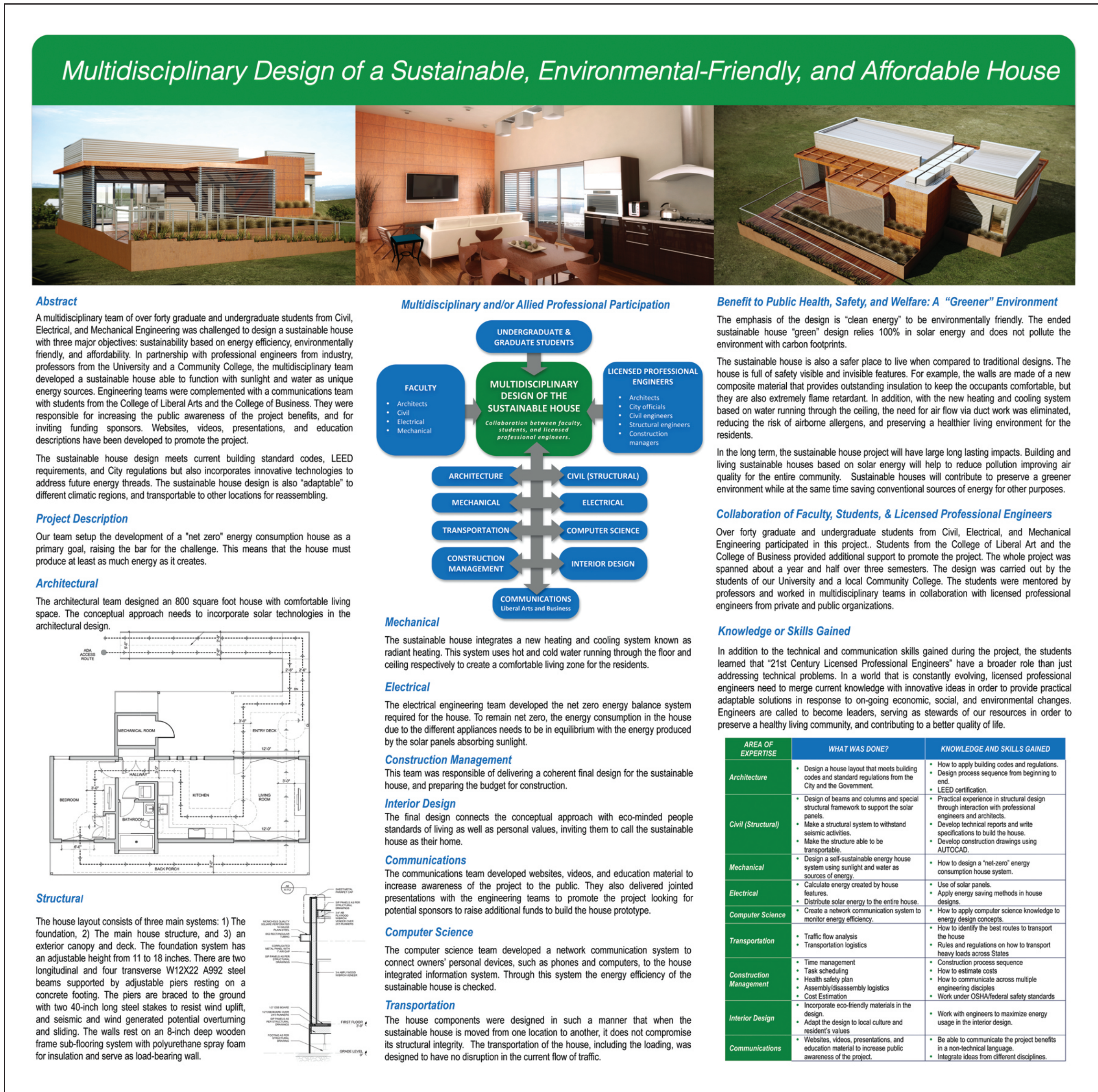
While working in this project, the students learned that 21st-century professional engineers have a broader role than just addressing conventional technical problems. In a world that is constantly evolving, professional engineers need to merge current knowledge with innovative ideas to provide practical solutions that are adaptable to ongoing economic, social, and environmental changes. Engineers are called to become leaders and serve as stewards of our resources in order to preserve a healthy living community and contribute to a better quality of life.



University of Texas at El Paso

Department of Civil Engineering

Multidisciplinary Design of a Sustainable, Environmentally Friendly, and Affordable House



Multidisciplinary Design of a Sustainable, Environmental-Friendly, and Affordable House

Abstract

A multidisciplinary team of over forty graduate and undergraduate students from Civil, Electrical, and Mechanical Engineering was challenged to design a sustainable house with three major objectives: sustainability based on energy efficiency, environmentally friendly, and affordability. In partnership with professional engineers from industry, professors from the University and a Community College, the multidisciplinary team developed a sustainable house able to function with sunlight and water as unique energy sources. Engineering teams were complemented with a communications team with students from the College of Liberal Arts and the College of Business. They were responsible for increasing the public awareness of the project benefits, and for inviting funding sponsors. Websites, videos, presentations, and education descriptions have been developed to promote the project.

The sustainable house design meets current building standard codes, LEED requirements, and City regulations but also incorporates innovative technologies to address future energy threads. The sustainable house design is also "adaptable" to different climatic regions, and transportable to other locations for reassembling.

Project Description

Our team setup the development of a "net zero" energy consumption house as a primary goal, raising the bar for the challenge. This means that the house must produce at least as much energy as it creates.

Architectural

The architectural team designed an 800 square foot house with comfortable living space. The conceptual approach needs to incorporate solar technologies in the architectural design.

ADA ACCESS ROUTE

BEDROOM

BATHROOM

KITCHEN

LIVING ROOM

BACK PORCH

Structural

The house layout consists of three main systems: 1) The foundation, 2) The main house structure, and 3) an exterior canopy and deck. The foundation system has an adjustable height from 11 to 18 inches. There are two longitudinal and four transverse W12X22 A992 steel beams supported by adjustable piers resting on a concrete footing. The piers are braced to the ground with two 40-inch long steel stakes to resist wind uplift, and seismic and wind generated potential overturning and sliding. The walls rest on an 8-inch deep wooden frame sub-flooring system with polyurethane spray foam for insulation and serve as load-bearing wall.

FIRST FLOOR

GRADE LEVEL

Multidisciplinary and/or Allied Professional Participation

UNDERGRADUATE & GRADUATE STUDENTS

FACULTY
- Architects
- Civil
- Electrical
- Mechanical

MULTIDISCIPLINARY DESIGN OF THE SUSTAINABLE HOUSE

Collaboration between faculty, students, and licensed professional engineers.

LICENSED PROFESSIONAL ENGINEERS
- Architects
- City officials
- Civil engineers
- Structural engineers
- Construction managers

ARCHITECTURE

CIVIL (STRUCTURAL)

MECHANICAL

ELECTRICAL

TRANSPORTATION

COMPUTER SCIENCE

CONSTRUCTION MANAGEMENT

INTERIOR DESIGN

COMMUNICATIONS
Liberal Arts and Business

Mechanical

The sustainable house integrates a new heating and cooling system known as radiant heating. This system uses hot and cold water running through the floor and ceiling respectively to create a comfortable living zone for the residents.

Electrical

The electrical engineering team developed the net zero energy balance system required for the house. To remain net zero, the energy consumption in the house due to the different appliances needs to be in equilibrium with the energy produced by the solar panels absorbing sunlight.

Construction Management

This team was responsible of delivering a coherent final design for the sustainable house, and preparing the budget for construction.

Interior Design

The final design connects the conceptual approach with eco-minded people standards of living as well as personal values, inviting them to call the sustainable house as their home.

Communications

The communications team developed websites, videos, and education material to increase awareness of the project to the public. They also delivered jointed presentations with the engineering teams to promote the project looking for potential sponsors to raise additional funds to build the house prototype.

Computer Science

The computer science team developed a network communication system to connect owners' personal devices, such as phones and computers, to the house integrated information system. Through this system the energy efficiency of the sustainable house is checked.

Transportation

The house components were designed in such a manner that when the sustainable house is moved from one location to another, it does not compromise its structural integrity. The transportation of the house, including the loading, was designed to have no disruption in the current flow of traffic.

Benefit to Public Health, Safety, and Welfare: A "Greener" Environment

The emphasis of the design is "clean energy" to be environmentally friendly. The ended sustainable house "green" design relies 100% in solar energy and does not pollute the environment with carbon footprints.

The sustainable house is also a safer place to live when compared to traditional designs. The house is full of safety visible and invisible features. For example, the walls are made of a new composite material that provides outstanding insulation to keep the occupants comfortable, but they are also extremely flame retardant. In addition, with the new heating and cooling system based on water running through the ceiling, the need for air flow via duct work was eliminated, reducing the risk of airborne allergens, and preserving a healthier living environment for the residents.

In the long term, the sustainable house project will have large long lasting impacts. Building and living sustainable houses based on solar energy will help to reduce pollution improving air quality for the entire community. Sustainable houses will contribute to preserve a greener environment while at the same time saving conventional sources of energy for other purposes.

Collaboration of Faculty, Students, & Licensed Professional Engineers

Over forty graduate and undergraduate students from Civil, Electrical, and Mechanical Engineering participated in this project.. Students from the College of Liberal Art and the College of Business provided additional support to promote the project. The whole project was spanned about a year and half over three semesters. The design was carried out by the students of our University and a local Community College. The students were mentored by professors and worked in multidisciplinary teams in collaboration with licensed professional engineers from private and public organizations.

Knowledge or Skills Gained

In addition to the technical and communication skills gained during the project, the students learned that "21st Century Licensed Professional Engineers" have a broader role than just addressing technical problems. In a world that is constantly evolving, licensed professional engineers need to merge current knowledge with innovative ideas in order to provide practical adaptable solutions in response to on-going economic, social, and environmental changes. Engineers are called to become leaders, serving as stewards of our resources in order to preserve a healthy living community, and contributing to a better quality of life.

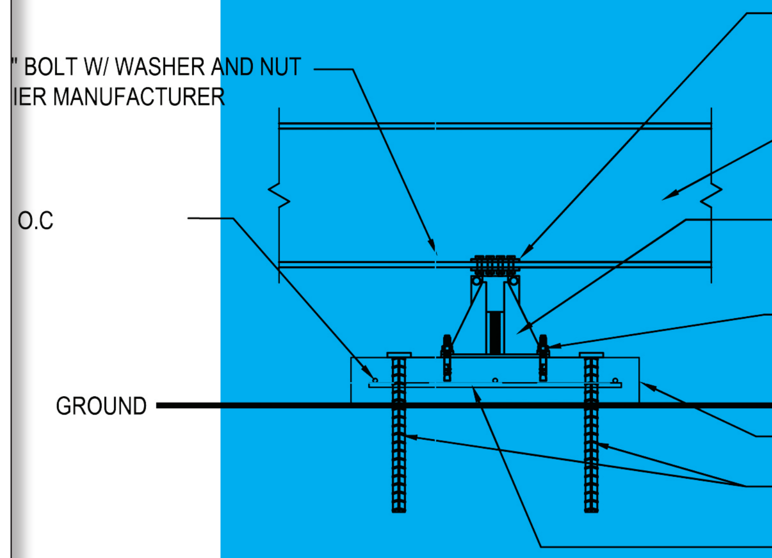
AREA OF EXPERTISE	WHAT WAS DONE?	KNOWLEDGE AND SKILLS GAINED
Architecture	• Design a house layout that meets building codes and standard regulations from the City and the Government.	• How to apply building codes and regulations. • Design process sequence from beginning to end. • LEED certification.
Civil (Structural)	• Design of beams and columns and special structural framework to support the solar panels. • Make a structural system to withstand seismic activities. • Make the structure able to be transportable.	• Practical experience in structural design through interaction with professional engineers and architects. • Develop technical reports and write specifications to build the house. • Develop construction drawings using AUTOCAD.
Mechanical	• Design a self-sustainable energy house system using sunlight and water as sources of energy.	• How to design a "net-zero" energy consumption house system.
Electrical	• Calculate energy created by house features. • Distribute solar energy to the entire house.	• Use of solar panels. • Apply energy saving methods in house designs.
Computer Science	• Create a network communication system to monitor energy efficiency.	• How to apply computer science knowledge to energy design concepts.
Transportation	• Traffic flow analysis • Transportation logistics	• How to identify the best routes to transport the house • Rules and regulations on how to transport heavy loads across States
Construction Management	• Time management • Task scheduling • Health safety plan • Assembly/disassembly logistics • Cost Estimation	• Construction process sequence • How to estimate costs • How to communicate across multiple engineering disciples • Work under OSHA/federal safety standards
Interior Design	• Incorporate eco-friendly materials in the design. • Adapt the design to local culture and resident's values	• Work with engineers to maximize energy usage in the interior design.
Communications	• Websites, videos, presentations, and education material to increase public awareness of the project.	• Be able to communicate the project benefits in a non-technical language. • Integrate ideas from different disciplines.

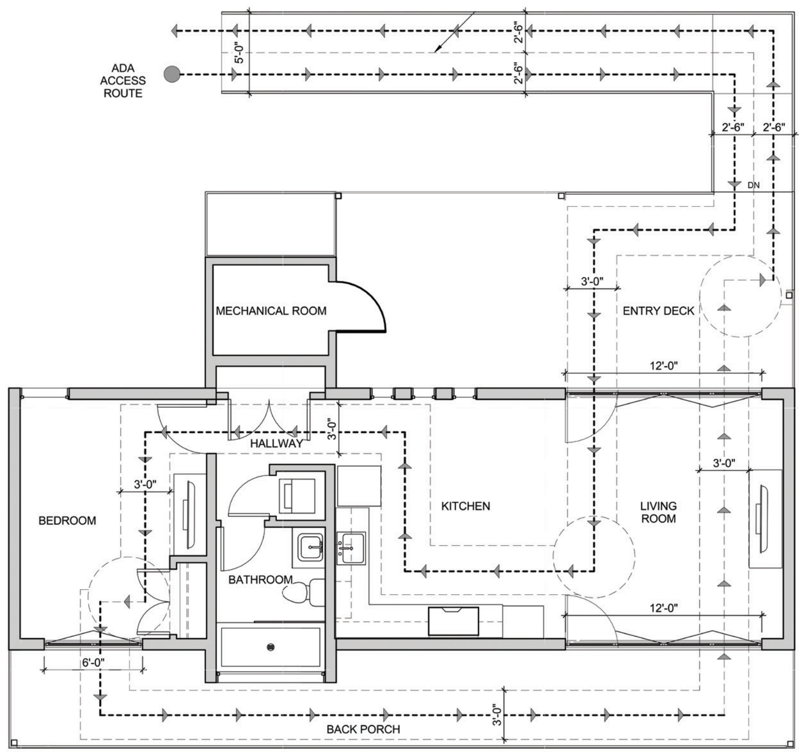
JURY COMMENTS

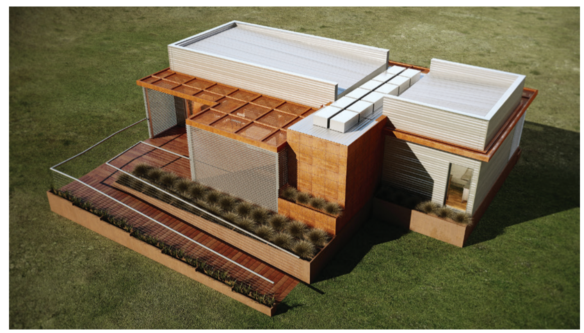
"An impressive body of work that demonstrates the power of multidisciplinary collaboration"

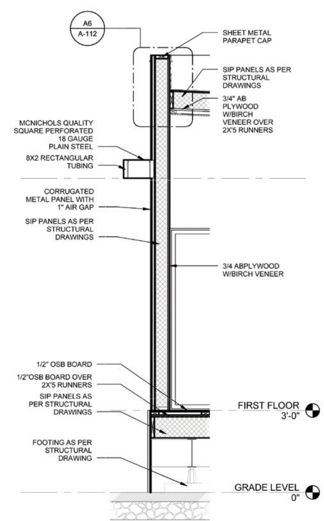
"With an arrant focus on green engineering, the unique design for sustainability and affordable housing is a timely topic for today and in the future."

"An excellent project that is replicable in many locations with broad-based collaboration"









PERSPECTIVES ON

The collaboration of faculty, students, and professional engineers

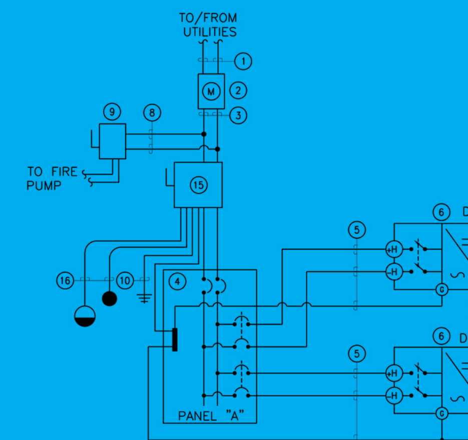
Over 40 graduate and undergraduate students from civil, electrical, and mechanical engineering participated in this project. The students were mentored by professors and worked in multidisciplinary teams in collaboration with professional engineers from private and public organizations. This project gave the students a unique opportunity to interact with other disciplines outside their field of expertise.

The whole project spanned about a year and half over three semesters. The initial design phase was carried out by the students of our university and a local community college. The designs were reviewed by professional engineers, and several changes were recommended. A revised design was developed in interaction with faculty and licensed professional engineers. With feedback continuously streaming through the students, faculty, and professional engineers, the final design was finally approved for construction. Some of the students that participated in the design phase have been hired by consulting firms involved in this project.

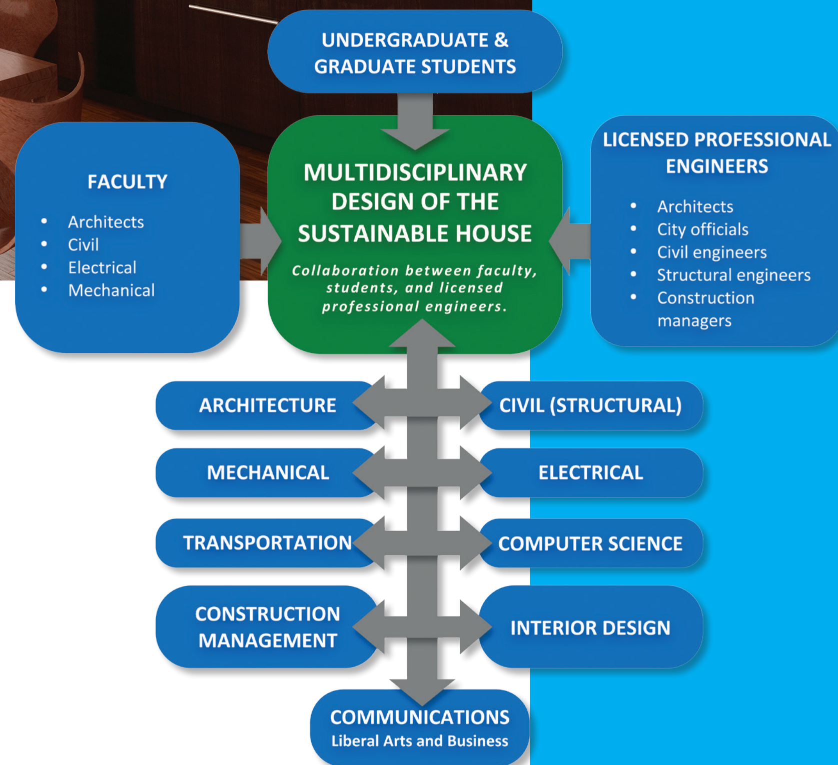
Multidiscipline or allied profession participation

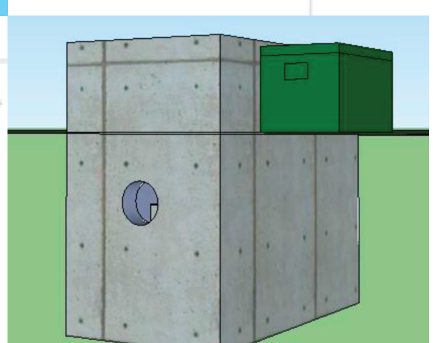
The sustainable house design required the participation of multiple engineering disciplines: civil, mechanical, and electrical. There was also a team from the college of liberal arts and the college of business who joined the engineering group to develop material to communicate the benefits

University of Texas at El Paso



of the project to the public and invite potential sponsors to contribute with additional funds to build the house. Licensed professional engineers, faculty professors from the university, and instructors from a community college mentored the students' teams to successfully address the architecture, structural, mechanical, and electrical aspects of the sustainable house design. This project gave the students an opportunity to work closely with licensed professional engineers, resulting in an unforgettable learning experience not possible with traditional education methods. Requirements to meet current building codes, LEED requirements, and city regulations demanded a close review of the designs prepared by students, applying knowledge that could be only acquired through years of engineering practice.





2013 PARTICIPANTS

California Polytechnic State University, San Luis Obispo
Architectural Engineering Department
Linking Multidisciplinary Learning and Practice: Samé Polytechnic Master Plan

California State University, Los Angeles
Department of Civil Engineering
Manhattan Beach Pump Plant Structural and Hydraulic Rehabilitation

California State University, Los Angeles
Department of Civil Engineering
Overhill Drive Urban Highway Improvement

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

Florida Atlantic University
Department of Civil, Environmental, and Geomatics Engineering
Dania Beach, Florida, Neighborhood Improvement Project

George Mason University
Dewberry Department of Civil, Environmental, and Infrastructure Engineering
2012 Water Quality Improvements, Las Mesas, Honduras

George Mason University
Dewberry Department of Civil, Environmental, and Infrastructure Engineering
BioSand Filtration and WASH Project in Maijuna, Peru

George Mason University
Dewberry Department of Civil, Environmental, and Infrastructure Engineering
Rehabilitation of a Drinking Water System in San Isidro, Peru

North Carolina State University
Department of Biomedical Engineering
Adhesive Dispenser for Neurostimulation Lead Migration

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

Oklahoma State University
School of Civil and Environmental Engineering
Design of a Track and Field Facility: Senior Design Capstone Project

Old Dominion University
Department of Civil and Environmental Engineering
High Rise Bridge Replacement: Design, Means, and Methods

Rutgers, The State University of New Jersey
Department of Environmental Sciences
Hamilton Township Hydrologic Evaluation and Water Resources Recommendations for Planning and Implementation

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

State University of New York
Department of Environmental Resources Engineering
Planning and Design for Urban Creek Revitalization

Stevens Institute of Technology
Schaefer School of Engineering and Science
COAST: Cogeneration at University A

The College of New Jersey
Department of Civil Engineering
Water for Hantham

University of Alaska Anchorage
Department of Civil Engineering
West Dowling Road

University of Dayton
Department of Civil and Environmental Engineering and Engineering Mechanics
Goodwill Easter Seals Regional Headquarters

University of Nevada, Reno
Department of Civil and Environmental Engineering
Capstone Design Project—SouthEast Connector

University of Tennessee at Chattanooga
College of Engineering and Computer Science
Anderson Avenue Stormwater Testbed Design

University of Texas at El Paso
Department of Civil Engineering
Multidisciplinary Design of a Sustainable, Environmentally Friendly, and Affordable House

University of Wisconsin–Platteville
College of Engineering, Mathematics, and Science
NAVA Primary School

West Virginia University
Department of Mechanical and Aerospace Engineering
Portable Solar-Powered Water Treatment System with Power Accessories

PREVIOUS WINNERS

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 Guardrail 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

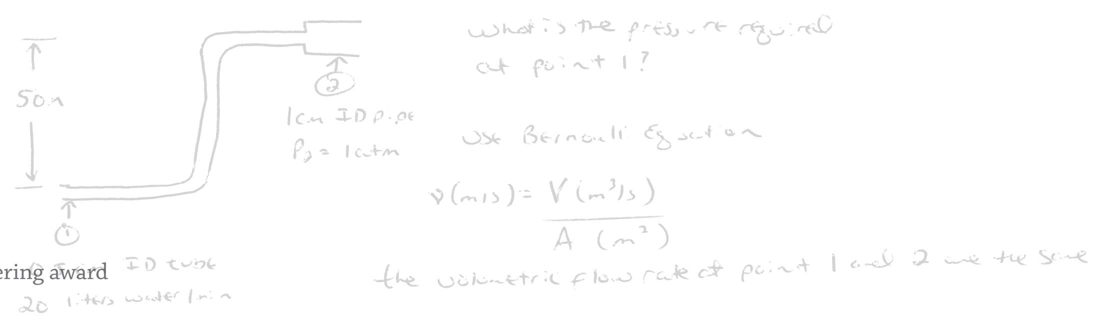
California State University, Los Angeles
Department of Civil Engineering
Connecting Professional Practice and Education through a Civil Engineering Capstone Project: Mud Flow Barrier

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

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 Tech
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

2014 Call for Submissions

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STONE
MON. FND.
STONE
CURB
AMUROL PRODUCTS, INC.
LOT 18
250.0'
LOT 17
250.0'
33'
12'
4'
4'
8'
50'
25'
25'
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MON. FND.
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