CIVIL ENGINEERING IMPACT

PURDUE UNIVERSITY | SPRING 2017

DESIGNS ON ENERGY-ABSORBING MATERIALS

Undergraduate researchers improve product safety

THOMAS A. PAGE PAVILION WELCOMES STUDENTS

PLUS

GLOBAL ENGINEERING IN KENYA

"IMPACT" CLASSROOMS

ALUMNUS PROFILE: DAN VICARI

Spring has always struck me as a unique time here at the Lyles School of Civil Engineering. Just as pleasant weather and fresh life return to the beautiful Purdue University campus, my mind cannot help but focus on how quickly the school year itself is coming to an end.

No doubt our students, too, are focused on the weeks to come, as finals and commencements approach. While I can certainly sympathize — I was once in their shoes — I feel confident that they all have a great chance to succeed, thanks to the incredible guidance from our faculty and invaluable support from our staff.

Inside and outside the classroom, our students, faculty and staff have been hard at work this year as they strive not only to advance their own knowledge of civil engineering but also to make a lasting impact around the world. In this newest Impact magazine, I look forward to sharing with you some of the fantastic work being done at our School.

In this edition, you will learn how our students are studying to improve traffic safety conditions in construction areas and how they are assisting millions of people around the world by engineering cleaner cooking methods. I think you will be fascinated to read how researchers, inspired by origami, are developing a new energy-absorption material for large structures. Also in this magazine, you'll learn how Purdue as a whole is working to improve student learning through an evolving classroom methodology and with summer research opportunities.

Every semester, the passion, creativity and ingenuity of our Purdue civils continue to surprise and delight me. I look forward to sharing even more of our accomplishments with you in this edition of Impact magazine — and in future issues.

Thank you, everyone, for reading — and I welcome you to stop by and visit us when your travels bring you this way.

RAO S. GOVINDARAJU
Bowen Engineering Head of Civil Engineering and Christopher B. and Susan S. Burke Professor of Civil Engineering

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On the cover: Phase-transforming cellular materials promise to make structures and products safer and more resilient.

EA/EOU
Produced in conjunction with the Office of Marketing and Media ■ ENGS-16-8416

CONGRATS TO WINTER 2016 GRADS

We at the Lyles School of Civil Engineering want to wish the very best to our students! In December, nearly 30 undergraduate students and more than 50 graduate students earned their degrees.

A celebration for our students was held in the Lyles Ideas to Innovation Laboratory in Hampton Hall after commencement. Despite icy weather, many came to celebrate our students' accomplishments.

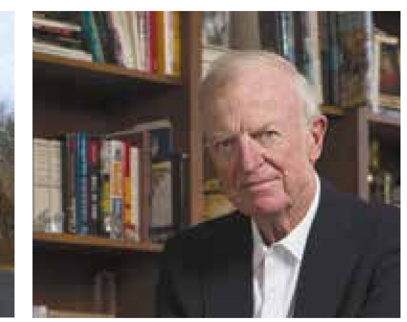
We are incredibly proud of what they have achieved at Purdue and know they will continue to succeed in their chosen paths.

BOILER UP!

Steven Johnson, associate professor of civil engineering, chats with Emily Wessel (BSCE '16) at the post-commencement CE reception held at Hampton Hall.

INTRODUCING THE THOMAS A. PAGE PAVILION

Thomas A. Page Pavilion



Thomas A. Page

Dedicated to amplifying impact and providing students with the tools to grow and succeed, the Purdue Lyles School of Civil Engineering recently completed construction of a new building, designed for student collaboration and competition.

In fall 2016, the school unveiled its newest addition — the Thomas A. Page Pavilion. The new facility — named after its primary donor, Tom Page (BSCE '55, MSIA '63, HDR '94) — serves as a place for student teams to plan, design, fabricate and finish projects. Part of the building will also be used for material staging for the adjacent Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research.

"Our students needed a place where they could work on their projects," Page says. "When I was told about this potential solution, I felt a need to help — and looking at the facility now, I know I made the right decision."

Page says he hopes the facility will be used by the students as a place where they learn the value of collaboration.

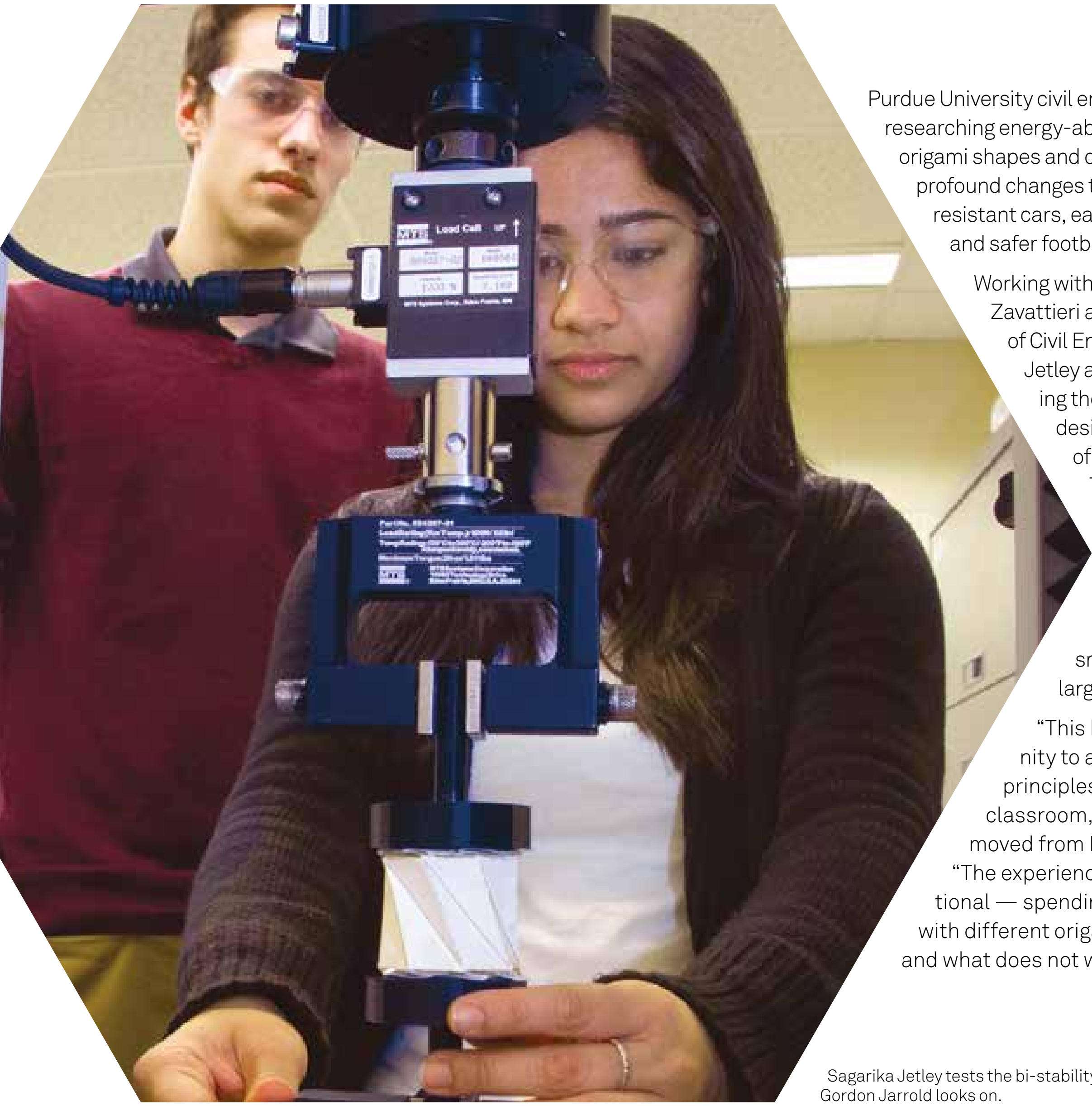
"I wanted this to be a place where these students could work together and share ideas. In my professional experience, one of the biggest things I've learned is that the chances for success dramatically increase when you are able to collaborate when working on projects."

This spring, CE students are already making use of the Page Pavilion to work on their entries into various competitions.

ADVISORY COUNCIL

ORIGAMI SHAPES

MAY LEAD TO SAFER STRUCTURES AND PRODUCTS



Sagarika Jetley tests the bi-stability of her PCXM design. Gordon Jarrold looks on.

Purdue University civil engineering undergraduates are researching energy-absorbing materials using simple origami shapes and designs. Their work could bring profound changes to products such as impact-resistant cars, earthquake-resistant buildings and safer football helmets.

Working with associate professor Pablo Zavattieri at his lab in the Hampton Hall of Civil Engineering, juniors Sagarika Jetley and Gordon Jarrold are testing these arts-and-crafts-like designs as models for new types of energy-absorbing materials. The students examine various designs, testing different types of paper and investigating other materials such as acrylic plastic and balsa to determine whether their small-scale models might have large-scale implications.

“This has been an exciting opportunity to apply some of the theoretical principles we have learned in the classroom,” says Jetley, whose family moved from India to Naperville, Illinois. “The experience has been fun and educational — spending hours and hours working with different origami shapes to see what does and what does not work.”

PHASE-TRANSFORMING CELLULAR MATERIALS

Zavattieri and his research team are exploring the development of these special materials — called phase-transforming cellular materials (PXCMs) — which absorb energy and help mitigate damage in the structural components of buildings, bridges and other large structures. Zavattieri’s research is in partnership with automaker General Motors Corp., with funding also from the National Science Foundation.

PXCMs contain unit cells that have multiple stable configurations; the structures can flex back and forth and remain in either position indefinitely, not unlike a flexing playing card or a metal tape measure. Transformation between stable configurations in large chains of unit cells allows for the dissipation of tremendous energy after an impact or cyclic event.

The super-elastic materials are reusable and less expensive than existing energy-absorption and damage-mitigating materials. And like other phase-transforming materials such as shape-memory alloys, PXCMs could be controlled using heat or other external stimuli, Zavattieri says. This concept of actuation also may prove helpful in making soft robots, which are flexible and able to conform to various shapes.

“We are evaluating new origami geometries to create thin-walled structures that show phase-transformation capabilities,” Zavattieri says. “This phase transformation that occurs at the unit-cell level exhibits negative stiffness, which is a property that leads to snap-through behavior. Thus, while these structures could be loaded at low frequencies (like in an earthquake), the snap-through behavior, which is a local instability, is employed to dissipate energy and consequently absorb energy under cyclic loading conditions.”

UNDERGRADUATE ENERGY IN THE LAB

The CE undergraduates are mentored by David Restrepo, a postdoctoral research assistant from Colombia who manages Zavattieri’s lab. Restrepo has expertise in the design, modeling, fabrication and testing of smart cellular materials, specifically multiscale modeling of naturally occurring, damage-tolerant materials and structures.

Jarrold, a junior from Bloomington, Indiana, is studying specific types of PXCMs — some developed with 3-D printing techniques — using computer modeling and computer-aided design. His designs, called “chiral PXCMs,” are geometric models that are connected with splices of metal measuring tape and aluminum tubing.

Gordon Jarrold tests chiral PXCM designs as lab manager David Restrepo looks on.

“This project has been really engaging, and I’ve been excited about being able to apply what I’ve learned in the classroom about the basics in materials, structures and other concepts,” Jarrold says.

Jetley is advancing origami designs developed last semester by student John Cleveland, a junior in aeronautics and astronautics from Scottsburg, Indiana. Jetley, who comes from a family of engineers, says she began working with a six-cell cylindrical origami prototype last semester. Then, Restrepo and doctoral student Yunlan Zhang encouraged her to focus on a single-cell design, which would make it easier for understanding bi-stable behavior and require less material. A bi-stable system has two resting states, like a light switch.

“We researched what boundaries we could go to and whether the design would still be bi-stable,” Jetley says.

MENTORSHIP MOTIVATES UNDERGRADUATES

“These students are passionate about contributing to the research, asking a lot of questions and challenging us every day,” Zavattieri says. “What’s more, these students are playing key roles in a type of work that breaks the stereotypes of civil engineering research, which can be as unpredictable and exciting as any engineering discipline in terms of what the future holds.”

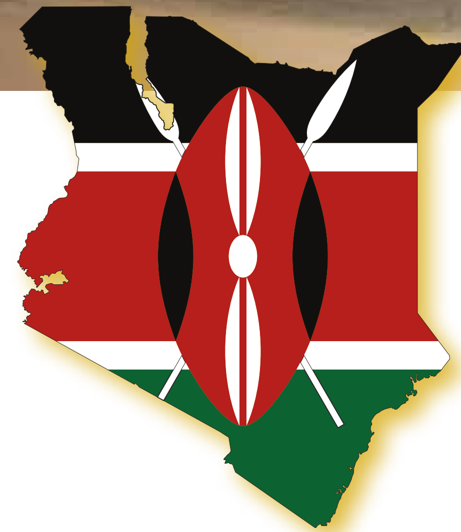
Jarrold credits participation in his high school robotics team and mentors from the Crane Naval Center for sparking a deeper interest in engineering.

“I’ve discovered that there are mistakes in nearly every step in the process. There is a lot of failure, but it’s about how you deal with those setbacks where much of the learning happens,” he says. “Professor Zavattieri, Dr. Restrepo and the team place a tremendous amount of trust in me. I’ve had a lot more creative freedom than I expected an undergraduate would have.”

As for Jetley, she is not surprised that Professor Zavattieri is so successful at recruiting undergraduate researchers to his lab, saying, “He’s very approachable.” — Phillip Fiorini

Purdue EPICS students are tackling an issue that could improve life for billions of people.

Brandon Boor, assistant professor of civil engineering, right, and student Michael Tishchenko monitor the air quality in a Nandi kitchen. Boor and his EPICS class have been researching methods to reduce the indoor air pollution generated by built-in stoves.



STUDENTS COOK UP A FIX FOR UNSAFE STOVES IN KENYA

Over winter break, Brandon Boor, his EPICS students, and Danielle Wagner flew to Kenya to get a hands-on understanding of the way built-in stoves are used and to build partnerships with the Nandi community.

On the surface, it seems like a noble but simple task: Improve the cooking methods employed by the families in the Nandi community of western Kenya.

However, the challenge is quite complicated, explains project leader Brandon Boor, assistant professor of civil engineering. Nevertheless, if the Purdue improvement plan is successful, it could impact the lives of nearly 1 million people in the Nandi region.

Built-in stoves — typically made of brick and clay — are widely used in the Nandi community. This traditional cooking method relies on solid, fast-burning biomass fuels such as wood, coal, dung and crop wastes. It is a common cooking method used by 3 billion people worldwide, largely in developing countries.

"This is a traditional cooking method for families, but it is dangerous and inefficient," Boor says. "Because it is such a pervasive custom, any proposed solution must be practical and affordable or it will never be adopted."

There are significant health risks associated with the built-in stove emissions, he says. The primary risk comes from wood smoke inhalation which, according to the World Health Organization, is responsible for 3-4 million deaths a year.

"The smoke produced by the inefficient combustion process and the poorly ventilated kitchens causes a great amount of indoor air pollution," Boor says. "Women and children are disproportionally affected by this health risk as they are the ones typically around the stove when the cooking is being done."

Several organizations have attempted to solve the problem with clean cookstove technologies, but the solutions are rarely adopted, he says.

"From an engineering standpoint, there have been very efficient solutions presented, but they missed the whole cultural aspect," Boor explains. "The newer, more efficient stoves changed their cooking techniques. They also could only cook one thing at a time on them, making meal preparation take much longer."

Several others are stepping up to work on this problem with Boor: Danielle Wagner, a graduate student in environmental and ecological engineering, along with the EPICS Global Air Quality Trekkers team. EPICS (Engineering Projects in Community Service) is a program that enlists undergraduates from engineering and other disciplines to solve community problems.

They join their project partners in the Kenya-based AMPATH Consortium of academic medical centers, David K. Lagat, MD, of Moi University, and Irene Kalamai — a retired nurse who lives in the Nandi community. Groups of women in the Nandi community have been working with Kalamai to modify their kitchens to include a chimney as well as additional ventilation pathways while preserving traditional Nandi built-in stove techniques.

Civil engineering student Scott Houldieson says this project has opened his eyes to a vital aspect of designing that can't be obtained from pure classwork.

"You really have to consider not just whether your design will work, but if it actually fits the system you're designing it for," Houldieson says. "It's an interesting challenge that forces you to focus on how this will affect others."

Over winter break, Boor, Wagner and four members of the EPICS team flew to Kenya to assess indoor air pollution and ventilation of traditional Nandi kitchens. The challenge now for the spring semester team is to analyze the data and further improve ventilation.

The Nandi project received a one-year seed grant from Purdue's Global Engineering Program and the Innovation for International Development (I2D) fund. Boor says he hopes to garner additional funds to continue the study.

For more information about EPICS and the work being done in the Nandi community, visit **engineering.purdue.edu/EPICS** and **engineering.purdue.edu/GEP/I2DLab**. In addition, you can follow the EPICS team's progress on Twitter: **twitter.com/AirQualityEPICS**. ■ — Drew Stone

3-D IMAGERY HELPS DETECT DANGER ZONES

Civil Engineering graduate students Yun-Jou "Rose" Lin and Tamer Shamseldin operate a research vehicle outfitted with a LiDAR camera. They, along with other grad and undergraduate students, drive along sections of road and collect images for research.

STUDY LINKS NARROWED LANES TO POOR DRIVING

Narrow lanes in work zones make for nervous and less attentive drivers, Purdue researchers say — and the data they're collecting is backing them up.

It's a common feeling drivers get on the road when the lanes shrink due to construction: nervousness, anxiety — perhaps even a bit of panic. Even if drivers feel only a little nervous, researcher Ayman Habib says these effects can cause significant shifts in a driver's attentiveness. Habib is a professor of civil engineering in the Lyles School.

"Whenever there are work zones and the lanes narrow, we've seen more stress in our drivers," Habib says. "The more stress they experience, the higher the probability of a crash."

Habib, along with staff and graduate and undergraduate student researchers, has been working with the Indiana Department of Transportation to increase traffic safety in work zones. Currently in Phase 1 of the study, Habib says they have observed a strong tie between narrow lanes and poor driving.

"From what we've observed so far, if a lane is narrowed to less than 10 feet wide — regardless of the type of vehicle driven — poorer driving increases," he says. "It is especially prevalent if the road has any turns. Turns make drivers more likely to drift into another lane because they aren't prepared for the shift in direction, or they overcorrect the other way."

To collect this data, student researchers drive vehicles equipped with LiDAR (light detection and ranging) devices that generate three-dimensional images. LiDAR is a surveying system that measures distance by illuminating a target with laser light.

With the LiDAR devices, researchers have 360 degrees of visual data to work with, rather than flat images. These 3-D images, Habib says, provide a much deeper level of understanding by revealing exactly where traffic is being most affected and why.

Jim Sturdevant, director of INDOT's Traffic Management Division, says the use of LiDAR technology has led to greater insight than previous studies.

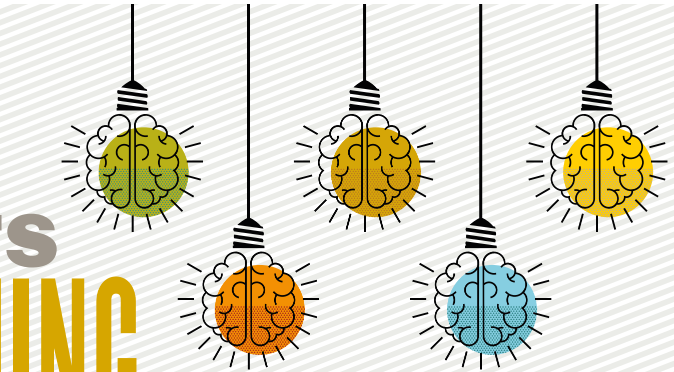
"Historically, our data-collection practice has been to mount a GoPro to the car," Sturdevant says. "You don't see side-to-side well, and you cannot measure distances across lanes under live traffic — so you just eyeball it. LiDAR instrumentation creates something resembling a 3-D wire frame model of the terrain. It allows us to measure to almost an inch."

Sturdevant adds that although research began only recently, in August 2016, he is optimistic about the work and hopes it results in increased traffic safety in work zones.

Phase 1 of the study continues through November 2017. Habib's team received $100,000 from the Federal Highway Administration and $50,000 from INDOT for the first phase.

During Phase 2, Habib says his team will expand its research to include other driving factors such as signage, shoulder width, shoulder barriers and lane marking conditions to better pinpoint other factors, in addition to road width, that contribute to driver anxiety and traffic congestion in work zones. ■ — Drew Stone

ACTIVE, COLLABORATIVE ENVIRONMENTS IMPROVE LEARNING



"In the IMPACT setting, the student and teacher collaboration allows for students to gain that understanding and keep up with the top performers."

Over the past five years, faculty in the Lyles School have implemented the IMPACT-style classroom methodology into undergraduate classes. The classroom setup emphasizes greater student-teacher interaction, smaller class sizes and in-class collaborative work. (IMPACT stands for Instruction Matters: Purdue Academic Course Transformation.)

"I've been teaching one of my hydraulics classes in an IMPACT setting for three semesters now, and I definitely would not go back to the traditional teaching setting," says Cary Troy, associate professor of civil engineering.

The overarching goal of IMPACT is to create a greater student-centered learning environment by incorporating active and collaborative learning as well as other student-centered teaching and learning practices and technologies into foundational courses with large enrollment. The creation of a student-centered learning environment is designed to foster student engagement and student competence, as well as increased attainment of course-specific learning outcomes.

Civil engineering student Drake Krohn says he noticed a positive difference from his other classes almost immediately.

Cary Troy, associate professor of civil engineering, reviews the work done by students David Magarici (left) and Kentaro Hwang. Troy's hydraulics class is set in an IMPACT classroom, which promotes a high level of interaction between students and teachers.

"With engineering, most of the classes are pretty difficult and there are times when you'll eventually stumble, but that really didn't happen in my IMPACT class," he says. "Whenever I felt like I wasn't understanding something, my professor or another student was able to help me out. When you're in a lecture hall, you don't usually get much interaction; you just end up having to move on to the professor's next point so you don't fall even further behind."

Troy says the "catch up" aspect of the IMPACT classrooms is one of the greatest benefits he has experienced.

"Oftentimes, a student who is struggling has failed to understand a critical piece of information, and it just snowballs from there," Troy says. "In the IMPACT setting, the student and teacher collaboration allows for students to gain that understanding and keep up with the top performers."

Early statistics support Troy's observation. Purdue reports that the average GPA in STEM classes has risen from 2.6 to 2.85. Non-STEM classes have shown a similar improvement — showing an average GPA increase from 2.7 to 2.95.

Another facet of IMPACT classrooms is a focus on personal responsibility. Students are expected to prepare before class to facilitate discussion. In an effort to hold his students accountable, Troy says, he issues online quizzes along with their study-material assignments.

Currently at Purdue, some 108 faculty and instructors representing nine colleges and 45 departments and schools are participating in the IMPACT program. For more information about the IMPACT program, visit **purdue.edu/impact**. ■

— Drew Stone

WHERE DID PURDUE CIVIL ENGINEERING TAKE YOU?

PURDUE CIVIL ENGINEER SOARS IN THE ROLE OF AVIATION EXEC

(Photo credit: The Times of Northwest Indiana)

Dan Vicari, Lyles School of Civil Engineering alumnus and Crown Point native, says he never expected his career path would lead to the skies above.

Vicari (BSCE '99, MSCE '01) serves as the executive director for the Gary/Chicago International Airport. He oversees the public-private partnership between the City of Gary, the Gary/Chicago International Airport Authority and AvPORTS, the private aviation facilities company that manages the airport.

In 2015, The Times of Northwest Indiana named Vicari one of its "20 under 40" for his leadership and commitment to the region. Referring to this honor, Denise Dillard of the Gary/Chicago International Airport Authority board says, "Dan has demonstrated an overwhelming commitment to revitalizing the community as a whole."

Vicari says, "I always planned on pursuing a career in environmental engineering. Even back in high school, I knew civil engineering with an environmental focus was what I wanted to study."

Vicari describes his college career as "stressful but fun." He has fond memories of studying under the guidance of Ernest "Chip" Blatchley III, professor of civil engineering and environmental and ecological engineering, and James Alleman, professor of civil engineering (now at Iowa State University).

In 2012, Vicari was appointed executive director of the Gary Sanitary and Storm Water District. He was responsible for managing the district's advanced wastewater treatment operation that serves 98 square miles across four cities in northwest Indiana at a plant that treats 120 million gallons a day.

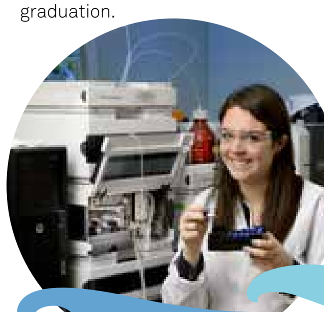
During this time, he met executives from the Gary/Chicago International Airport. The airport was looking to expand and sought advice from knowledgable city and county employees. Vicari was among the people who provided counsel — which led to the offer to serve as the project manager for the airport's $174 million runway extension project. A year later, he became the airport's executive director.

Looking back, Vicari says he feels fortunate to have had so many opportunities in his life — many of which were made possible through the education he received at Purdue University.

"Purdue's civil engineering education prepared me well and gave me the tools I needed to succeed," he says. "I'm proud of what I've accomplished, and I'm proud of my Purdue roots." ■

— Drew Stone

CIVIL ENGINEERING UNDERGRADS MAKE WAVES IN THE SURF PROGRAM



The SURF experience helps student Holly Haflich decide what she wants to do after graduation.

Brian Rogers presents his research data at the 2016 SURF Research Symposium.

Student Nadia Aljabi discovers her role as researcher in the SURF program.

Alan Kanybek discusses the serviceability of reinforced concrete structures at the symposium.

Nathaniel Kallmyer (center) stands with his mentors, Professor Ernest "Chip" Blatchley III (left), and Professor Zhi "George" Zhou.

Purdue University's Summer Undergraduate Research Fellowship (SURF) program offers students a rich opportunity to take part in academic research — something students typically may not experience until graduate school. In addition to researching with faculty and grad students, SURF participants are paid for their efforts, get to attend professional development and research seminars, present their research discoveries at the SURF symposium, and enjoy social activities with other members.

Santiago Pujol, civil engineering professor and SURF mentor, says there is no better way for an undergrad to accelerate their knowledge than through this summer program.

"To actually experience and participate in research as an undergrad is something many students never get the opportunity to do — not to this degree, at least," Pujol says. "Through SURF, students get to learn about the actual practice of civil engineering, beyond what they've studied and worked on in labs."

Brian Rogers, a civil engineering student and 2016 SURF participant — who explored the strength of reinforced concrete beams with high-strength steel — says not only did his experience translate to better understanding in his coursework, but it also led to other academic opportunities.

"Before SURF, I did not know much at all about graduate school, but Professor Pujol really helped me see what that life is like and the dedication required of a grad student," Rogers says. "I also now have an internship for the coming summer, and I am convinced that a huge reason I was able to land the opportunity is due to my SURF experience."

Pujol says a key benefit from SURF is that it sparks students' interest in continuing their studies beyond a bachelor's degree.

"What the SURF program does well is show students just how interesting graduate school can be here at Purdue," he says. "We're always looking for promising candidates, and SURF does a great job of exposing undergrads to the work we're doing."

For more information about the SURF program, visit **engineering.purdue.edu/Engr/Research/SURF**. ■ — Drew Stone

Since 2012, nearly half of the SURF students hosted by Purdue's School of Civil Engineering have been accepted into graduate programs at Purdue. Each year, five or more CE faculty welcome SURF students into their labs.

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LYLES SCHOOL OF CIVIL ENGINEERING
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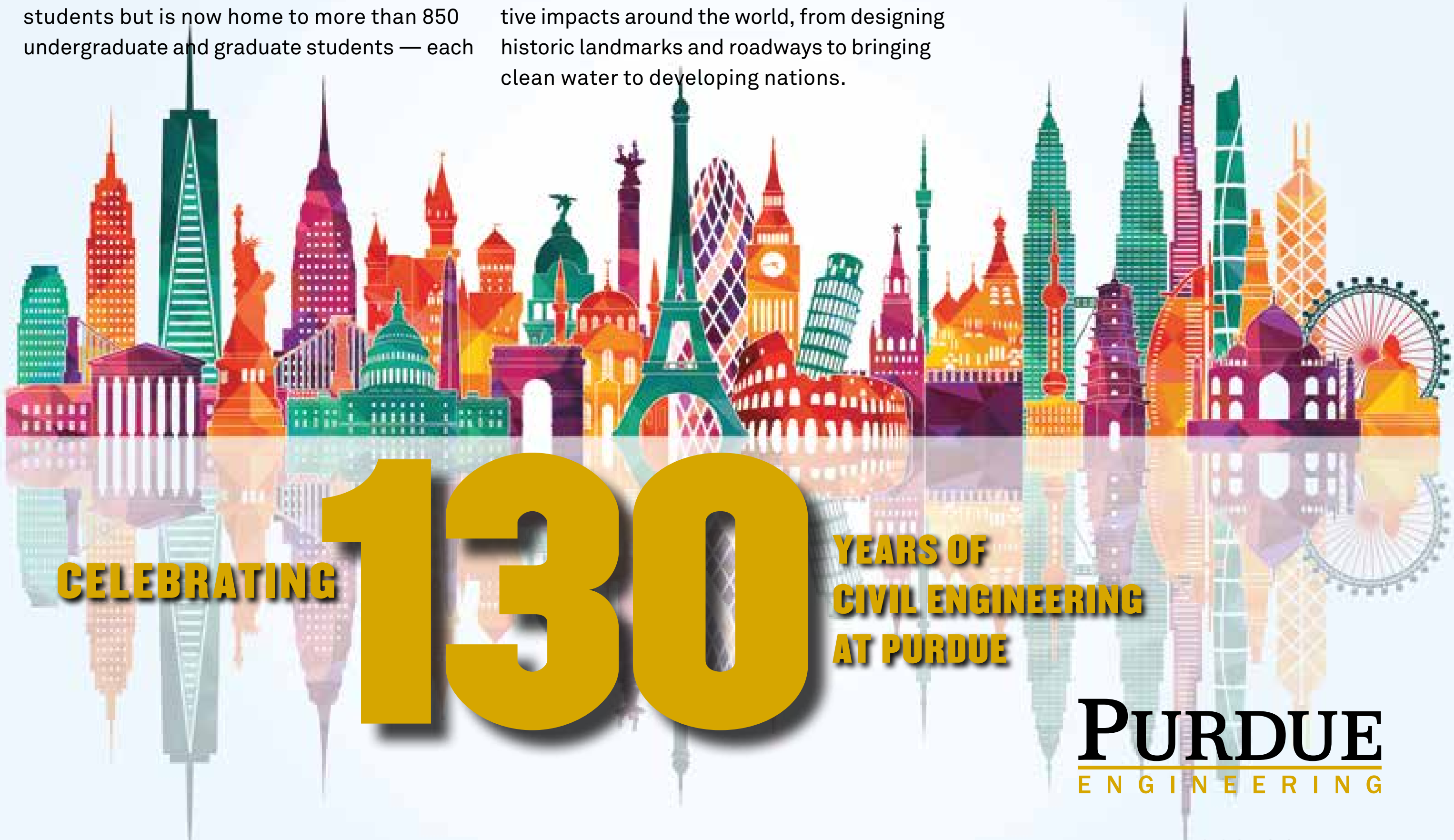
Since 1887, Purdue Civil Engineering has sought to educate the world's brightest students and advance the discipline through education and research. Now, 130 years later, the Lyles School of Civil Engineering is vaunted as one of the world's top CE programs.

Our school started with just 39 registered students but is now home to more than 850 undergraduate and graduate students — each drawing from a wide spectrum of offerings, spanning architectural, construction, environmental, geomatics, geotechnical, hydraulic and hydrologic, materials, structural, transportation engineering, and more.

Our students, alums, faculty and staff have made — and continue to make — lasting positive impacts around the world, from designing historic landmarks and roadways to bringing clean water to developing nations.

Our rich, substantial history affords us a solid foundation on which we will continue to build. And as we make new strides in education and research, we will help forge a better future for all mankind.

**BECAUSE WE ARE CIVIL ENGINEERS.
TOGETHER, WE BUILD!**



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