CIVIL

ENGINEERING IMPACT

PURDUE UNIVERSITY | SPRING 2018

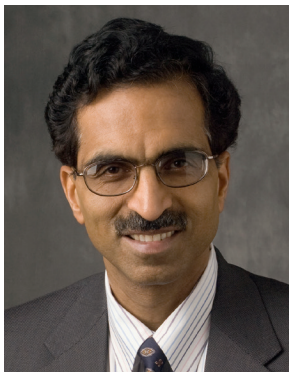
INNOVATION

STUDENT

SOLUTIONS

RESEARCH

HEAD'S MESSAGE



The spring semester is in full swing at Purdue University, which means we are rapidly approaching the end of yet another incredible academic year at the Lyles School of Civil Engineering.

Throughout the year, our students, faculty and staff have invested a tremendous amount of effort in both their academic and research-oriented pursuits. It has been a pleasure to see the passion and drive exhibited by everyone, every day, to succeed in their endeavors. This longstanding culture of diligence and innovation is something one cannot find simply anywhere.

First and foremost, though, our school aims to ensure that our students receive the best education possible and have the greatest research tools available to them — and that our faculty and staff continually seek new and better ways to enhance the education experience.

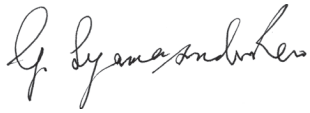
In this edition of CE Impact, we feature a few of the efforts the Lyles School is undertaking to ensure that our students have opportunities to participate in research and acquire valuable writing and public speaking skills. As the world becomes smaller with each passing year, effective collaboration and communication are key skills for current and future civil engineers.

We also detail how 3-D printing technology is — quite literally — adding new dimensions to several areas of research. From re-creating crash sites to drawing inspiration from insect anatomy, 3-D printing allows our researchers to approach their studies from entirely new angles.

Our educational opportunities are not confined to the West Lafayette campus. In this issue, we feature our school's multiple study abroad opportunities, which grant our undergraduates the chance to gain firsthand experience in the study and practice of civil engineering as it is conducted around the world.

These are just a handful of examples of how the Lyles School of Civil Engineering is working to create a fulfilling education experience for our undergraduates. We will continue to innovate how we teach. If you have recommendations, be sure to let me know. I am always interested in hearing ways to better our program. ■

All the best,



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

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Education priorities at the Lyles School of Civil Engineering include providing research experiences for undergraduates and updating the curriculum with courses that develop skills in communication and innovation.

LYLES SCHOOL OF CIVIL ENGINEERING

Rao S. Govindaraju
Head

Garrett D. Jeong
Associate Head

Don Fry
Chief Development Officer

Drew Stone
Director of Marketing and Communications

Sue Khalifah
Director of Student Experience

L. Scott Hinkel
Director of Development

Kathy Heath
Program Administration Manager

Moving?
Send change of address to:

Lyles School of Civil Engineering
Delon and Elizabeth Hampton Hall
550 Stadium Mall Drive
West Lafayette, IN 47907-2051

Or email: heathk@purdue.edu
Or call: 765-494-2166

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ANNUAL HOMECOMING BREAKFAST

Assistant Professor Antoine Aubeneau takes the next omelet order.

It was another beautiful breakfast bash at the Lyles School of Civil Engineering.

On Sept. 23, 2017, hundreds of students, faculty, staff, alumni and friends joined us for our annual Homecoming Breakfast at Hampton Hall. The improved football season made the fresh omelets taste even better!

For years now, our Purdue Civil Engineering faculty have been serving up free omelet breakfasts before the Purdue football homecoming game. The event is a great way for multiple generations of Purdue Civil Engineering alumni to gather and swap stories with each other and current students.

Be sure to join us next fall, on Sept. 22, and cheer on the Purdue Boilermakers as they try to build on their promising 2017 season! ■

BOILER UP!®

WINTER GRADUATION

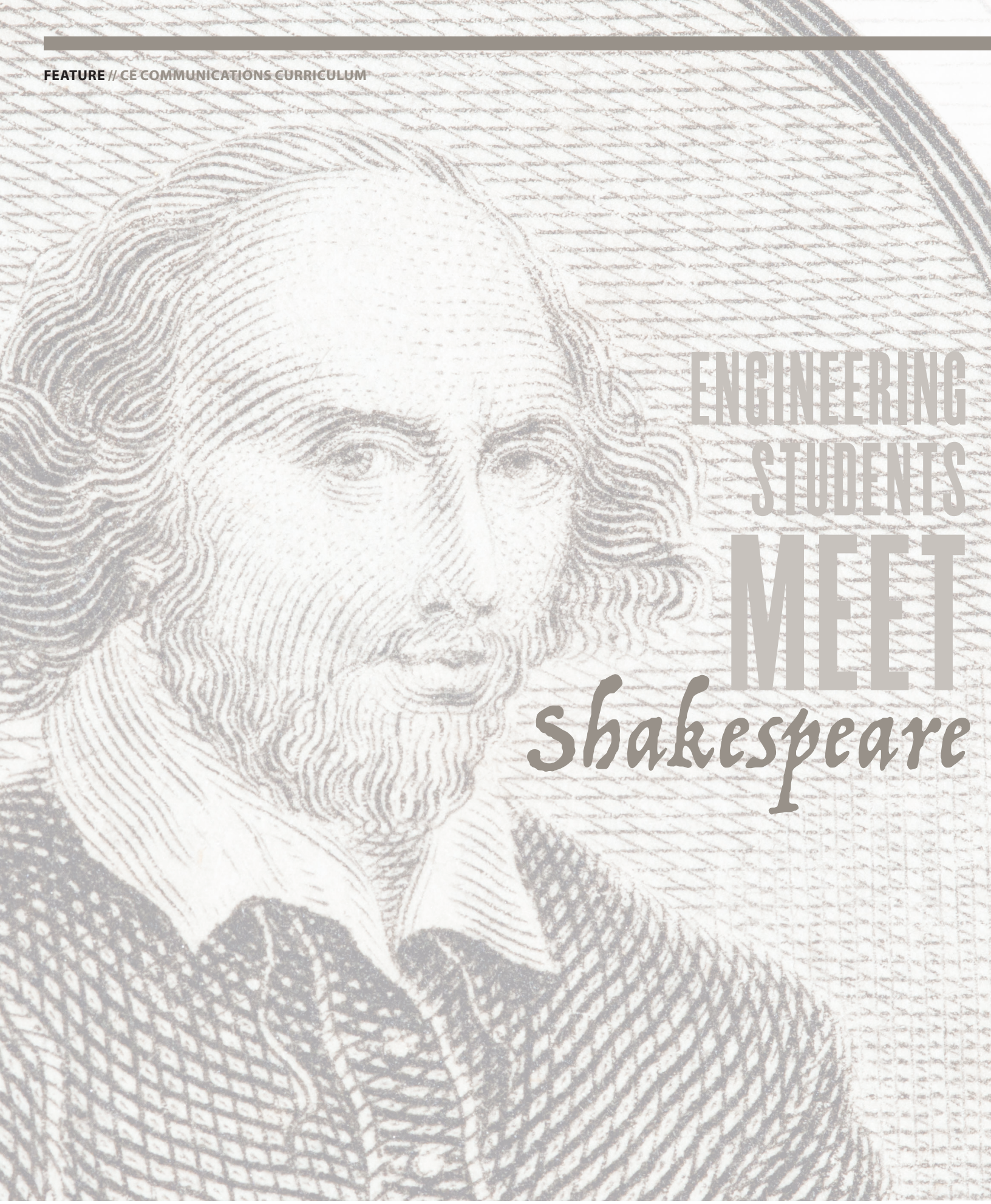
Thank you to everyone who joined us for the December 2017 Winter Commencement ceremony.

Nearly 100 graduate and undergraduate students earned their civil engineering degrees last semester. We were honored that so many graduates, their families and friends were able to share in the celebration back at Delon and Elizabeth Hampton Hall. We at the Lyles School of Civil Engineering wish all of our graduates the very best in their professional and personal pursuits.

We also would like to thank Bill Dudley, Purdue Civil Engineering Class of '74 alumnus and retired vice chairman of Bechtel Group Inc., who gave the commencement address. It was a fantastic opportunity for Purdue engineering students to hear from such an inspiring Boilermaker. ■

Civil Engineering Professor Jon Fricker was happy to tell Mariah Cummings' family what a tremendous student she was.

ADVISORY COUNCIL



ENGINEERING STUDENTS MEET *Shakespeare*

John C. Tompkins, PhD, observing a student's performance.

Student B.J. Fowler performs solo passages from the works of Shakespeare.

Shakespeare and civil engineering might seem incompatible — but Purdue has found a way for these seemingly star-crossed disciplines to form a fruitful union.

Today, more than ever, civil engineers who want to rise in their profession need to be effective communicators. Realizing this, the Lyles School and its Advisory Council decided to expand communication offerings.

In 2014, the school transformed its writing course from a lecture to a lab that focuses on student projects and skill improvement. The school also added an entirely new public speaking course to its core classes.

"It had become apparent that — in order to continue providing a world-class education — our school must provide more than pure civil engineering classes," says Professor Rao "G.S." Govindaraju. "Strong writing and communication skills are absolutely vital for today's civil engineers — for both collaborating with colleagues and getting your message across to the public."

Since the course expansion three years ago, continuing lecturer John C. Tompkins, PhD, has taught both the writing (Contemporary Issues) and the public speaking (Technical Communications) courses.

In the Contemporary Issues class, students work on preparing a résumé, drafting proposals and writing letters to potential employers. And, as of the 2017-18 school year, students in Tompkins' Technical Communications class have found themselves in the footlights.

"Much of the student feedback I received is that they especially needed help with public speaking," Tompkins says. "Personally, it was acting that got me out of my shell when I was younger. I decided to try the same with my students by giving them something many of them have never tried before."

Students select solo passages from the works of Shakespeare and perform before the class. They are graded on memorization, audience engagement and overall performance.

"It was definitely something new for me, but it really made me think about how to perform my piece," says Mia Sheppard, who took on the role of Juliet. "I had to think about how I needed to say something, rather than just focusing on the subject matter itself."

Tompkins intends to continue using acting assignments in his class. He believes it helps prepare students for the professional realm — especially as they move up the ladder. "Oftentimes in civil engineering, the higher you move up, the more you must rely on your communication skills," he says. "And typically, individuals who communicate better are more likely to earn promotions in the first place." ■

MAKING AN IMPACT

Unsurprisingly, Tompkins' Contemporary Issues course was accepted into Purdue's curriculum improvement program called IMPACT (Instruction Matters: Purdue Academic Course Transformation). This spring, IMPACT experts will analyze the course and provide detailed reports on ways to improve the course and increase student engagement.

IMPACT is a highly sought-after program for faculty who want to put their classes under the microscope. Since its creation in 2010, the program has redesigned 120 courses at Purdue.

As of 2017, more than a dozen Lyles School faculty members have been accepted into the IMPACT program. They include Ernest Blatchley, Hubo Cai, Inez Hua, Judy Liu, Loring F. Nies, Arun Prakash, John C. Tompkins, Cary Troy, Satish Ukkusuri, William Weiss and Pablo Zavattieri.

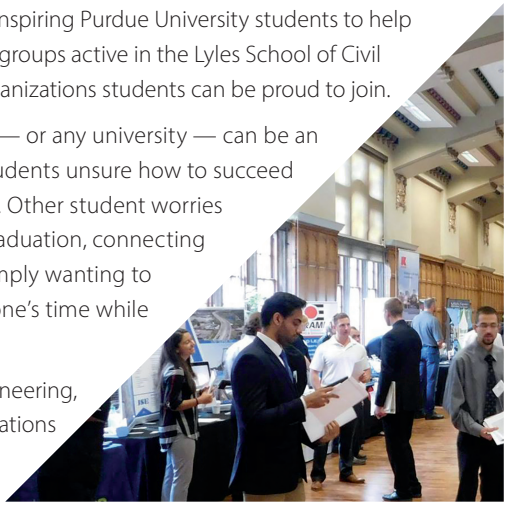
For more information about the program, visit **purdue.edu/impact**.

STUDENT ORGANIZATIONS

STUDENT GROUPS: ASSETS FOR FUTURE LEADERS

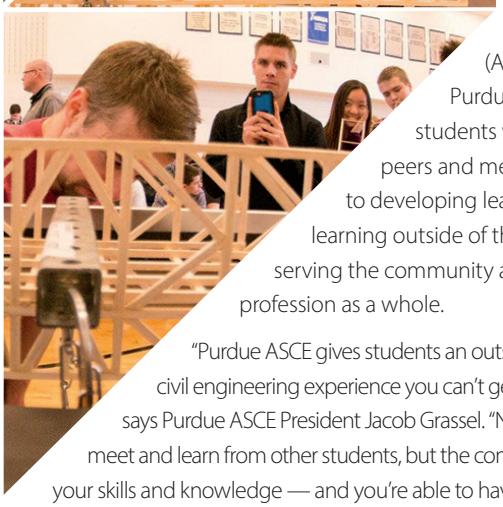
Whether it is networking to create business contacts, engaging in competitions or inspiring Purdue University students to help others, the student groups active in the Lyles School of Civil Engineering are organizations students can be proud to join.

Coming to Purdue — or any university — can be an anxious time for students unsure how to succeed socially on campus. Other student worries include life after graduation, connecting with faculty and simply wanting to make the most of one's time while at college.



At Purdue Civil Engineering, student-led organizations help alleviate such concerns, and they always welcome new members.

"One of our school's greatest assets is our students," says Civil Engineering Professor and Chi Epsilon Faculty Advisor Mark Bowman. "Their active involvement in student organizations is invaluable, and it plays a vital role in providing a well-rounded college experience."



PURDUE ASCE

The Purdue University Chapter of the American Society of Civil Engineers (ASCE) provides Purdue civil engineering students with a network of peers and mentors committed to developing leadership skills, learning outside of the classroom, serving the community and promoting the profession as a whole.

"Purdue ASCE gives students an outside-the-classroom civil engineering experience you can't get anywhere else," says Purdue ASCE President Jacob Grassel. "Not only is it great to meet and learn from other students, but the competitions really test your skills and knowledge — and you're able to have a direct impact on high school students with our outreach."

Every year, university ASCE organizations around the nation compete in events such as the concrete canoe, seismic design and steel bridge competitions. Purdue ASCE also hosts its own event on campus, the annual bridge bust, in which hundreds of high school students from the Midwest come to Purdue to test the carrying capacity of their balsa wood bridges.

"The bridge bust is always a really fun time of the year for us," Grassel says. "It's incredibly rewarding to see so many high school students come out and be so excited to participate in a civil engineering competition."

PURDUE CESAC

The Civil Engineering Student Advisory Council (CESAC) was founded to increase interaction between engineering students and faculty in the Lyles School. The organization builds partnerships between students, faculty, administrators, alumni and industry to continue pursuing Purdue Engineering's excellence in education, research and service.

"One of our biggest goals is to make Purdue Civil Engineering feel more like a community, rather than just a place to study," CESAC President Haley Smith says. "We're here to connect students to faculty and be a place for students to learn from each other as well."

The biggest event CESAC hosts is its annual career fair — and it is one of the most attended engineering events at Purdue. In 2017, more than 100 employers came to Purdue, all with full-time, internship and co-op positions ready to be filled.

"Our career fair gets better every year, and Purdue's faculty have been extremely supportive of it," Smith says. "I've known a few professors who have moved their exam schedules around to make sure their students have the opportunity to attend."

PURDUE CEGSAC

The Civil Engineering Graduate Student Advisory Council (CEGSAC) serves the same core mission as CESAC : to foster and maintain strong relationships with faculty and students — specifically, graduate students.

"Since much of a graduate student's work and research is connected to faculty, it's important that we continually strive to improve and maintain a strong relationship between the two groups," CEGSAC President Ali Ghahari says. "We also encourage graduate students to get involved in matters outside their labs."

Events and activities headed by CEGSAC include charity fundraising for disaster relief, student-faculty social events, and College of Engineering social events, all of which allow graduate students from various engineering programs to collaborate.

CHI EPSILON

Chi Epsilon, the national civil engineering honor society, is dedicated to maintaining and promoting the status of civil engineering as a profession. Chi Epsilon recognizes the characteristics of the ideal civil engineer, attributes fundamental to the successful pursuit of an engineering career. Members help one another develop those characteristics in themselves.

"Students who join Chi Epsilon comprise some of the very best in Purdue Civil Engineering," Chi Epsilon Vice President Annie Chen says. "Those who join us strive to do their best in their studies and want to make a difference in the world."

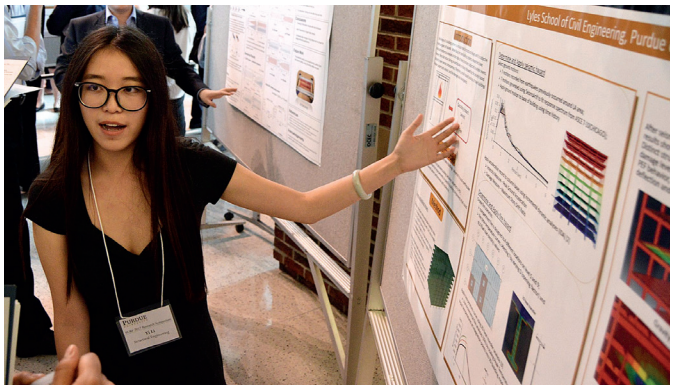
The organization's objective is to contribute to the improvement of the profession, develop and exercise sound traits of character and technical ability among civil engineers, and guide its members toward an ever-higher standard of professional service.

Chi Epsilon's public service work includes tutoring, providing school and program information, and performing community service. ■

UNDERGRADUATE RESEARCH
A TOP PRIORITY

Purdue Civil Engineering strongly supports the belief that one of the best ways for undergrads to truly understand their studies is through hands-on research.

In 2017, the Lyles School of Civil Engineering participated in three programs aimed at giving undergraduates an opportunity to take an active role in ongoing research conducted by our graduate students, faculty and staff. The three programs are Purdue University's Summer Undergraduate Research Fellowship (SURF), the Purdue Undergraduate Research Experience (PURE) and the S.N. Bose Scholars Program.



CE undergrad Yi Li conducted research on post-earthquake fire assessment of steel buildings. SURF participants deliver poster presentations on the work they have done.

S.N. Bose Scholar Program participant Vrushali Sanjeev Garde assisted in research comparing simple and advanced methods of analysis in American Institute of Steel Construction (AISC) 360 for fire-resistant design.

"For Purdue Civil Engineering, we believe it is vitally important to expose undergrad students to the many cutting-edge research opportunities available," says Amit Varma, professor of civil engineering and director of the Robert L. and Terry L. Bowen Laboratory. "It's an enriching experience for the undergraduates and for the grad students they work with."

Varma adds that a major factor in Purdue's success with its undergrad research programs is that the selected students are carefully placed in the fields and research areas that best suit them.

"I'd say 90 percent of success is ensuring students are placed in the right environment," he says. "When their placing is a good fit, they naturally feel more excited and eager to participate, assist researchers and write papers."

In addition to gaining firsthand research experience, participants are paid for their efforts. They also get to attend professional development and research seminars, present their research discoveries, and enjoy networking and social activities with other student researchers.

Civil engineering undergrad Yi Li worked at the Bowen Lab with Rachel Chicchi, a civil engineering PhD student, researching post-earthquake fire assessment of steel buildings.

"She was an incredibly big help for my research; we both learned a lot from each other," Chicchi says. "The work we did continually had her asking questions and finding new answers that she probably never would have considered solely from classroom work."

Li was grateful for the opportunity to work on a major research project.

"Thanks to SURF, I got to really enhance my understanding of research being done in my field of study, and I gained a lot of additional writing experience," she says. "I felt like I was truly a vital member of the team."

Varma said Li's experience is what all undergrad research program participants strive to achieve. "These programs' greatest function is to demonstrate to students where the classroom knowledge is coming from," he says. "It shows that the equations and examples they study in class actually come from somewhere — they are not made up — and they have very practical applications."

For more information about Purdue's undergraduate research programs, visit **purdue.edu/research/ugrad**. ■

WHERE DID **PURDUE CIVIL ENGINEERING** TAKE YOU?

ENVIRONMENTAL ENGINEER **SUCCEEDS AS LOBBYIST AND LAWYER**

Martha Rees (BSCE '73) has never been one to back down from a challenge — and she spends much of her time encouraging others to adopt the same attitude.

In the 40-plus years since graduating from Purdue University, Rees established an impressive career at DuPont. She retired as the company's vice president and assistant general counsel in 2015.

As a result of her accomplishments, Rees has been honored by her alma mater twice — with the Civil Engineering Alumni Achievement Award in 2003 and the Purdue College of Engineering Distinguished Engineering Alumna Award in 2009.

Rees says she is proud to be a Boilermaker and part of the continuing legacy of Purdue Civil Engineering.

"I always love coming back to the school when I'm on campus, especially when I get to interact with students," she says. "Civil engineering is the foundation of the quality of life we have today — and the next generation of civil engineers are needed now more than ever."

After graduating from Purdue in 1973, Rees started working for DuPont as an environmental engineer; her research focused on wastewater treatment processes using DuPont products. She then moved to manufacturing, where her concentration shifted to plant environmental regulatory compliance, an area that involved increased interaction with attorneys. Though Rees jokes that "Perry Mason" episodes constituted the extent of her legal knowledge before this time, this position proved to be a pivotal one in her career, ultimately piquing her interest in attending law school.

In the summer of 1980, Rees moved to Washington, D.C., where she worked for DuPont as a lobbyist by day and attended Georgetown University Law School by night.

"Working as a lobbyist was probably the most developmental experience I have had — on a professional as well as personal level," Rees says. "I really learned how to connect with and influence people during this time."

After receiving her law degree, Rees worked on a broad range of assignments in the DuPont legal department, and in 1998 was appointed associate general counsel and chief environmental counsel. In October 2006, Rees assumed the position of vice president and assistant general counsel of DuPont Legal, where her duties included international managerial responsibilities for DuPont's law departments outside the U.S., in addition to the commercial, environment/real estate, corporate/securities, and merger and acquisitions practices for worldwide function. She also served as the chief antitrust counsel and chief environment counsel for DuPont.

She served in that position until her retirement in 2015.

In 2008, Rees was selected as a Purdue Old Master, which she says was a terrific experience and a great honor. Currently, Rees is a member of the board and executive committee of the Purdue Alumni Association. She has served on the Civil Engineering Advisory Council and is a chapter honor member of Chi Epsilon. ■

In October 2017, alumna Martha Rees returned to campus to speak with CE students and faculty about the impact civil engineering has on the quality of life around the world.

DETECTING POT

A team of Purdue University students are working to bring automated pothole detection to Greater Lafayette. The students are part of EPICS, or Engineering Projects in Community Service, a service-learning program that gives students real-world experiences in engineering — and helps the community in the process. The project partner is the City of West Lafayette.

Assistant Professor Mohammad Jahanshahi is leading Purdue's EPICS Smart City team, whose goal is to use available technology to improve city roads. The team is creating a device to scan roads for potholes and catalog them.

"The goal before us is to find an inexpensive solution to a costly problem for the city and its drivers," Jahanshahi says. "There are existing machines and technology that can find and measure potholes, but the cost is significant and the data processing is not fully automated."

A LOW-COST SOLUTION

The team modified a Kinect device, a motion-sensing mechanism that acts as a camera and sensor for video game playing, then combined it with an ultrasonic sensor and a GPS. The amalgamation of hardware is stored in a case and attached to the back of a vehicle.

Although a prototype is still in the development stage, the EPICS team has created and tested one with promising results. The team also has developed a program to read and display the information so that future city employees can read and track the information easily.

"It's been pretty amazing to see where we've got to, so far," first-year engineering student Dan Hershberger says. "We're getting very good data. Also, we're learning from our mistakes and improving almost every day."

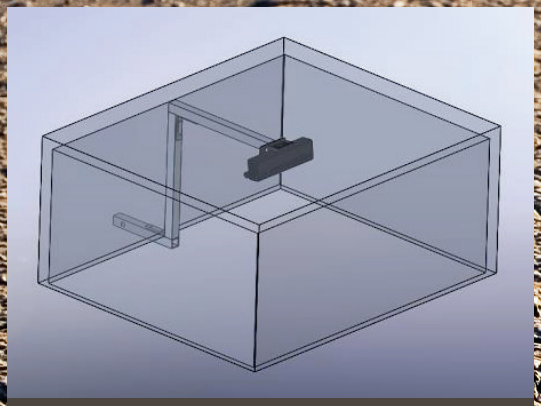
INTERDISCIPLINARY TEAMWORK

Hershberger says that another benefit from this EPICS project has been learning from other students who come from several different engineering schools at Purdue.

"I found myself learning so much from my teammates," he says. "Everyone has a different perspective, and they bring unique skills to the table. You can't help but learn something new after every session."

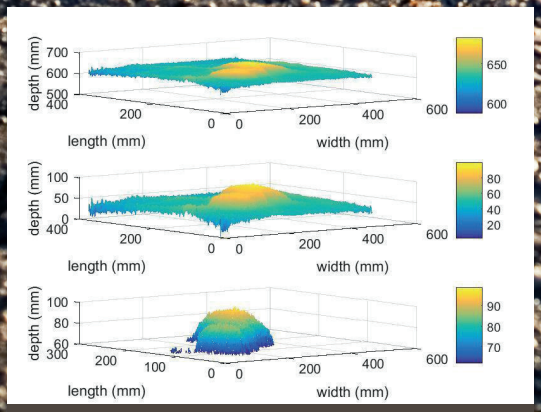
Additionally, the Smart City EPICS team has developed an application for mobile devices that is expected to come out this spring. The app will enable users to report the location of a pothole or any other road damage, alerting the city to the necessity of a repair. The city will be looking out for the most frequent areas that are reported, as well as the most severe potholes that need to be repaired.

"As a teacher, this is the sort of creativity that really makes you proud," Jahanshahi says. "To approach a solution like they did took an incredible amount of teamwork, research and cooperation. I very much look forward to seeing how the project progresses." ■



Early design of the pothole scanner apparatus.

The camera is housed in a case designed by students and attached to the back of a vehicle.



Early testing of the pothole scanner shows promising results. Above, data show that the scanner has successfully measured the size and depth of a pothole.

HOLES

RESEARCH GAINS FROM 3-D PRINTING TECHNOLOGY

The advent of 3-D printing has afforded the Lyles School of Civil Engineering a new dimension of data across multiple research areas. Researchers have been finding many beneficial ways to incorporate the tool in applications across a wide range of topics. They include creating 3-D printouts of traffic areas and crash sites, printing objects mimicking an insect shell for structure joints and re-creating Martian soil samples.

MAKING MARTIAN SOIL

Two undergraduate students, Nestor Fabian Rodriguez Buitrago and Oscar Ojeda Ramirez, both natives of Colombia, conducted research on a material simulating Martian soil (referred to as "Martian soil simulator" or Regolith). The two students worked with PhD student M. Reza Moini and civil engineering professors Jan Olek and Pablo Zavattieri as part of a National Science Foundation (NSF) project and the Undergraduate Research Experience Purdue-Colombia (UREP-C) program.

One of the tasks of their research project was to explore the applicability of additive manufacturing (also known a 3-D printing) to create various structural elements from Regolith. If successful, such an approach can potentially lead to the possibility of manufacturing extraterrestrial habitats for future Mars exploration using materials available on the surface of the planet.

Through 3-D printing, Civil Engineering undergrads Nestor Fabian Rodriguez Buitrago and Oscar Ojeda Ramirez re-created Martian soil for architecture behavior testing.

"Oscar and Fabian quickly became team players upon joining the team in June 2016 and demonstrated their passion and capabilities in the field of 3-D printing of infrastructure materials," Reza Moini says.

Ojeda Ramirez says it has been an exciting opportunity to collect and study material simulating soil from an alien world in the comfort of an oxygen-rich laboratory. "This has been an amazing experience for me," he says. "This was something I wouldn't have even thought possible until recently, and now we're beginning to study something truly different."

As part of the project, the students have also been evaluating selected mechanical properties of 3-D printed elements with different internal architectures and comparing them to the properties obtained from elements created using conventional (i.e., cast) fabrication methods. That aspect of the study is expected to shed light on how the ability to control the internal architecture of the structure via 3-D printing can enhance the mechanical response of the resulting structural element.

RE-CREATING ROAD ACCIDENTS

Civil Engineering Professor Ayman Habib and Lyles Family Professor of Civil Engineering Darcy Bullock are using 3-D printing and unmanned aerial vehicle imaging to gain a greater understanding of roads and crash sites. Through the use of UAVs and thermal imaging, Bullock and Habib are able to re-create scenes with details and data points that a two-dimensional image cannot provide.

Civil engineering student Brandon Hardin has been assisting Bullock and Habib since August and says the use of newer technologies has been an eye-opening experience.

"The continued addition of 3-D printing to research at Purdue has been very exciting and has given me a completely new perspective on how future research could be conducted," Hardin says. "It just goes to show how adaptable civil engineering has always been and continues to be."

Bullock and Habib take dozens of images collected from the UAV to re-create a near-perfect 3-D printed scale model of a traffic scene. The printed model, they say, gives researchers a reference tool of these recorded events and affords investigators a far greater understanding of potential causes of a crash.

"The details, measurements and distances between objects that we are getting from our UAV are incredible," Bullock says. "This has been

Civil engineering professors Darcy Bullock (left) and Ayman Habib review their latest 3-D printed traffic site. The professors used UAV image data to print a three-dimensional, physical copy.

The ironclad beetle inspires tough new materials.

especially helpful where, for example, it's night and it's very difficult to survey a crash site. With a UAV's thermal imaging, you're able to clearly re-create the scene and gather data that you simply cannot gain from a flat image."

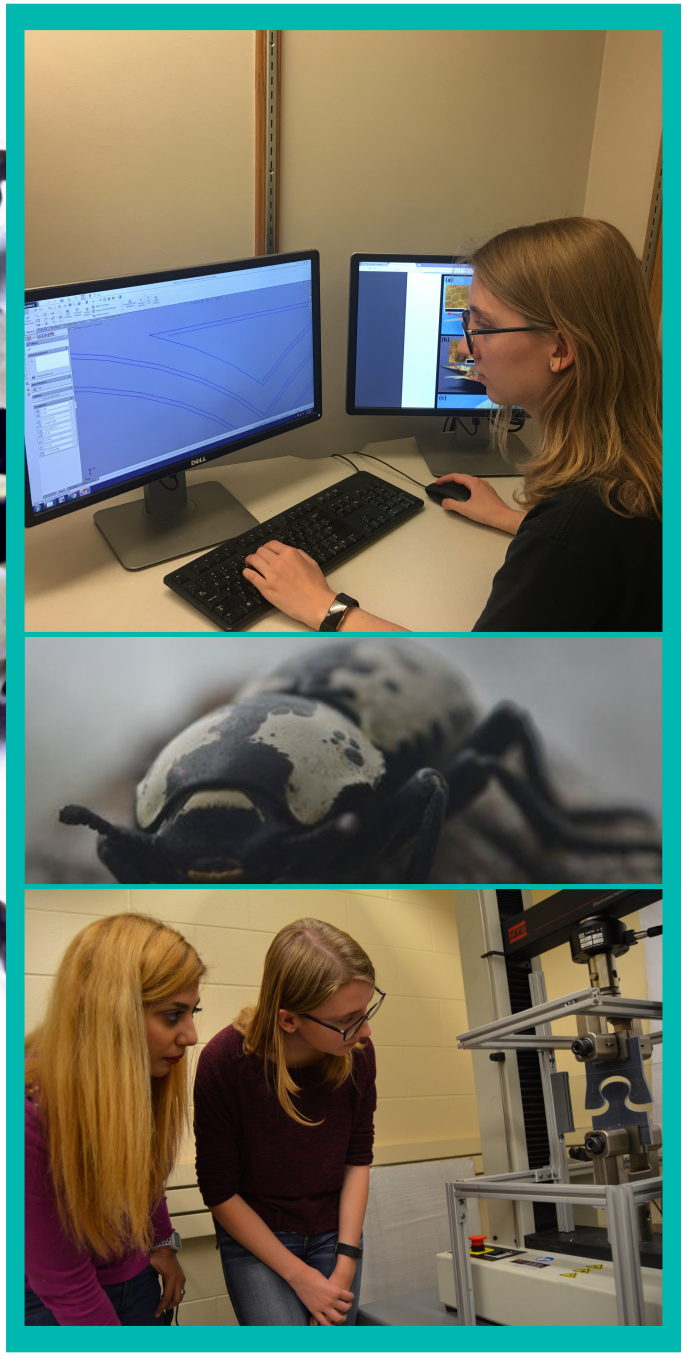
For now, Habib says, the research team will continue to refine its work and provide greater, tangible results.

"The thermal imaging on the UAV is really something new, and we're still finding ways to utilize it," Habib adds. "We've only been working on this particular study for about a year, but we are excited about the future of this research."

INSECT INSPIRATION

Undergrad Molly Cooper has been working in Professor Pablo Zavattieri's laboratory, exploring naturally occurring joints in nature. More precisely, she studies the puzzle-like connection found in the elytra (the hardened forewing) of the ironclad beetle, one of the toughest beetles on Earth. This beetle is so tough that an electrical drill is needed to penetrate its shell.

"These are beetles that can be run over by cars and come out alive,"



Working with PhD student Maryam Hosseini, undergrad Molly Cooper has re-created the jigsaw puzzle-like configuration of the iron-clad beetle via 3-D printing. The printed material is capable of displacing a tremendous amount of energy when under pressure.

Cooper says. "It seemed like a great sample to study and see if we could re-create that strength."

By creating a jigsaw-like pattern, Cooper has been able to create a 3-D printed material that can displace force up to 10 times the amount of an unmodified, similarly sized sample. ■

INNOVATION

NEW UNDERGRADUATE MINOR PREPARES STUDENTS TO LEAD

Many future engineering challenges will require innovation — new or different ideas introduced into use or practice that have a positive impact on society — and Purdue wants to ensure that today's students are prepared to tackle them.

In January 2017, the College of Engineering began offering courses for a new minor: innovation and transformational change. Joseph Sinfield, director of the college's Innovation and Leadership Studies Program, is spearheading the effort.

Sinfield, an associate professor of civil engineering, says he began developing the new minor a year ago because he sees a great need for students to gain experience addressing large-scale socio-technical problems.

"Often, problem-solving in engineering focuses on incremental developments," Sinfield says. "However, many issues engineers will face after college involve complex, multi-faceted challenges, such as developing urban infrastructure, achieving environmental sustainability, facilitating renewable energy development and adoption, and enabling potable water availability. Achieving solutions to problems like these at a societal level may require a shift in paradigm — something non-incremental."

Civil Engineering Associate Professor Joseph Sinfield offers suggestions to the student group consisting of (from left) Santiago Balzaretti, Vanessa Bahk, Eleanor Ericson, Ford Fisher and Yu-Chung Lin. The group has been tasked with the issue of reducing traffic in large cities.

Students minoring in innovation and transformational change will take core classes dealing with problem-framing, solution space development, innovation and design fundamentals. The minor also requires an in-depth experiential learning opportunity for students to apply their skills to a grand challenge problem.

"Purdue engineering students are increasingly engaged in developing solutions to major challenges that have wide-ranging implications on society," says Mung Chiang, the John A. Edwardson Dean of Purdue's College of Engineering. "The new minor in innovation and transformational change, as pioneered by Professor Sinfield and other colleagues, provides students with rigorous methods to embrace stakeholder perspectives and design holistic solutions that achieve operational and economic sustainability. The mindset and the science of innovation help prepare Purdue engineers for leadership roles in the nation and around the world."

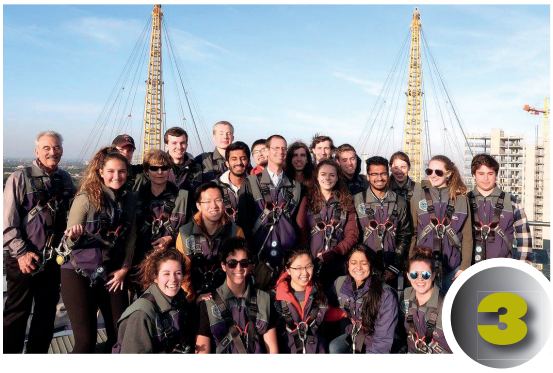
In other classes for the minor, students can develop perspectives and skills that are vital for addressing complex challenges through innovation. Sinfield believes that the minor will be especially beneficial to civil engineering students because it tackles many of the world's large-scale problems.

"When you think about the grand challenges we face — the environment, water, energy, infrastructure — these all rely upon civil engineering," Sinfield says. "Incremental steps won't keep pace with these growing problems; they require high-impact solutions and fundamental changes in human behavior."

Sinfield adds that the minor aims to instill a sense of discovery and persistence when dealing with adversity.

"Innovation is not easy to pursue, let alone to succeed at immediately, but we greatly increase our chances of success through rigorous and systematic problem-solving anchored in the success patterns of innovation science," he says. "We can't always be right, but we can certainly improve our odds." ■

STUDY ABROAD



In 2017, adventures in the 21st Century Transportation class included visits to London's Crossrail sites (1), a Segway tour of Berlin (2), London's O2 dome (3), and a closeup view of a tunnel-boring machine (4). (Photos: twitter.com/eurotr17)

TRAVELS ENLIGHTEN STUDENT ENGINEERS

Every year, Purdue Civil Engineering students are given the opportunity to study abroad. The goal of these trips is to offer students a unique perspective on the application of civil engineering techniques around the world.

This year, civil engineering professors Darcy Bullock and Samuel Labi will lead separate study abroad trips during the summer break.

Bullock's study abroad trip, 21st Century Transportation, will make several stops throughout Europe — in England, France, Germany and Austria.

"The goal for this trip is to show students the variety of approaches that other countries are taking to mass transportation and transportation infrastructure," Lyles Family Professor Bullock says. "There's nothing better to broaden a student's perspective on engineering than seeing the differing, real-world approaches other professionals have taken."

Past study abroad opportunities have involved bike tours of London and Paris, an Eiffel Tower climb, the Paris sewer museum, a technical tour of the new Berlin Brandenburg Airport construction site, the Hamburg Airbus aircraft assembly plant and a ramp tour of the Munich airport. Another past highlight included visits to several of London's Crossrail sites to observe the 15 billion-pound ($20 billion) construction project being managed by Bechtel Corp.

STUDYING ABROAD, EASTERN-STYLE

The second study abroad opportunity this summer, Intelligent Infrastructure Management, will be in Singapore. Professor Labi says the country was chosen because it is considered the most "technology-ready" nation and it is a multicultural hub of global commerce, finance and transportation. English is the most commonly used language there, Labi says, which makes for more convenient traveling.

"It's a unique area that has an impressive array of civil engineering infrastructure developed over the years, so it is an exciting country to visit for engineers," Labi says. "We have several students and faculty from that part of the world, which came in handy when planning the trip and setting up site visits."

Labi says the students will travel extensively in Singapore. In particular, they will visit the Marina Coastal Expressway (the first undersea road in the region), the Changi Airport (rated among the world's best airports), the Port of Singapore (one of the world's busiest ports), and the seawater processing plant.

"Of these places, two are marvels for civil engineers," Labi says. "Seeing the highway run under the sea will be an amazing opportunity.

"The seawater plant also is an impressive site. Before this plant, Singapore had to import fresh water from Malaysia. Thanks to this civil engineering effort, Singapore has a self-sustaining water supply."

Visit **purdue.edu/ce/global** for the Lyles School's full list of study abroad opportunities. ■

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