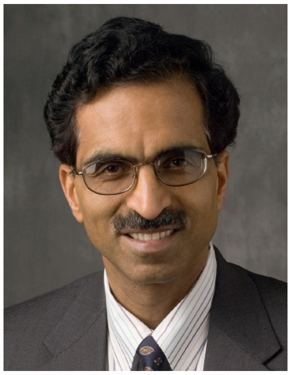
CIVIL
ENGINEERING IMPACT
PURDUE UNIVERSITY | FALL 2017

OUT OF THIS WORLD
CIVIL ENGINEERING LEADS THE SEARCH FOR RESILIENT EXTRATERRESTRIAL HABITATS



The start of the fall semester is always such an exciting — and beautiful — time on campus. With the colorful foliage and innumerable Purdue students everywhere, one cannot help but feel a strong sense of Boilermaker pride.

I suppose that is also why I find it so fulfilling to communicate with you through this magazine. While I receive daily reminders of how excellent our students, faculty and staff are — it is a less frequent pleasure to chat with our alumni, family and friends, who faithfully support the Lyles School of Civil Engineering, sometimes from thousands of miles away.

I can confidently say their faith is not misplaced — and in reading through this magazine, you will feel the same way, I am sure.

In this edition, you will learn about our faculty's efforts to create a program called Resilient Extraterrestrial Habitat Engineering. And, yes, it's exactly what it sounds like. Our professors are working on developing new technologies and systems to allow humans to live on the moon or other planets.

You will learn about plenty of Earth-based research as well. These efforts include using satellites to monitor the displacement rate of the Mosul Dam, conducting an unusual large-scale pipe-pile study on a bridge under construction, and developing software that allows for a more accurate inspection of nuclear reactors.

Another piece of exciting news you will read about is the naming of our graduate program. The Christopher B. and Susan S. Burke Graduate Program was named in recognition of the Burke family's generosity and commitment to Purdue.

Our civil engineering graduate program is one of the first named civil engineering graduate programs in the United States. We are ever thankful to the Burkes and all of our wonderful alumni, friends, and family who continue to support us in making an impact on society.

Thanks to each of you for your continued interest in our school. I encourage you to drop us a note to update us on your accomplishments. Please do stop by whenever your path brings 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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An imaginary Martian city of the future, built in a protective underground environment. The multidisciplinary Resilient Extraterrestrial Habitats team, led by the Lyles School of Civil Engineering, seeks to address the grand challenge of designing permanent human settlements on the moon and other planets.

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BURKE FAMILY NAMES GRADUATE PROGRAM

In April 2017, in recognition of the Burke family's generosity and commitment to Purdue, the school named its graduate program the Christopher B. and Susan S. Burke Graduate Program.

Susan and Chris Burke

CE alumnus Chris Burke says the unique educational opportunities and experiences he and his family received are the reasons for the gift.

"We think that the direction the University is headed is fantastic, and we really want to do our part to keep that great tradition of excellence," Burke says. "We believe a gift to the graduate program will help carry on that tradition."

Over the years, four generations of the Burke family have received 38 degrees from Purdue. Chris Burke earned his bachelor's, master's and PhD degrees in the civil engineering program. He was awarded an honorary doctorate from Purdue Civil Engineering in 2010. Susan earned her bachelor's degree in speech and hearing.

Rao S. Govindaraju, the Bowen Engineering Head and Christopher B. and Susan S. Burke Professor of Civil Engineering, says he is delighted to have the school's graduate program associated with Chris and Susan Burke.

"This program has grown in recent years, in keeping with the increase in faculty numbers," he says. "We continue to receive an ever-increasing number of top applicants to our graduate program, from within the U.S. and abroad. This gift will enable us to develop and support new initiatives that enhance our graduate student experiences."

Purdue's is one of the first named graduate programs in civil engineering in the U.S. The Burkes' gift allows the Lyles School to set yet another benchmark for the program.

The Burkes are major benefactors and supporters of the Lyles School. Among their gifts are the Burke Undergraduate Hydraulic Laboratory, the Christopher and Susan Burke Hydraulics and Hydrology Laboratory, and the Christopher and Susan Burke Professorship. They've also helped fund the Civil Engineering Center for Applications of UAS for a Sustainable Environment. ■

INTER-UNIVERSITY SYMPOSIUM ON INFRASTRUCTURE MANAGEMENT

In June 2017, Purdue University hosted the 13th annual Inter-University Symposium on Infrastructure Management (AISIM). Lyles School graduate students Seyedali Ghahari and Tariq Usman Saeed served as the co-chairs for the international event. Kumares Sinha, the Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering, delivered the keynote speech.

The AISIM event provides networking opportunities for graduate students. Purdue was selected to host this year's event in recognition of the University's strong reputation worldwide in the areas of infrastructure management, research and technology transfer. Faculty advisors were Purdue Civil Engineering Professor Samuel Labi and Sue McNeil, professor of civil and environmental engineering at the University of Delaware.

AISIM attendees were taken on a tour of the Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research.

"We were incredibly honored to have been the host for this year's AISIM," Ghahari says. "The symposium can improve prospects and shape a grad student's career."

The theme was "the State of Infrastructure Management: Challenges, Sustainability and Innovation."

Topics covered infrastructure management functions and featured highway and railway modes. The papers represented a significant contribution to the field of infrastructure management and to civil engineering in general.

AISIM attendees took tours of Purdue's Steel Bridge Research, Inspection, Training, and Engineering (S-BRITE) Center and the Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research. ■

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PANKOW-FUNDED PROJECTS

CE RESEARCH MAY BENEFIT FUTURE DESIGNS OF WORLD'S TALLEST SKYSCRAPERS

Research conducted at Purdue University could potentially change how the world designs its tallest buildings.

With more than $700,000 in funding from the Charles Pankow Foundation and support from the American Institute of Steel Construction, Amit Varma, professor of civil engineering and Bowen Lab director, is leading a pair of research efforts on the use of concrete-filled composite plate shear walls (CF-CPSW). The three-year project aims to generate experimental data and numerical models that will lead to guidelines for optimizing design and speeding construction schedules for high-rise buildings.

In addition to speeding the construction process, the research could result in more creative options for skyscraper designs. “When you’re designing and constructing tall buildings — 50 stories tall and higher — you have to design for wind shear,” Varma says. “Buildings get more flexible as they get taller, so you need a solid core of reinforced concrete.”

The tried-and-true concrete and rebar core is effective, but it can limit design options. “You can’t realistically design the core for anywhere else but in connection to the elevator area,” he says. “It’s just too thick to work anywhere else. The taller the building, the thicker the core needs to be.”

In July, Varma and his team began testing at the Robert L. and Terry L. Bowen Laboratory for Large-Scale Engineering Research using scale versions of the CF-CPSW. The core consists of two steel plates that serve as the framework and main reinforcement. Concrete is then poured in between the steel frames.

“We’ve had to come up with an entirely new test setup for the walls,” says graduate student April Wang. “These walls have been used before, but in just a few cases. Our goal here is to extensively test them and write them into code.”

Ron Klemencic, Charles Pankow Foundation board director, says he is looking forward to seeing — and utilizing — the results from Varma’s research. Klemencic also is chairman and CEO of Magnusson Klemencic Associates.

“Concrete-filled composite plate shear walls represent the next generation of tall building structural systems, providing a significant schedule benefit over more traditional construction methods,” Klemencic says. “Magnusson Klemencic Associates is already incorporating this system into a 900-foot-tall tower in Seattle and anticipates many, many more buildings will adopt this system for its efficiency and speed of construction.”

Phase one of research is expected to continue through summer 2018. ■

PANKOW FOUNDATION FUNDS HIGH-STRENGTH REINFORCEMENT RESEARCH

The Charles Pankow Foundation also is funding a research effort led by Robert Frosch, professor of civil engineering and associate dean for resource planning and management for the College of Engineering.

Frosch's team received $260,000 in January to research and address the development and splicing of reinforcement for seismic and non-seismic applications. Special attention will be given to splicing of high-strength reinforcement at the bases of walls for structures required to resist earthquake demands.

Mark Perniconi, the executive director of the Charles Pankow Foundation, says Purdue Civil Engineering's proven record of thorough and respected research has made the school a valuable and trusted partner.

"The Charles Pankow Foundation has deep ties to the Lyles School of Civil Engineering, and we are extremely pleased to be sponsoring several research projects at the Bowen Lab," Perniconi says. "It is one of the preeminent structural engineering research labs in the world."

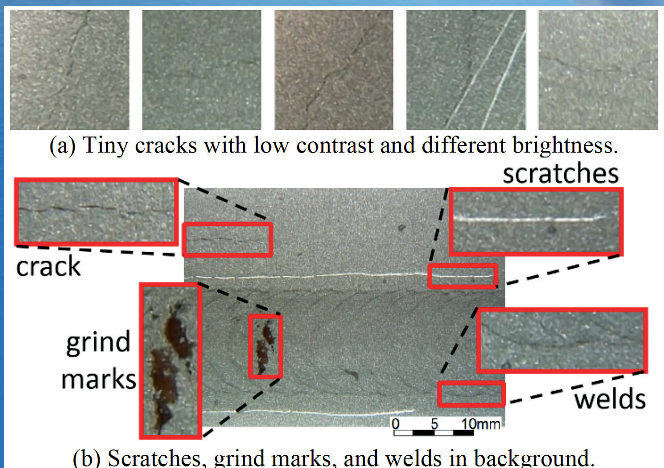
Research on this project is scheduled to continue through September 2018.

Above, Rebecca Glucksman, CE graduate student, and Harry Tidrick, Bowen Lab manager, place concrete into the formwork. Professor Robert Frosch leads the research team that is testing and codifying splice-length requirements when using high-strength steel for seismic and non-seismic applications.

Left, Civil Engineering graduate student April Wang measures the recently delivered composite plate shear walls in the Bowen Lab. The pieces will be tested this fall.

IMPROVING THE SAFETY OF NUCLEAR POWER

NEW DEEP-LEARNING SYSTEM DETECTS CRACKS IN NUCLEAR POWER PLANT INFRASTRUCTURE



(a) Tiny cracks with low contrast and different brightness.

(b) Scratches, grind marks, and welds in background.

Above: The CRAQ detection software uses a camera to automatically detect cracks and scratches inside a nuclear reactor. Above, Mohammad Jahanshahi, assistant professor of civil engineering, and Fu-Chen Chen, PhD student, review results using the CRAQ system.

Purdue Civil Engineering researchers have developed an automated system that detects cracks in the steel components of nuclear power plants — and it has already proven to be more accurate than its predecessors.

"Periodic inspection of the components of nuclear power plants is important to avoid accidents and ensure safe operation," says Mohammad R. Jahanshahi, assistant professor of civil engineering. "However, current inspection practices are time-consuming, tedious and subjective because they involve an operator manually locating cracks in metallic surfaces."

Other automatic crack detection algorithms under development often do not detect cracks in metallic surfaces because the cracks are usually small, have low contrast and are difficult to distinguish from welds, scratches and grind marks.

In 2016, Jahanshahi and his team developed a crack detection system called CRAQ that overcame these limitations by using a texture-analysis approach. Subsequently, the team developed a new version of CRAQ based on an advanced algorithm and a powerful "deep learning" technique to detect cracks on steel surfaces using a convolutional neural network, data fusion, statistics and Bayesian probability. The new version significantly outperforms its predecessor.

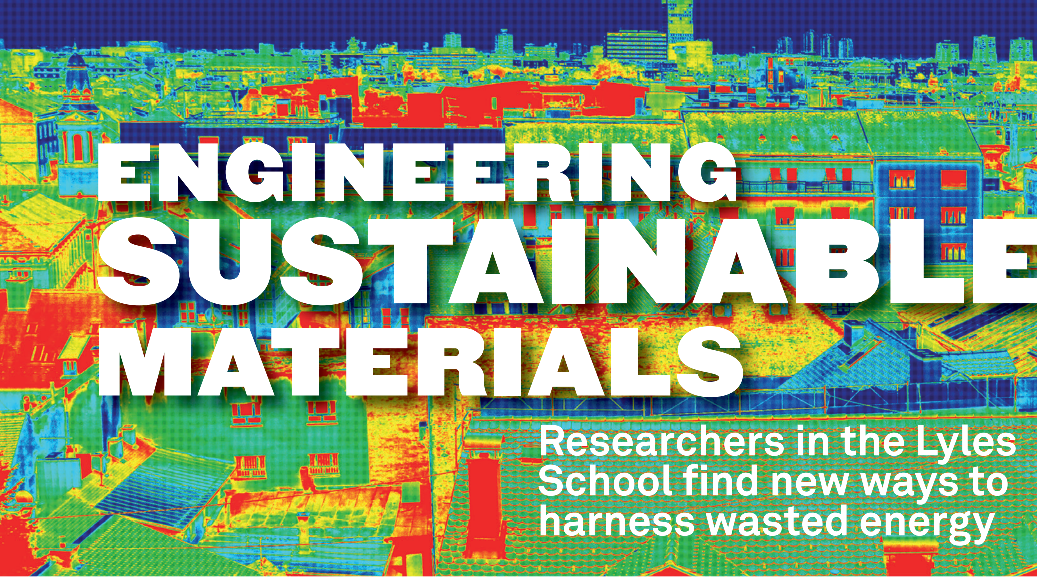
The United States operates 99 commercial nuclear power plants, which account for about 20 percent of total U.S. electricity generation. Aging materials in the structures suffer cracking, fatigue, embrittlement of metal components, wear, erosion, corrosion and oxidation.

"Cracking is an important factor in aging degradation that may cause leaking and result in hazardous incidents," Jahanshahi says. "For instance, the Millstone Nuclear Power Station in Connecticut had an accident in 1996 that was caused by a leaking valve, and the accident cost $254 million. In 2010, the Vermont Yankee Nuclear Power Plant had an accident where deteriorating underground pipes leaked radioactive tritium into groundwater supplies, resulting in $700 million in damage."

The inspection process is challenging because nuclear reactors are submerged in water to maintain cooling. In addition, other automated crack-detection systems typically are designed for processing single images, whereas the new method processes multiple video frames, providing more robust results. Findings show the Purdue system outperformed two others under development.

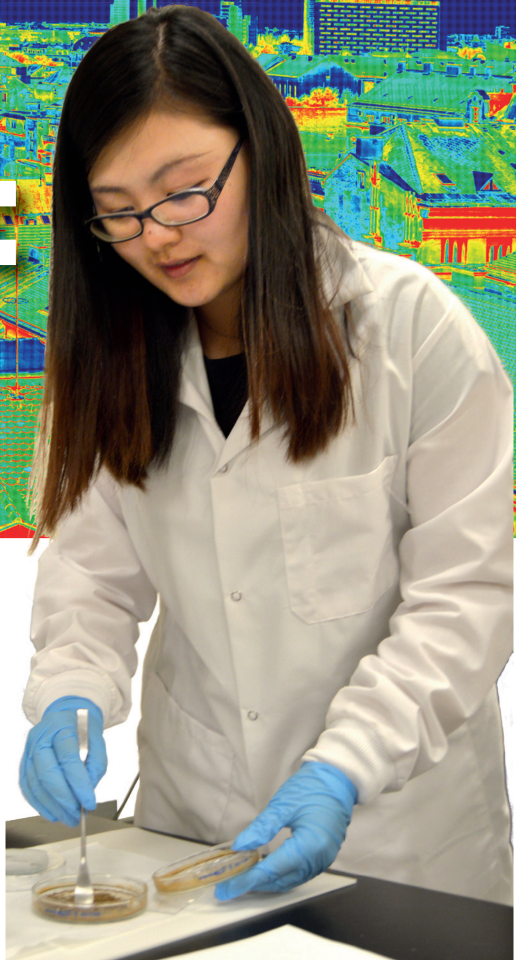
The system assigns "confidence levels," assessing whether the detected cracks are real and provides color-coded confidence levels. The processing procedure takes about a minute.

The researchers have filed a patent application through the Purdue Research Foundation's Office of Technology Commercialization. The work was supported in part under a contract with the Electric Power Research Institute, an independent, nonprofit energy and environmental research organization.



ENGINEERING SUSTAINABLE MATERIALS

Researchers in the Lyles School find new ways to harness wasted energy



Civil engineering PhD student Yining Feng reviews the freshly synthesized thermoelectric materials, which will be used to continue her research into converting heat into energy.

Na (Luna) Lu, associate professor of civil engineering, leads two teams in separate but connected research endeavors. The first involves developing cost-effective thermoelectric materials and systems for civil infrastructure applications. The second involves developing high-performance piezoelectric sensors for nondestructive testing and structural health monitoring.

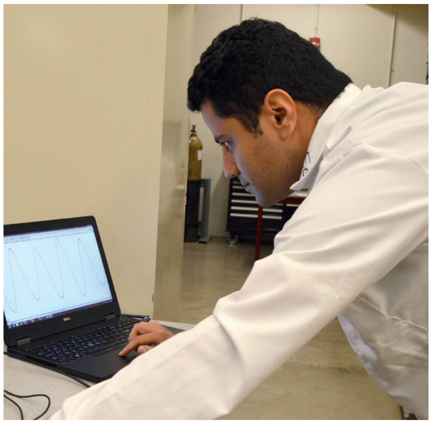
Simply put: Lu's team is researching how to create reliable, effective devices that can convert heat and vibrations into electricity.

"We are developing these to be low-cost, high-performance devices to power the future," Lu says. "We are very excited with the work we have done so far."

Lu explains that as much as 60 percent of the energy produced in the United States is wasted as a form of heat, which could be directly converted into electricity using cost-effective thermoelectric materials. As such, thermoelectric materials offer great promise for energy-efficient power generation in civil infrastructures, by recovering wasted heat from HVAC systems and building envelopes, for instance.

However, Lu says, the potential impact of thermoelectric materials is greatly hindered by the heavy use of toxic, rare and expensive elements necessary to manufacture them. Through a National Science Foundation CAREER Program grant, Purdue Civil Engineering's Sustainable Materials and Renewable Technology (SMART) Lab has developed nanostructured oxides and nitrides as promising, cost-effective materials to overcome this challenge due to their favorable properties and earth abundance.

On the piezoelectric side of Lu's research, her team is working to create devices that can directly convert mechanical vibration into electrical energy and vice versa. This reciprocal energy conversion



PhD student Ehsan Ghafari reviews the latest data collected from his piezoelectric research.

effect of piezoelectric materials enables them to be used as sensors, transducers, actuators and power sources.

"The issue in the past with this kind of research has been that the ceramic materials typically used are too brittle and can be toxic," says Ehsan Ghafari, civil engineering PhD student. "We needed to find a new material that could be flexible, safe and inexpensive."

The SMART Lab's answer is the polymer material polyvinylidene fluoride (PVDF).

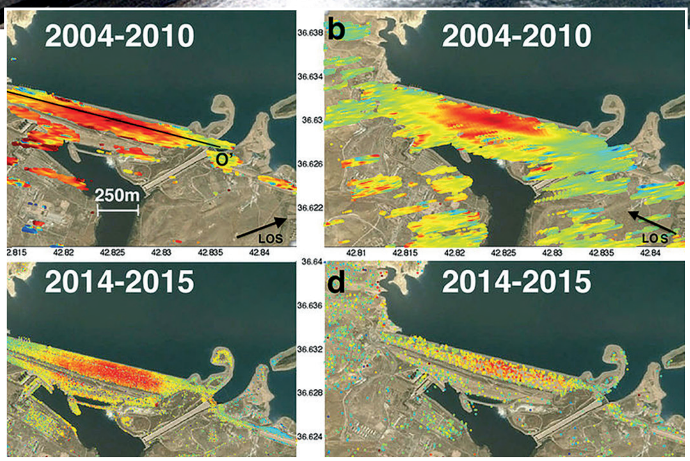
PVDF can be used to create lightweight, high-performance and low-cost piezoelectric devices that can be mounted on civil infrastructures for energy harvesting, nondestructive testing and structural health monitoring.

Lu says these piezoelectric sensors potentially could be used to monitor concrete properties to determine the optimal traffic times around a construction site via the vibration absorbed from passing vehicles. Similarly, these PVDF-based piezoelectric sensors can be used for in situ monitoring of bridge deflection, pavement cracking, de-bonding, corrosion and other damage.

"The uses for these devices are really promising," Lu says. "The sustainable energy from both materials could completely change how future cities are powered. It's an exciting prospect." ■

SATELLITE DATA: IRAQ'S MOSUL DAM IN DANGER

STUDY REVEALS IRAQ'S LARGEST DAM IS AT RISK OF FAILURE



Perissin's team developed a multisensor cumulative deformation map for the dam based on satellite data. (Image source: Daniele Perissin, Nature.)

Water flows down the Mosul Dam chute. The spillway was built with a "ski jump" section to dissipate the energy of outflowing water. The dam is located on the Tigris River. It was built in 1986 and is Iraq's largest hydraulic structure. Photo: U.S. Army, Brendan Stephens

Researcher Daniele Perissin, assistant professor of civil engineering.

Through studying satellite images over a 12-year period, Purdue Civil Engineering researchers have made an alarming discovery: Iraq's Mosul Dam is destabilizing and in danger of failing.

The work is led by Daniele Perissin, assistant professor of civil engineering in the Lyles School. He and his research team — in partnership with the NASA Jet Propulsion Laboratory — recently presented a detailed survey of the ongoing destabilization process of the Mosul Dam. Since 2004, the dam has undergone a displacement of more than 100 millimeters (about four inches). The 3-kilometer-long dam, located on the Tigris River, was built in 1986 and is the biggest hydraulic structure in Iraq.

Perissin's team developed a multisensor cumulative deformation map for the dam, generated from space-based interferometric synthetic aperture radar measurements from the Italian constellation COSMO-SkyMed and the European sensor Sentinel-1A from 2014 through 2016. The data spanning 2004-10 was acquired with the European Envisat satellite.

Perissin's team concluded that the dam foundation is poor due to its site geology, which is formed by alternating strata of highly soluble materials including gypsum, anhydrite, marl and limestone. As a result, the dam is at risk of failure and catastrophic flooding that could affect about 1.5 million people living near the Tigris.

Perissin says it is his hope that the information he has compiled will be used to assist in future dam repair planning.

> "We want people to know what is happening and the potential dangers," Perissin says. "We have collected a large amount of data that we hope can be useful for everyone involved."

In 2016, the U.S. Army Corps of Engineers issued a $300 million contract to the Trevi Group to make repairs. Maintenance and cement grouting operations have since ceased. The spillways also remain blocked, raising concerns about possible dam failure, Perissin adds.

"We will continue to monitor and track the dam," Perissin says. "Our goals are to inform and be of assistance in the future." ■

GRATEFUL
ALUM RECALLS CARING FACULTY

WHERE DID PURDUE CIVIL ENGINEERING TAKE YOU?

Alumnus Ed Copeland says Purdue Civil Engineering not only gave him the education necessary to succeed, but opened professional doors for him as well.

Copeland (BSCE ’83, MSCE ’88) serves as principal engineer and vice president of Arcadis — a global design, engineering and management consulting company with more than 350 offices in 40 countries. It is the twelfth-largest company of its kind in the world with more than 27,000 employees. Copeland has been with the company for 17 years.

He has also been a regular golfer at the Lyles School of Civil Engineering’s annual CE Open for over a decade. “I love coming out to this event every year,” he says. “Attending Purdue was a very special time for me, and I always enjoy coming back to campus whenever I can.”

Copeland has had a successful 30-plus-year career since earning his degrees from Purdue. However, he says, his path may not have been the same if not for the incredible and caring faculty — namely Professor Jim Etzel.

“I remember I was getting set to graduate and I didn’t have a job lined up yet, so I was considering getting my master’s degree right away,” Copeland says. “I was talking to Jim about it and he said, ‘Would you like to get a job instead? I can help you out.’”

Copeland says he eagerly accepted Etzel’s help — and, in short order, he was interviewing for a job at General Motors.

“He said he just needed to make a call,” Copeland says. “When I went there for the interview, I practically already had the job. Jim was so well-respected there; they trusted his recommendation of me. I went to work for the company shortly thereafter.”

Copeland pursued his master’s degree in civil engineering a few years later. He went on to work for Heritage Environmental Services as senior project engineer in 1988 and then at IT Corporation as principal engineer in 1996. In 2000, Copeland found his new professional home at Arcadis.

“It’s been wonderful working there,” Copeland said. “And it’s thanks to what I learned at Purdue and from Jim. He really emphasized the applied science of engineering and that has been instrumental to my success.” ■

OPEN-ENDED BRIDGE PILES

PURDUE, INDOT STUDY NEW TYPE OF PILE FOR WABASH RIVER BRIDGE

The Lyles School of Civil Engineering is leading a project with the Indiana Department of Transportation to learn how to use a type of bridge pile that is typically used in offshore applications. Although these piles have been used in a few states for major onshore structures, much uncertainty remains as to how best to design them.

The piles are being used in the foundations of a bridge spanning the Wabash River near the Purdue campus in West Lafayette. Called large, open-ended pipe piles, the lengths of steel pipe (about 100 feet long and two feet in diameter) will make up the bridge's center piers.

Although data is still being collected, the results thus far have been quite encouraging, says researcher Rodrigo Salgado, the Charles Pankow Professor in Civil Engineering.

Leading the study with Salgado is Professor Monica Prezzi. The project also involves engineers at the Indiana Department of Transportation through the Joint Transportation Research Program at Purdue.

The team built a specially designed, double-wall test pile containing an inner and outer pipe, one slid into the other. Because the two segments are connected only at the top, they can deform independently, a design that makes it possible to measure precisely and separately the forces exerted by the soil on the internal and external surfaces.

"We are extremely pleased with what we have learned," Salgado says. "When you design a bridge, you have to estimate what the live loads (such as traffic and wind) will be. It is very rare to be able to measure these loads at such a large scale ahead of time."

Sensors are placed on both inner and outer walls of the test pile, allowing the researchers to measure how much of the load is transferred to the soil as the pile is being driven into the ground and also later, during static load tests. At the same time, the researchers are examining a second test pile that has a closed end, allowing a direct comparison. Unlike the open-ended piles, the closed-ended pile contains a pointed shoe at its base.

The more than 200 sensors used to instrument the piles will be linked to a data acquisition system by 24,000 feet of electrical cables.

"If the loads are not the same at different locations, it's because some load along this length was transferred to the soil, which is what you want to happen," Prezzi says. "By measuring the strains at different cross-sections, you can determine how the load is decreasing down the pile as it's being transferred to the soil."

The fabrication of the double-wall, open-ended pipe pile and the instrumentation of both test piles were performed at Purdue's Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research. ■

OLD TOOL, NEW RESEARCH

REFURBISHED TOWING TANK ENABLES MORE EXPERIMENTATION IN HYDRAULICS AND HYDROLOGY

The Purdue University Civil Engineering Hydraulics and Hydrology Group will be making waves — literally — this school year.

This fall, the Lyles School towing and wave tank will be fully operational. The 150-foot-long, 11-foot-wide and 5-foot-deep water basin will be used for coastal engineering and fluid dynamics research. It is located in the basement of Hampton Hall, in the Christopher and Susan Burke Hydraulics and Hydrology Laboratory.

"We're all very excited about what this can do for our research," says Cary Troy, associate professor of civil engineering. "We have spent years working on this project, and we are happy to have it up and working."

With a large carriage affixed to the top — which can move as fast as 5 meters per second — the tank will be used in a wide range of hydrodynamic and coastal engineering studies. A wave maker has been installed to study coastal erosion effects and wave forces. Additionally, the tank is equipped with a water-filtration system, viewing ports to monitor flow, a 3-D particle image velocimetry system, wave guages, and load cells to measure fluid forces on towed objects.

The towing tank's carriage runs on rails and can move as fast as five meters per second. The carriage is used to haul objects through the water-filled tank (below) to quantify flow patterns and hydrodynamic forces.

The towing tank, a 150-foot-long, 11-foot-wide and five-foot-deep water basin, will be used for coastal engineering and fluid dynamics research in the Burke Lab.

HISTORY REVIVED

The towing tank was originally constructed in the 1960s along with Hampton Hall itself. However, over the decades, the tank fell into disrepair. It has not been used since 2007.

Preparations for the renovations began about four years ago, when the Civil Engineering and Mechanical Engineering schools received a grant from Purdue to overhaul the facility.

"We expect this to help set Purdue apart as one of the best civil engineering schools in the world and to provide us with greater and more conveniently located research opportunities," Troy says. "Also, it's just nice to restore a piece of our school's history."

Rao "G.S." Govindaraju, the Bowen Engineering Head and Christopher B. and Susan S. Burke Professor of Civil Engineering, says he is excited to see the new research opportunities the towing tank will provide."We are always looking to improve and add to our school so that our students, faculty and staff can have the best resources available to them," Govindaraju says. "Not only will this create new avenues for research, it revitalizes our facility and restores some of our venerable history." ■

NONLINEAR TESTING

Purdue Civil Engineering is approaching structural systems analysis from a new, digital angle.

Shirley Dyke, professor of civil engineering and mechanical engineering, and Arun Prakash, associate professor of civil engineering, are co-principal investigators leading a team that hopes to transform structural evaluation through cyber-physical experimentation. The team is conducting its research via real-time hybrid simulation (RTHS) — a cyber-physical technique used to examine the global behavior of structural systems that are too large or complex to test in a laboratory at large scale.

Dyke says that the RTHS technique fills a testing gap that needs to be addressed.

Amin Maghareh, recent Lyles School PhD graduate, explains how real-time hybrid simulation is being used used to examine the global behavior of structural systems that are too large or complex to test in a laboratory at large scale. The testing is being conducted at the Bowen Laboratory.

Shirley Dyke, professor of civil engineering and mechanical engineering.

Arun Prakash, associate professor of civil engineering.

"We can't always predict how new building design concepts are going to behave under extreme conditions out in the real world, and testing serves to illuminate potential pitfalls," she says. "This is a way to do less expensive and rapid testing, without the large shake tables. It is also for structures that wouldn't fit in a laboratory at all."

Prakash adds that he hopes this will ultimately lead to more efficient testing that can be utilized by engineers all around the world.

"We truly want to advance the art of hybrid simulation here," Prakash says. "It is our hope that our work will be accepted by the structures community and lead to new innovations."

Assisting Dyke and Prakash is Amin Maghareh, who earned his PhD from Purdue in August. Maghareh says the work being done by the team will improve how structures are tested in the future.

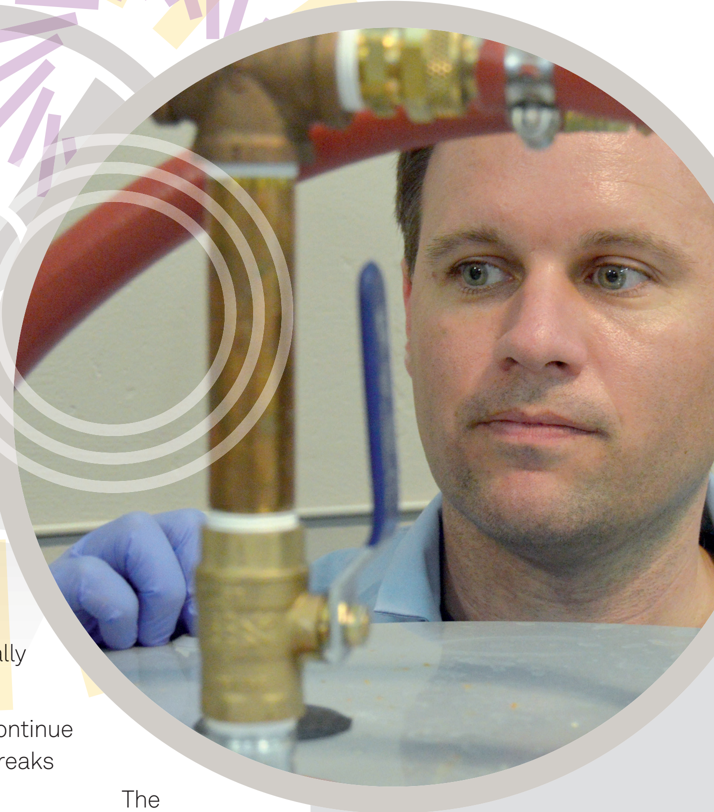
"Current testing is somewhat limited," he says. "With this research, we're able to simulate larger, more complex models. This process and the results are things that have never been seen before."

RTHS is highly interdisciplinary, requiring expertise in structural mechanics, modeling, control, signal processing and computer science. In the Intelligent Infrastructure Systems Laboratory, located in the Bowen Laboratory facility, Purdue faculty and graduate students from civil engineering and mechanical engineering are working in partnership with computer scientists from Washington University in St. Louis. Together, they are making major advances in the science and implementation of RTHS techniques.

The research is funded through a $1.8 million National Science Foundation grant — split evenly between Purdue and Washington universities. ■

LOW-FLOW SYSTEMS at RISK

A collaborative grant enables researchers to address health risks of low-flow water systems

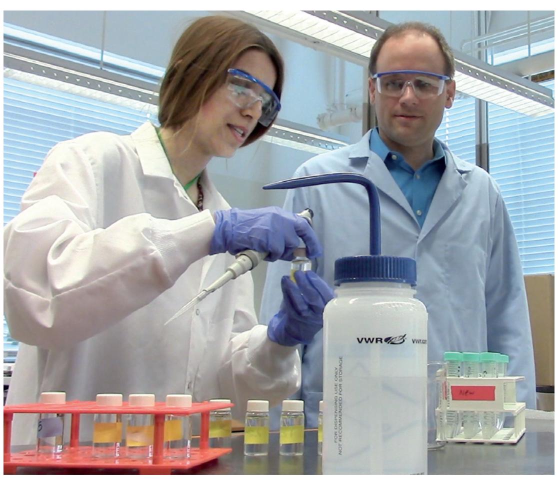


Professor Andrew Whelton leads a research team that is studying low flow water systems in buildings.

Low-flow water systems in buildings are designed to conserve water, but they pose potential health hazards because they may cause an increase in disease-causing organisms and harmful chemicals.

A new Environmental Protection Agency-funded project led by Andrew Whelton, assistant professor of civil engineering, aims to help solve the problem.

“The increasing occurrence of low flows in water distribution systems and building plumbing presents an emerging health concern. Opportunistic pathogens more easily multiply under low-flow conditions,” Whelton says. “Building designers, managers, and health officials need better information and models to predict health risks in plumbing systems found in all sorts of buildings, from schools, to homes, to healthcare facilities.”



Professor Andrew Whelton and post-doctoral student Maryam Salehi work in the environmental engineering laboratory in Hampton Hall on low-flow water systems research.

The organisms include the bacterium Legionella pneumophila, which causes Legionnaires disease; the brain-eating amoeba Naegleria fowleri; Pseudomonas aeruginosa, an antibiotic-resistant pathogen associated with serious illnesses; and Mycobacterium avium, which causes respiratory illness, especially in immunocompromised people.

“These opportunistic pathogens continue to cause waterborne disease outbreaks across the country,” Whelton says. “In fact, Legionella remains the most identifiable cause of waterborne disease in the U.S.”

Purdue will work with researchers at Michigan State University (MSU) and San Jose State University (SJSU) to better understand and predict water quality and health risks posed by declining water usage due to water conservation fixtures, reduced water usage and low flows. The group is funded with a $2 million grant from the EPA. The three-year project, which began in January 2017, also will be funded with $1.1 million from non-federal sources, including Whirlpool Corp., Citizens Energy Group and the Avon Community School Corporation.

“The research announced today will guide decision makers as they design, renovate or manage plumbing systems to provide safe and clean drinking water,” says Thomas Burke, agency science adviser and deputy assistant administrator of EPA’s Office of Research and Development.

The grant application from the Purdue-SJSU-MSU team included numerous letters from people who have benefited from the advice of researchers. Letters of participation and support were submitted by the American Society of Plumbing Engineers, the United States Green Building Council, Indiana Rural Water Association, water utilities, architectural and engineering firms, and researchers from Canada, Denmark, Israel and the United States. Support also was expressed by the American Water Works Association, Healthy Building Network, National Institute of Standards and Technology, and the National Environmental Health Association.

“We designed our project based on drinking water safety concerns from the public, industry and government agencies. Our approach harnesses world-class expertise from industry and other academics,” Whelton says. “We have an amazing team and are eager to start working more closely with our project collaborators and supporters.” ■

ENGINEERING DWELLINGS TO SURVIVE ON MOON or mar

RESEARCHERS BRING CIVIL ENGINEERING DISCIPLINE TO THE DESIGN OF RESILIENT

If you've seen the movie "The Martian," starring Matt Damon as an astronaut presumed dead and left behind on Mars, then you know he manages to stay alive for years inside an artificial habitat nicknamed "The Hab." Just how realistic is that structure? Not very, says Antonio Bobet, professor of civil engineering.

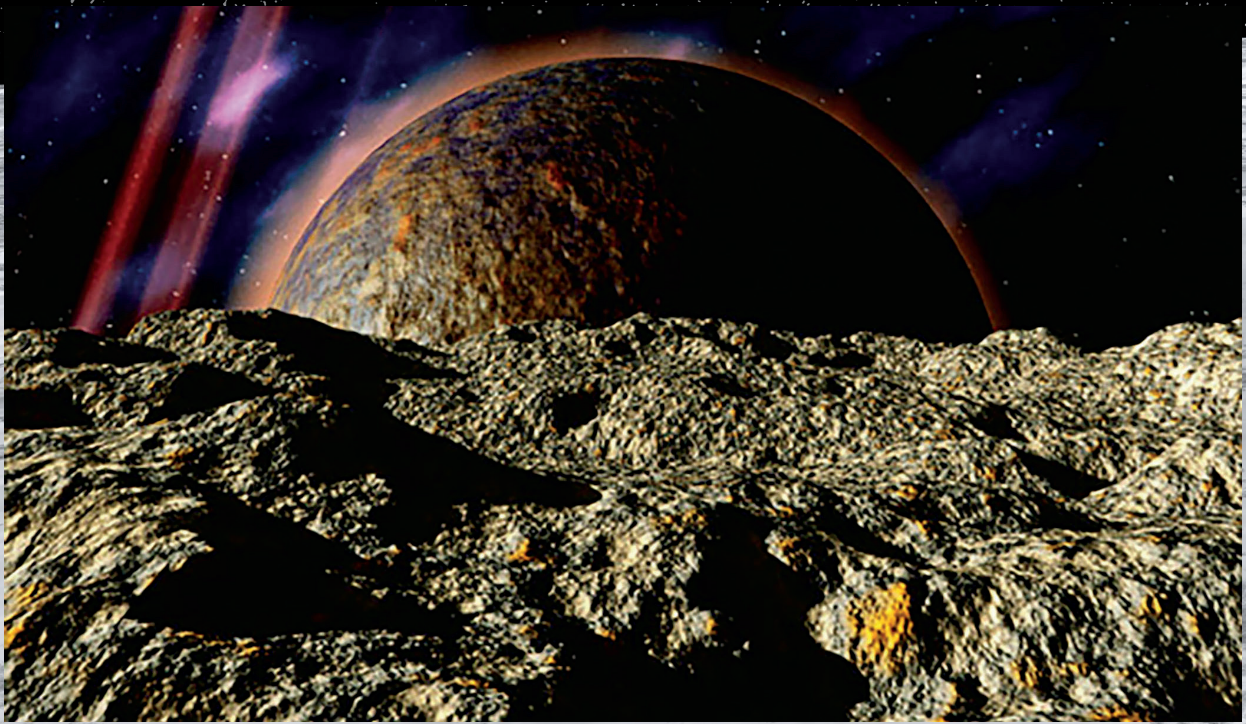
"We've seen a lot of conceptual designs similar to the one shown in the movie, but they won't work," he says. "They're not resilient. They won't protect human or plant life from wild temperature fluctuations and hazards such as meteoroid impacts and intense particle radiation."

What will? That's what Purdue's new Resilient Extraterrestrial Habitats (RETH) team has set out to discover. Comprised of Bobet, four other principal investigators and several postdoctoral and student researchers (see sidebar for full list), the team received the first New Horizons grant awarded by the Office of the Provost in March 2017. New Horizons is a competitive program challenging established senior faculty to create new academic areas for the coming decades.

"There's a great deal of interest from NASA and others to send people to the Moon and Mars, and plenty of science already exists on the effects of radiation on humans and on the geology and properties of space materials," Bobet says. "What we're doing is transferring that science to engineering. We're looking at the hazards systematically, then quantifying and expressing the results in a way that is useful to engineers."

Student researcher Herta Montoya, for example, is exploring the effects of meteoroid impacts on the lunar surface — a hazard that typically isn't considered when designing structures on Earth. A civil engineering student at the University of Texas at San Antonio, Montoya joined the RETH team as part of Purdue's Summer Undergraduate Research Fellowship Program.

"It's a big challenge to design extraterrestrial habitats because of the extreme conditions faced out of the Earth's atmosphere," she says. "Few studies have proposed a numerical approach or methodology to develop risk assessments for a



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EXTRATERRESTRIAL HABITATS

lunar habitat in terms of hazards. We're doing rigorous research to help conceptualize and quantify these hazards to assure a safe design for future extraterrestrial habitats."

By the midway point of its two-year grant, the RETH team hopes to host an international workshop focused on key hazards. Creating a network of experts both within and outside Purdue will help the team define its key research questions and prepare to approach funding agencies with its ideas.

Another goal is to create a path for a minor in extraterrestrial habitat engineering within Purdue's Lyles School of Civil Engineering. The RETH team is multidisciplinary — including researchers from earth, atmospheric, and planetary sciences, mechanical engineering, and aeronautical and astronautical engineering — with civil engineering taking the lead.

"Civil engineers help drive progress, communications and economic and cultural exchange," Bobet says. "The infrastructure we create will satisfy human needs for research, exploration and daily living — ultimately enabling humans to survive and thrive away from Earth." ■

JAY MELOSH ANTONIO BOBET SHIRLEY DYKE JULIO RAMIREZ

PURDUE'S RETH FACULTY TEAM

Designing an extra-strength habitat suitable for life beyond Earth requires a multidisciplinary team. To follow the RETH team's progress, check in on the website: **purdue.edu/reth**

Antonio Bobet
professor of civil engineering

Daniel Dumbacher
professor of engineering practice, aeronautics and astronautics

Shirley Dyke
professor of mechanical and civil engineering

Jay Melosh
Distinguished Professor of Earth, Atmospheric Sciences and Physics

Julio Ramirez
professor of civil engineering, director of the Network Coordination Office for the Natural Hazards Engineering Research Infrastructure

Postdoctoral and student researchers

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Hayley Bower
Daniel Gómez Pizano
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Herta Montoya
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HAMPTON HALL RENOVATIONS

When the world wants innovative, monumental engineering feats, it looks to civil engineers. Purdue University has awarded more than 14,000 civil engineering degrees and continues to graduate 150 students each year.

In the Lyles School of Civil Engineering, facility updates are underway to better educate and equip the 21st Century civil engineer. Set for fall 2018 completion, the ground-floor and basement-level renovations will provide an accessible entryway, improved air circulation, updates to existing laboratories for state-of-the-art civil engineering teaching and research, and new flexible-use teaching laboratories.

SPECIFICALLY, THE PLAN WILL DELIVER:

- Three flexible teaching labs to accommodate evolving teaching needs, such as: 1,735 sq. ft. for architectural engineering; 1,151 sq. ft. for geomatics engineering; and 1,395 sq. ft. for structural engineering.
- Additional geomatics staging/lab prep/surveying lockers — 492 sq. ft.
- A new student lounge to promote collaboration — 204 sq. ft.

Having flexible laboratories will allow us to anticipate future teaching and research needs by providing easily modifiable spaces calibrated to accommodate varying class sizes and a broad range of interdisciplinary activities. These labs will address the constant evolution of civil engineering practices by providing modern facilities that encourage hands-on experimentation, active computer simulation and the seamless integration of these technologies.

PURDUE ENGINEERING

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